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EVIDENCE FOR TREATING TWO TAXA OF *RUDBECKIA* (ASTERACEAE) AS SPECIES

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ABSTRACT

Rudbeckia grandiflora for most of its recent taxonomic history has included the typical variety and var. *alismifolia*. Digitized herbarium collections and citizen science programs have made it easier to examine morphological variation and more precisely document their geographic ranges. A digital review was supplemented with field studies of their habitat preferences and associated species. The results suggest that specific rank is more appropriate for these taxa, as *R. grandiflora*, and *R. alismifolia*. Range maps, diagnostic images, and a dichotomous key are provided for them. Also, observations on their conservation status in various states are given.

Rough coneflower, *Rudbeckia grandiflora* s. lato is species of the south-central grasslands. The clumps of tall, unbranched stems arise from substantial rhizomes and generally each supports a single, large, showy head. While *Rudbeckia grandiflora* s. lato is readily distinguished from other species, the distinctiveness of its two varieties, var. *alismifolia* and var. *grandiflora* (hereafter as *alismifolia* and *grandiflora* s. stricto), has been largely unappreciated. The two taxa were initially described as species, then later as varieties (Perdue 1957; Shinners 1949 and citations within each). Herbarium specimens have not been commonly annotated to varietal or specific ranks (pers. obs.). Most modern works have differentiated the two taxa on the basis of stem vestiture alone, and while some have outlined a vague geographical range of each variety (see Kelley 2020 for discussion on Louisiana), none has provided multi-state, county-level range maps (Britton & Brown 1913; Cronquist 1980; Gleason & Cronquist 1963; Gandhi and Thomas 1989; Kartesz 2015; USDA NRCS 2014; Weakley 2020).

Extensive field and herbarium observations of these taxa led to the discovery of additional distinctions in their morphology. The correspondence of such morphological differences with their geographic ranges and habitat differences lead to the conclusion that the taxa are best treated at specific rank.

Materials and methods

The Symbiota portals (https://symbiota.org/symbiota-portals/) were used to study high resolution images of specimens of *Rudbeckia grandiflora* s. lato rangewide for diagnostic features and to observe label data to determine the occurrence of both taxa as I had done previously for Louisiana and Oklahoma (Kelley 2020, 2023). All specimens at BRIT, FTPK, LSUS, NLU, and VBT were annotated along with nearly 250 observations of *R. grandiflora* s. lato on iNaturalist (https://www.inaturalist.org/).

All populations known to me of either taxon in Caddo, Bossier, and Webster parishes in Louisiana were visited to take field measurements and notes. Within each of 15 sub-populations in this field study (8 *alismifolia* / 7 *grandiflora* s. stricto*)* a basal leaf was randomly selected for the comparison (Figures 4, 5). This region represents a likely edge-of-range for each entity. A comparison of basal leaf features from outside this region was also made.

Occurrence records from herbarium specimens and iNaturalist records were used to draft a map in Google Earth Pro covering Arkansas, Louisiana, Oklahoma, and Texas — this draft was then used to calculate the proportion of sympatric range and to examine ecoregional affinities. Field and lab notes were used to develop a dichotomous key, and the key was tested on dried specimens and living plants in areas where the taxa grew nearest to each other to confirm their distinctions. Candlestick charts were also constructed to illustrate certain differences between the taxa.

Results and discussion

A range map from my review of herbarium records, iNaturalist observations, and voucher-based maps from Kartesz (2015) and Gentry et al. (2013) is provided above (Figure 1). The map illustrates the largely allopatric ranges for the taxa; estimated sympatry is only 5-6% as mapped by county borders.

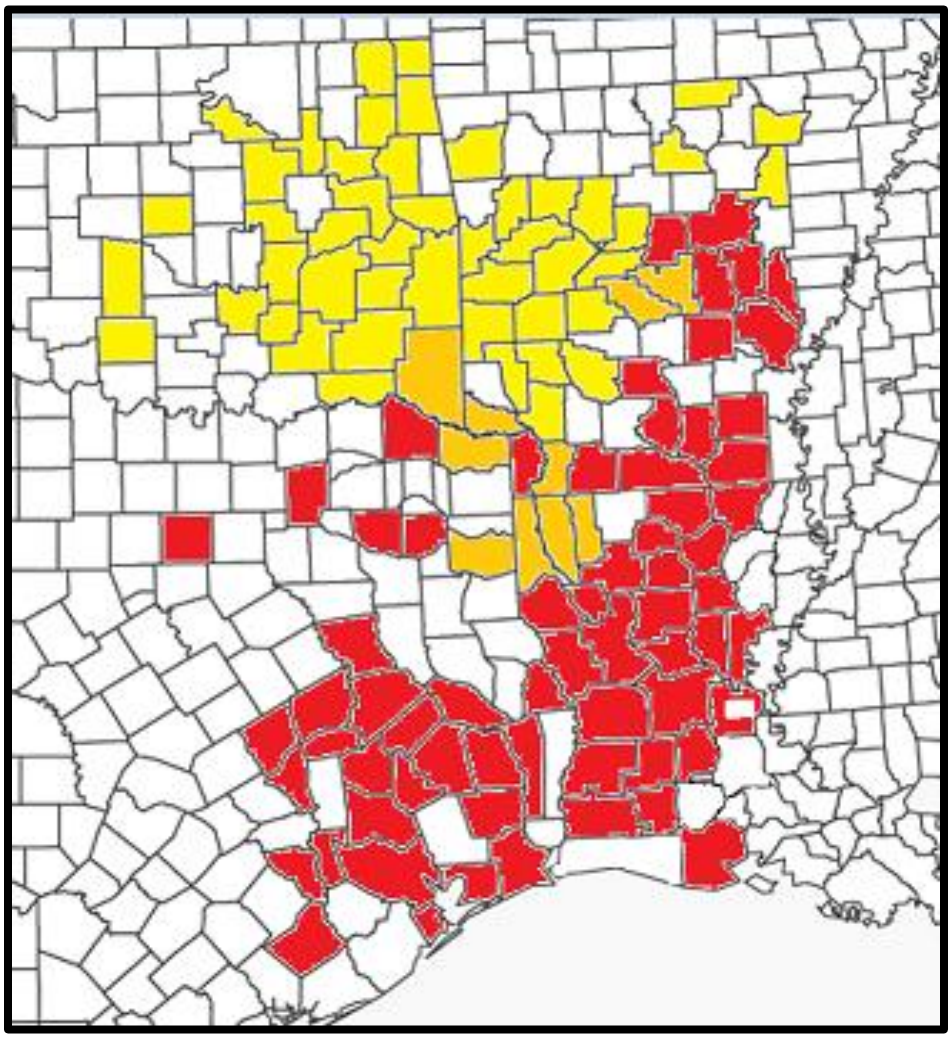

Figure 1. Map of known distributions in the core of the range for variety *alismifolia* (red) and *grandiflora* s. stricto (yellow) with their zones of sympatry (orange).

The sympatric zones occur along the floodplains of the Red and Arkansas rivers. Sympatry in Louisiana results from the occurrence of acidic-lowland and calcareous-upland grasslands in close proximity (MacRoberts et al. 1997; MacRoberts and MacRoberts 1997; MacRoberts et al. 2009; Soilweb 2019). I have found no evidence of close sympatry (co-occurrence at a single site) in

Louisiana, Arkansas, and Texas. The closest the taxa were observed growing to one another was 2.3 kilometers apart on disparate soil series. In general, *alismifolia* is the southern entity found in pine savannas, mima-mounded prairies on loess or loamy alluvium, generally in wet-mesic, acidic situations (pers. obs.). G*randiflora* s. stricto is found farther north, often in drier situations, often on circumneutral or calcareous clay, loams, or stone, and is often in dry prairies, glades, or oak woodlands (pers. obs.). In the sympatric zone, *Tephrosia onobrychoides*, *Paspalum laeve*, and *Liatris pycnostachya* are frequent and potentially differential associates of *alismifolia* (pers. obs.), while *Liatris aspera*, *Helianthus hirsutus*, and *Parthenium hispidum* are associated with *grandiflora* s. stricto (pers. obs.).

Small (1933) provided the best prior treatment of these taxa, and some of the morphological features in the present key were mentioned by him as diagnostic for species recognition. Quantitative comparisons and photos for these attributes are provided in Figures 2-6. Some physical distinctions that appear to be novel have been incorporated into the present key. A few of these characters, such as basal leaf shape, while diagnostic the majority of the time are too weak to be relied upon absolutely. Their combination, however, makes identification quite certain in any season. No confounding specimens or indeterminable populations were encountered in the present investigation. The midstem clustering of leaves in *alismifolia* was particularly useful among the new distinctions discovered. The shared traits (e.g. narrow leaves and coarse indument) between *grandiflora* s. stricto and *R. missouriensis* are interesting — they each occupy dry glades and prairies. The glade-dwelling *R. heliopsidis*, shown as sister to *grandiflora* s. lato by Urbatsch et al. (2000), is quite similar to *grandiflora* s. stricto in vestiture and basal leaf shape.

KEY TO SPECIES

1. Lower stems, petioles, & leaf faces with conspicuous, mostly spreading hairs ca. 1 mm in length, basal leaves usually lanceolate, broadest below the midpoint, apices acute, typically with acute marginal teeth and 2 prominent veins on each side of the midrib, ca. 4 cauline leaves per unbranched stem, uppermost leaves >4.5x (commonly ca. 7x) longer than wide, outer phyllaries >3x longer than wide, these strigose and planar, primarily found in the Interior Highlands and Plains ..... **Rudbeckia grandiflora**

1. Lower stems, petioles, and leaf faces with inconspicuous, mostly appressed hairs ca. 0.5 mm in length, basal leaves usually elliptic, widest near the midpoint, apices obtuse or acute, typically with undulate-crenate margins and 1 prominent vein on each side of the midrib, often crowded at midstem level, ca. 7 cauline leaves per unbranched stem, uppermost leaves <4.5x (commonly ca. 2.5x) longer than wide, outer phyllaries <3.5x longer than wide, these glabrate & convolute, primarily found in the Coastal Plain ..... **Rudbeckia alismifolia**

Evidence suports treatment of these taxa at specific rank, their authorship as *Rudbeckia alismifolia* Torrey & A. Gray, *Rudbeckia grandiflora* (Sweet) DC. (see Perdue 1957; Shinners 1949). Weakley's Flora of the Southeastern United States (2023) has already incorporated this view at my suggestion. Representative specimens are shown for each in Figures 7-11.

Notes on state conservation status

LOUISIANA- *Grandiflora* s. stricto is rare in Louisiana. In the course of this study three undocumented populations of it were discovered (Kelley 2020), and specimens and photos from these are held at KBL. These newly found populations are all small and imperiled by roadside spraying (pers. obs.), so the rank of S1S2 (critically imperiled to imperiled) seems appropriate. All were on soils mapped as the Gore series. Wrightsville and Kolins soils frequently hosted *alismifolia* in the northwest Louisiana zone of sympatry. The latter grows abundantly in this state and is judged to be secure.

TEXAS- From Texas, only two collections of *grandiflora* s. stricto were found. There is also an iNaturalist observation for *grandiflora* s. stricto near the boundaries of Caddo Lake State Park. The species was not relocated by the staff in the summer of 2022 (Dustin Schrock, pers. comm.). A rank of S1? (critically imperiled, with uncertainty) seems appropriate. Abundant collections and observations on iNaturalist show that *alismifolia* is secure in Texas.

OKLAHOMA- For the state of Oklahoma, I found that *alismifolia* has been collected from Red Slough WMA in McCurtain County (Kelley 2023), where it is now regarded as historical. On the other hand, *grandiflora* s. stricto appears to be secure.

ARKANSAS- Distribution records for both taxa in Arkansas were compiled from the maps in that state's atlas (Gentry et al 2013) and no new records were discovered in the present investigation. Both taxa appear to be secure. My travels highlighted the importance of *alismifolia* to the Grand Prairie ecosystem in the east-central part of the state, where it dominates many acres.

MISSISSIPPI- Vouchers and iNaturalist observations of *alismifolia* were found from roadside grassland remnants in northern Mississippi. Floristically, these probably represent extensions of the Arkansas Grand Prairies. The conservative nature of its associated species and the paucity of collections in Mississippi suggest that the species is native but rare, and it probably deserves to be tracked.

MISSOURI- Specimens examined for Missouri support the perception by Gleason and Cronqist (1963) and Thomas and Ladd (2015) that *grandiflora* s. stricto is adventive.

KENTUCKY- Perhaps the most perplexing disjunction is the occurrence of *R. grandiflora* s. lato on rocky glades in Kentucky, where the plants have conservative associates (Adam Mattingly, pers. comm.). Occurrences were first recorded near Louisville in the 1940s by P.A. Davies (*748*, APSC), and the stations seem natural except that the photographs and specimens I have seen all appear to be *alismifolia*. If this identity is correct, and if the populations are natural, these would represent disjunctions of 600-900 km in a habitat more typical of *grandiflora* s. stricto. By whatever means they arrived, they are extant and have been posted to iNaturalist within the last few years. These sites deserve attention; a comprehensive description of the site histories, vegetation plots, site checklists, and demographic values might shed light on their origin. In the meantime, *alismifolia* might be tracked out of abundant caution.

GEORGIA- A single collection by Cronquist in 1948 documents *grandiflora* s. stricto from Catoosa County. The details provided in the collection notes suggest a natural occurrence, a matter that needs further investigation.

ACKNOWLEDGEMENTS

From herbaria, Jennie Kluse (LSU) and Tiana Rehman (BRIT) were always willing to help with odd requests and annotations. Alan Weakley incorporated my *Rudbeckia* conclusions into FSUS 2023 and provided encouraging comments on my work to that point. Barbara MacRoberts gave helpful comments on an earlier draft. The late Michael MacRoberts forced me to read deeply on this topic to defend against his skepticism. Lowell Urbatsch reviewed an earlier version of this paper and offered helpful responses to inquiries about the genus in general; his substantive review greatly improved the manuscript. I thank them each.

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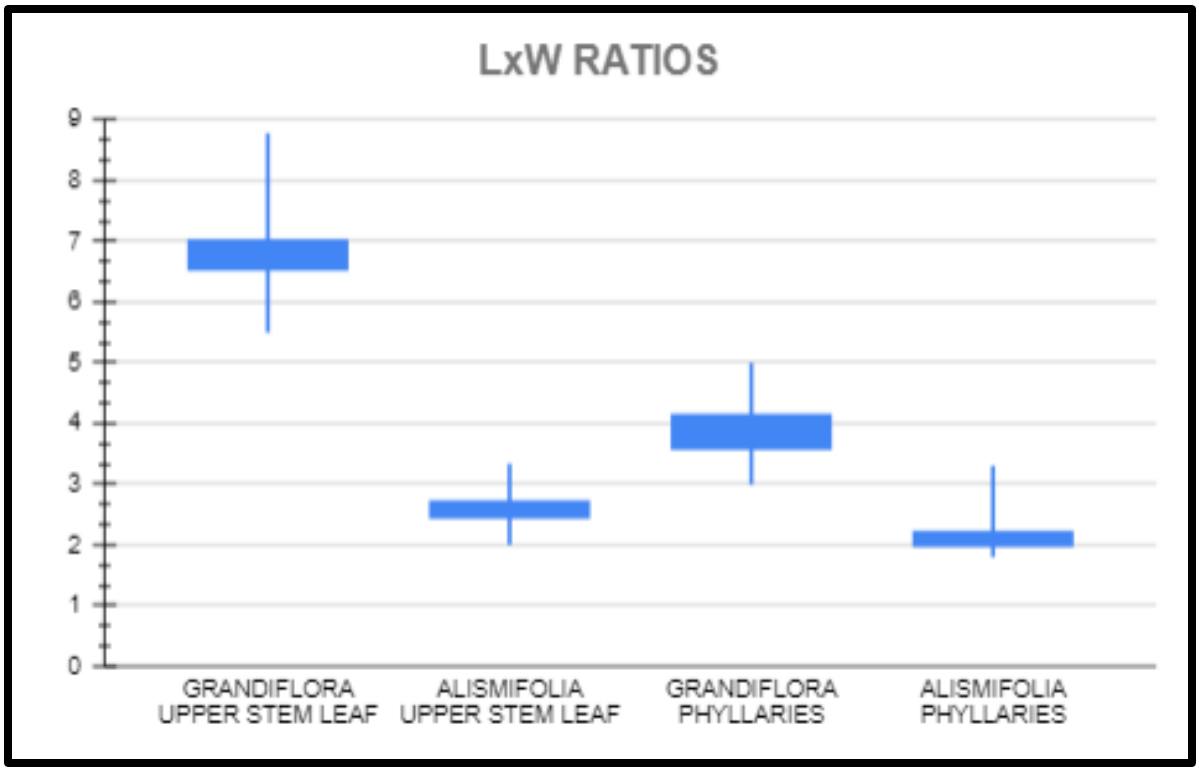

Figure 2. Upper leaf and outer phyllary LxW ratios from 10 sheets each with all characters and the extremes padded by living and pressed specimens.

Figure 3. Pubescence on the proximal abaxial leaf surface of *Rudbeckia grandiflora* s. stricto (left) and *Rudbeckia alismifolia* (right).

Figure 4. Curvature, shape, and pubescence on the phyllaries of *Rudbeckia grandiflora* s. stricto (left) and *Rudbeckia alismifolia* (right).

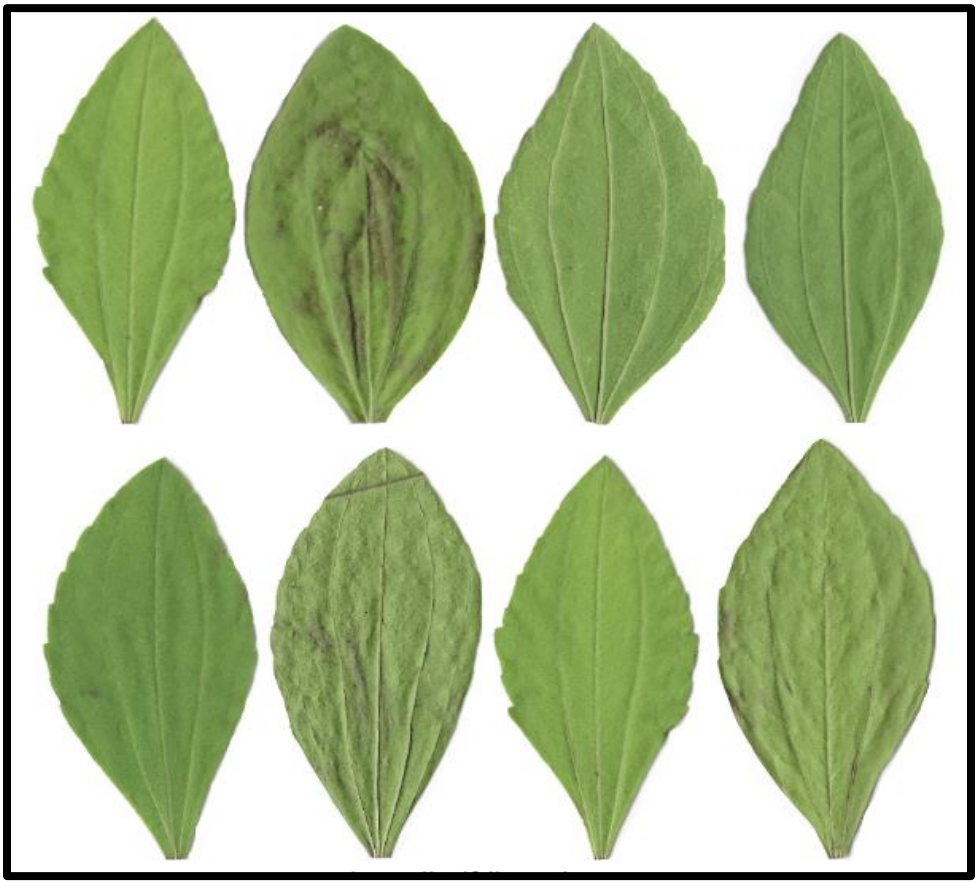

Figure 5. Basal leaves of *Rudbeckia alismifolia* showing the elliptic shape, crenulated margins, and three conspicuous veins.

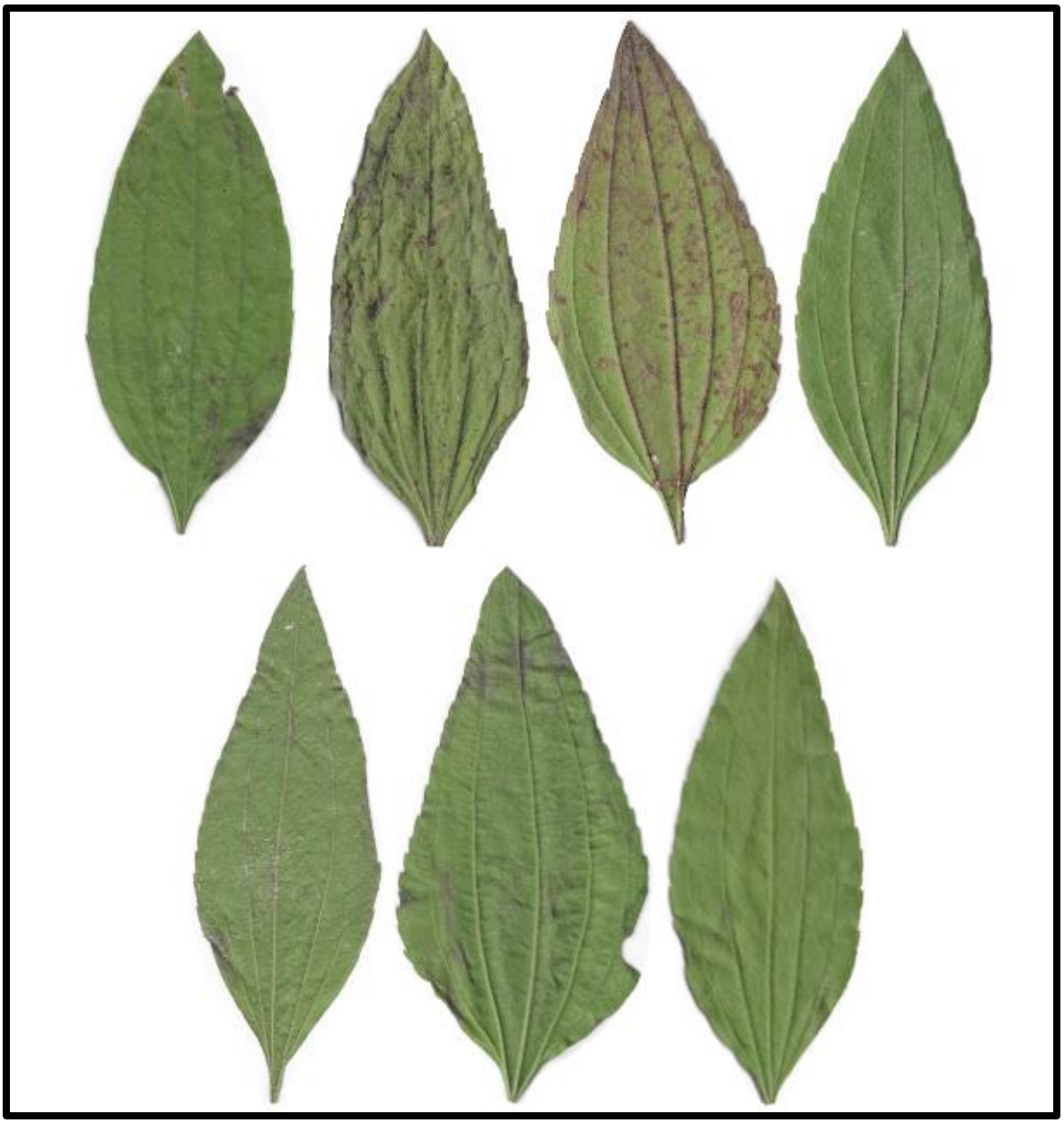

Figure 6. Basal leaves of *Rudbeckia grandiflora* s. stricto showing the ovate-lanceolate shape, sharply serrated margins, and five conspicuous veins.

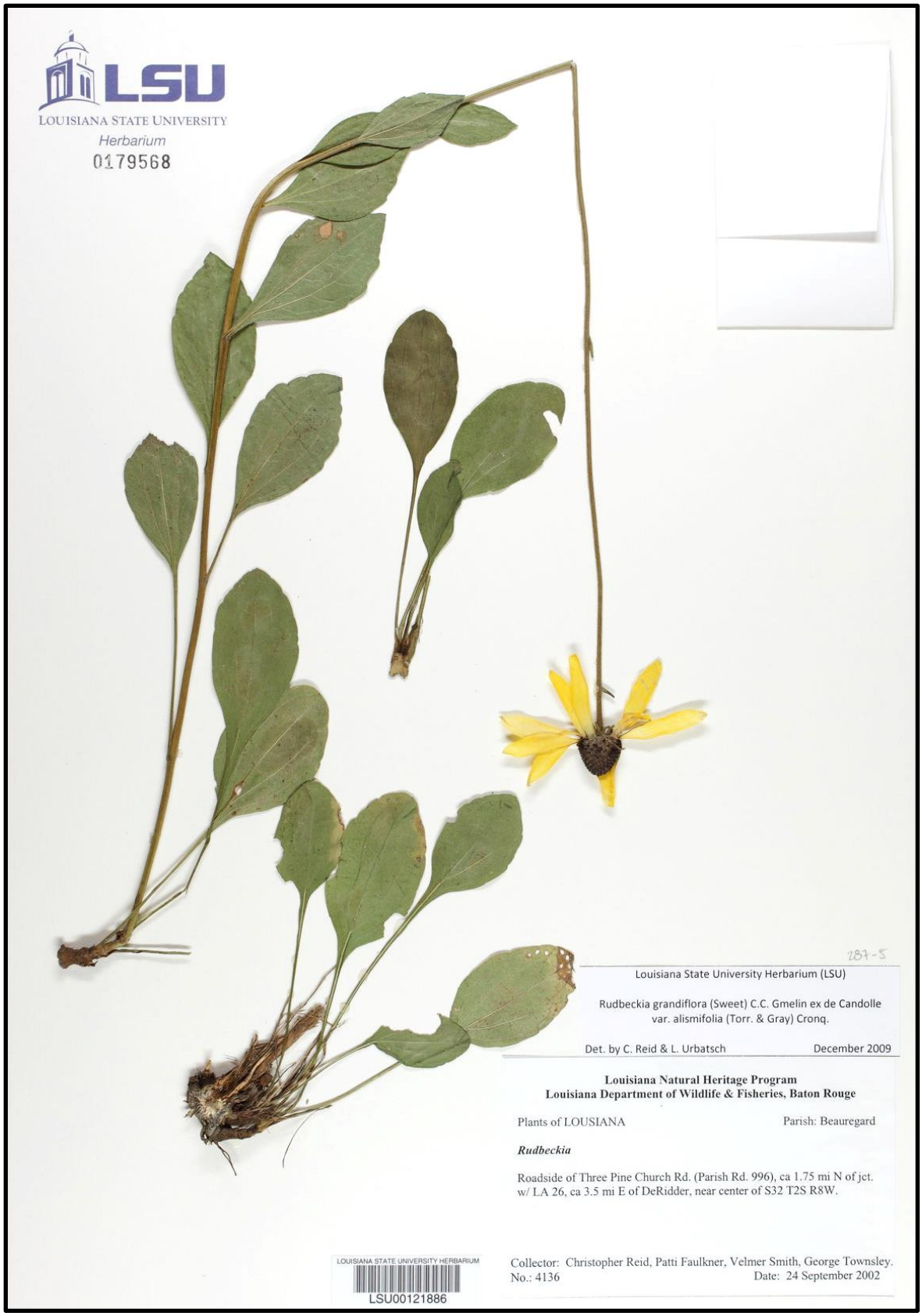

Figure 7. Representative collection of *Rudbeckia alismifolia* (LSU, CC-BY-NC).

Figure 8. Representative collection of *Rudbeckia alismifolia* (ANHC, CC-BY-NC).

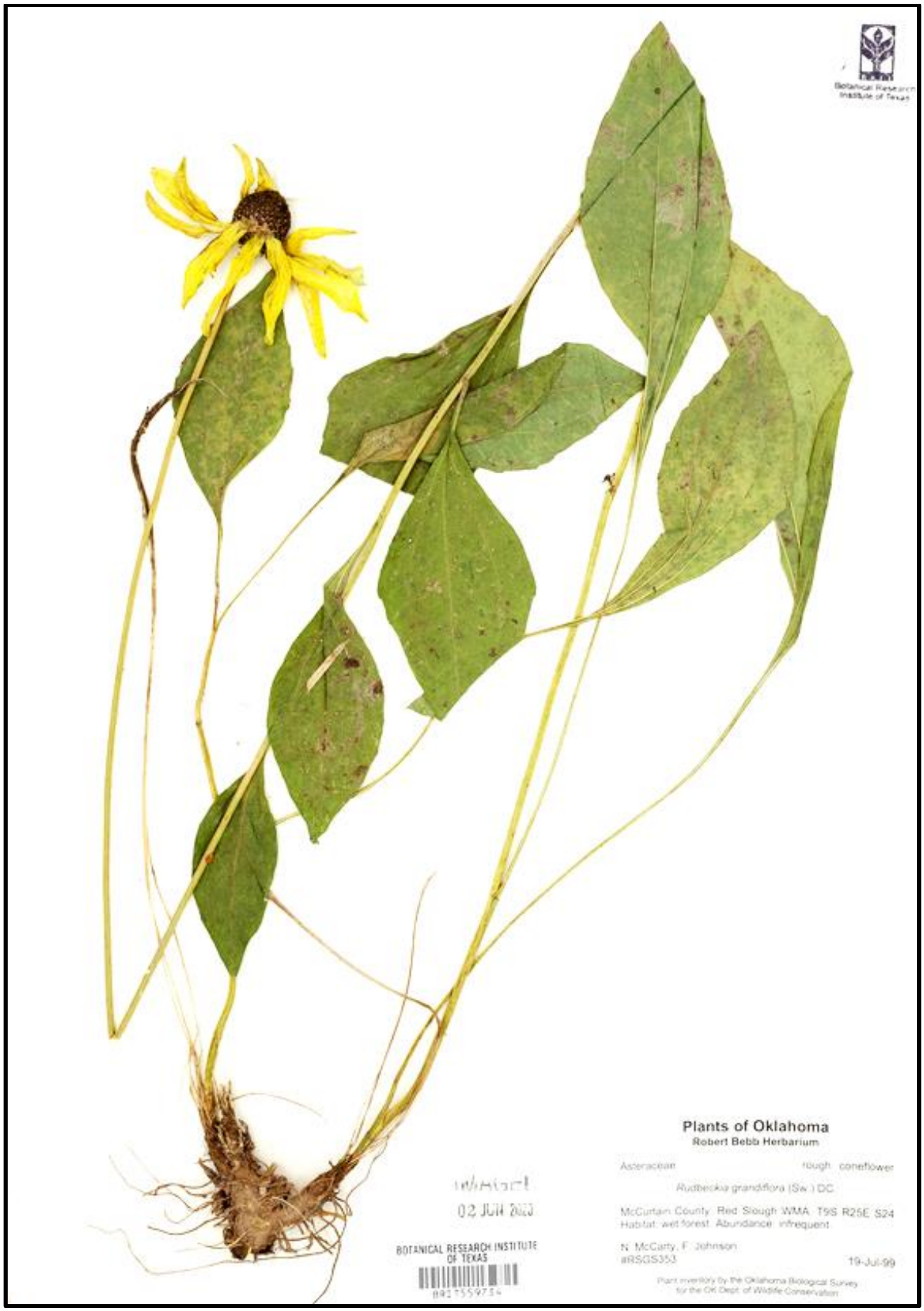

Figure 9. Representative collection of *Rudbeckia alismifolia* (BRIT, CC0).

Figure 10 Representative collection of *Rudbeckia grandiflora* s. stricto (UARK, CC-BY-NC).

Figure 11. Representative collections of *Rudbeckia grandiflora* s. stricto (UARK, CC-BY-NC).

Figure 12. Representative collection of *Rudbeckia grandiflora* s. stricto (UARK, CC-BY-NC).