**Juncus fascinatus** (Juncaceae), a new combination in *Juncus* sect. *Ozophyllum* and notes on morphologically similar species

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Abstract

Research of the morphologic variation within *Juncus* (Juncaceae) sect. *Ozophyllum* has revealed the need for a new combination, *Juncus fascinatus*. Univariate and multivariate statistical analyses show that *J. fascinatus* is morphologically distinct from *J. validus*. *Juncus fascinatus* is described, illustrated, and compared to the superficially similar species *J. paludosus*, *J. polycephalos*, and *J. validus*. *Juncus fascinatus* is endemic to 25 counties in north-central and southeastern Texas whereas *J. validus* is more widespread and weedy. *Juncus fascinatus* is ecologically distinct from *J. validus* and has shown a rapid range expansion throughout the southeastern United States and into the Mid-Atlantic. *Juncus validus* is most likely non-native west of the Mississippi River. The morphologically similar *J. paludosus* is reported from Alabama, Georgia, Louisiana, and South Carolina for the first time. *Juncus polycephalos* is reported from Kansas.

Key words: principal components analysis, cluster analysis, endemic, morphology, conservation concern, *Juncus validus*

Introduction

*Juncus* Linnaeus (1753: 325, Juncaceae) is a cosmopolitan genus of approximately 315 species. *Juncus* sect. *Ozophyllum* Dumortier (1827: 142) (=subg. *Septati* Buchenau 1875: 406) is the largest section in the genus and comprises approximately 84 species with 32 species in North America (Brooks & Clemants 2000, Kirschner 2002). This section is most diverse in eastern North America, southwestern Europe and the Far East. Members of section *Ozophyllum* are distinguished as having septa that form complete bands across the leaves and flowers lacking subtending bracteoles (=eprophyllate).

*Juncus validus* was described by Coville (1895: 305). Though there has been some debate about the appropriate name for this species (Kirschner & Drábková 2007) it has been universally accepted as distinct from other members of section *Ozophyllum*. Marshal C. Johnston described *J. validus* var. *fascinatus* (Johnston 1964: 313) and named it after its type locality, Enchanted Rock, a unique natural area spanning Gillespie and Llano Counties, Texas. Johnston (1964) distinguished var. *fascinatus* based upon its diminutive inflorescence of 2–5 cm, with heads 6–15 flowered, and capsules remaining united at the apex at maturity.

Authors of treatments and floras vary in their recognition of *J. validus* var. *fascinatus*. Treatments focusing on Texas (Jones *et al.* 1997, Diggs *et al.* 1999, Turner *et al.* 2003) and many broader geographic treatments (Brooks & Clemants 2000, Kirschner 2002) all recognize var. *fascinatus*. It is unclear if treatments from other States and regions that do not list any varieties within *J. validus* are disputing the legitimacy of var. *fascinatus* or are not being explicit in listing var. *validus* (Godfrey & Wooten 1979, Gleason & Cronquist 1991, Yatskievych 1999, Wunderlin & Hensen 2003). No study has been published examining this taxon and all treatments that recognize this variety cite the characters published by Johnston (1964).

While working toward the Juncaceae treatment for the *New Manual of Vascular Flora of the Northeastern United States and Adjacent Canada* (Naczi & collaborators in prep.) and revising the *Juncus* treatment for the *Flora of the Southern and Mid-Atlantic States* (Sorrie & Knapp 2012), I examined material matching the description of var. *fascinatus*. This material was strikingly distinct from typical *J. validus* and I concluded a reevaluation of this taxon was in order. It is also apparent widespread confusion surrounds the identification of two morphologically similar species
of *J.* section *Ozophyllum*, *J. paludosus* Bridges & Orzell (2008: 294) and *J. validus*, and a morphologically similar species of section *Iridifolii* Snogerup & Kirschner (1999: 382), *J. polypepalos* (Michaux 1803: 192). This confusion stems from many factors including confusing or poorly constructed keys and the fact *J. paludosus* was only recently described (Bridges & Orzell 2008).

Here I present the results of a morphological study of *J. validus* from throughout its geographic range. I then present a taxonomic revision of *J. validus* including a key, illustrations, description, representative specimens and provide illustrations of superficially similar species to assist in proper identification.

**Materials and Methods**

I studied the morphology, geographic distribution, and habitat of *J. validus* in the field from 2002–2014 at as many sites as possible. My knowledge of *J. fascinatus* is from herbarium specimens and literature. I have studied *J. validus* in Alabama, Georgia, Delaware, Maryland, Mississippi, North Carolina, South Carolina, and Virginia. I have studied nearly 600 specimens from throughout the geographic range of *J. fascinatus* and *J. validus* from the following 22 herbaria: BALT, BRIT, Cylburn Arboretum Herbarium, DOV, FLAS, FSU, GA, KANU, LL, LSU, MARY, MO, NA, NCU, NY, PH, SMU, TAWES, TEX, WILLI, US, and VDB. Herbarium abbreviations follow Index Herbariorum (2014) with the exception of the Cylburn Arboretum Herbarium (4915 Greenspring Ave, Baltimore, MD 21209, U.S.A.). I created distribution maps based on herbarium specimens; every mapped symbol is based on at least one voucher specimen.

I selected a representative subset of specimens for analysis. I used only mature, complete collections. These collections represented the full range of morphologic variation and are from throughout the geographic range of the two species. Specimens measured are denoted by an asterisk (*) after the herbarium acronym in the citations of representative specimens.

**Statistical Analysis**

A set of 55 complete specimens (22 *J. fascinatus* and 33 *J. validus*) from throughout the geographic and morphological range of *J. validus* were chosen for detailed morphologic analysis. Specimens measured for analysis came from unique populations. This helped prevent artificially weighing the morphology of any particular population in the dataset. Given the limited number of specimens discovered and the restricted geographic range of *J. fascinatus* only 22 specimens of this species were suitable for measurement. After careful review of all literature and examination of hundreds of herbarium specimens a list of 10 potentially diagnostic characters was developed (Table 1). I measured all of these characters on ten specimens each of the two taxa recognized by the most inclusive taxonomic and floristic treatments (e.g., Brooks & Clemants 2000, Kirschner 2002). I included those characters whose loadings were >0.5 on principal components analysis in future analysis. I then measured these characters (Table 1) on an additional 35 specimens. Summary statistics including means, standard deviation, and ranges were calculated for each character.

<table>
<thead>
<tr>
<th>TABLE 1. List of all characters examined with the component loadings and percent variance explained by the first two Principal Components.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characters Examined</td>
</tr>
<tr>
<td>Inner tepal length</td>
</tr>
<tr>
<td>Outer tepal length</td>
</tr>
<tr>
<td>Capsule length</td>
</tr>
<tr>
<td>Length capsule exceeds inner tepals</td>
</tr>
<tr>
<td>Inflorescence length</td>
</tr>
<tr>
<td>Inflorescence width</td>
</tr>
<tr>
<td>Inflorescence length/width ratio</td>
</tr>
<tr>
<td>Longest primary branch of the inflorescence</td>
</tr>
<tr>
<td>Longest secondary branch of the inflorescence</td>
</tr>
<tr>
<td>Percent Total Variance Explained</td>
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</tbody>
</table>
When multiple individuals were present on a single sheet, I measured all characters from a single individual. When measuring a character that was present more than once per individual (e.g., capsule length), I measured the one with the greatest value. Measurements were only taken from mature specimens. Inflorescence length was measured from the base of the inflorescence bract to the tip of the inflorescence. Inflorescence width was measured at the widest point of the inflorescence. Capsule length was measured from the base of the capsule to the tip and was often aided by removing the capsule from the tepals. Inner and outer tepals were measured from the base of the tepal to the tip.

I submitted all characters to Pearson Correlation Analysis. When two characters were highly correlated ($r > 0.7$), the character with the higher component loading (as determined by Principal Component Analysis) was retained. The other character was excluded from multivariate statistical analysis in order to avoid weighting potentially redundant morphologic characters.

I conducted statistical tests on the measurements using Systat version 12 (SPSS 2007). An Analysis of Variance (ANOVA) was conducted to test the null hypothesis that there is no morphologic discontinuity between *J. fascinatus* and *J. validus*. A Principal Component Analysis (PCA) determined the amount of morphological variation in the data set and the characters that are most diagnostic to *J. fascinatus*. Before conducting PCA the dataset was standardized so each variable would have a mean of 0 and a standard deviation of 1. A Cluster Analysis (CA) determined which specimens were the most morphologically similar by grouping each specimen by its overall phenetic similarity. The CA examined all 55 specimens using Euclidean distance and average linkage. Such methods have been useful in similar studies (Saarela *et al.* 2003, Kjaer *et al.* 2004, Knapp & Naczi 2008).

**Geographic distribution**

I calculated latitude and longitude coordinates for each specimen studied based on label data using Google Maps (2014). Species locations were compiled in Microsoft Excel for Mac (2011) and mapped using ArcMap 10 (ESRI 2010). This data was sorted by date and mapped to show known collection locations by date for *J. validus*. To be as inclusive as possible in searching for early collection records of *J. validus*, I conducted searches on the Alabama Plant Atlas website (2014), which searches nine Alabama Herbaria, and the Tomas M. Pullen Herbarium website (2014), which searches the collections of MISS.

**Results**

**Correlation analysis**

The Pearson Correlation Analysis revealed many characters to be highly correlated ($r > 0.7$). Length of the longest primary inflorescence branch and length of the longest secondary branch of the inflorescence are highly correlated to the total inflorescence length ($r = 0.94$, $p<0.0001$ & $r = 0.95$, $p<0.0001$, respectively). Length of the longest primary inflorescence branch and length of the longest secondary branch of the inflorescence are also highly correlated to the total inflorescence width ($r = 0.80$, $p<0.0001$, & $r = 0.80$, $p<0.0001$, respectively). Inner tepal length was highly correlated to outer tepal length ($r = 0.84$, $p<0.0001$). Capsule length was highly correlated to inner tepal length, outer tepal length, and the length the capsule was exerted beyond the inner tepals ($r = 0.85$, $p<0.0001$; $r = 0.80$, $p<0.0001$; & $r = 0.84$, $p = 0.0002$, respectively). The length of the longest primary inflorescence branch, length of the longest secondary inflorescence branch, length of the outer tepals and the capsule length are excluded from multivariate statistical analysis because their component loadings are less than the loadings for the characters with which they are highly correlated.

**Univariate analysis**

The ANOVA (Table 2) showed the characters accounting for the most morphologic dissimilarity between taxa. These were: inner tepal length, inflorescence width, and inflorescence length. The characters with the two highest $F$-values were plotted graphically (Fig. 1) and reveal no overlap between groups. This shows that by using inner tepal length and inflorescence width *J. fascinatus* and *J. validus* can be distinguished.

**Multivariate analysis**

A scatter plot of the scores of components I and II from PCA reveals two distinct groups (Fig. 2). The first two principal components account for 80.6% of the variation. Component I accounts for 65.8% of the variation and component II accounts for 14.8% (Table 1). The variables with the highest loadings on component I are inflorescence...
width, inflorescence length, and capsule length exposed beyond inner tepals, in descending order. The variables with the highest loadings on component II are the capsule length exposed beyond outer tepals, inflorescence length, and the capsule length exposed beyond outer tepals, in descending order. A dendrogram resulting from the Cluster Analysis (CA) shows two groups (Fig. 3). No specimens were incorrectly clustered. All specimens of *J. fascinatus* cluster together and all specimens of *J. validus* cluster together.

**FIGURE 1.** Scatterplot of the two most important characters (inflorescence width and tepal length) for distinguishing *J. fascinatus* from *J. validus* as revealed by ANOVA. Circles represent *J. fascinatus* (N = 22) and triangles represent *J. validus* (N = 33).

**Morphological characters**

*Juncus fascinatus* is easily distinguished from *J. validus* by a number of morphological characters. *Juncus fascinatus* has a capsule apex that remains united at maturity (Fig. 4), whereas the capsule of *J. validus* separates into three distinct portions at maturity (Fig. 5). The inflorescence is shorter (4.6–13 cm) and narrower (2.5–8.1 cm) in *J. fascinatus*, giving a much more congested look than the longer (13.3–25.9 cm) and wider (9.4–19.4 cm) inflorescence of *J. validus* (Figs. 4 & 5, Table 2). The capsules of *J. fascinatus* are shorter (3.5–4.3 mm) compared to the larger capsules (4.7–5.5 mm) of *J. validus* (Figs. 4 & 5, Table 2). The inner and outer tepals are shorter (2.4–2.8 mm & 3.1–3.9 mm, respectively) in *J. fascinatus* than the longer inner and outer tepals (3.2–3.6 & 3.8–4.4, respectively) of *J. validus* (Figs. 4 & 5, Table 2). The capsule is also less exserted beyond the inner and outer tepals in *J. fascinatus* (0.8–1.6 mm & 0.1–0.9 mm, respectively) than *J. validus* (1.4–2.2 mm & 0.7–1.3 mm, respectively; Figs. 4 & 5, Table 2).
TABLE 2. Morphologic characters measured on *J. fascinatus* and *J. validus* showing mean ± 1 standard deviation and range (in parentheses) for each character. N = sample size. Within a row all means differ significantly with each other (*P* < 0.0005).

<table>
<thead>
<tr>
<th>Character (mm)</th>
<th><em>J. fascinatus</em> (N = 22)</th>
<th><em>J. validus</em> (N = 33)</th>
<th>ANOVA F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner tepal length</td>
<td>2.6 ± 0.2 (2.4–2.8)</td>
<td>3.4 ± 0.2 (3.2–3.6)</td>
<td>147.9</td>
</tr>
<tr>
<td>Inflorescence width (cm)</td>
<td>5.3 ± 2.8 (2.5–8.1)</td>
<td>14.4 ± 5.0 (9.4–19.4)</td>
<td>56.8</td>
</tr>
<tr>
<td>Inflorescence length (cm)</td>
<td>8.8 ± 4.2 (4.6–13.0)</td>
<td>19.6 ± 6.3 (13.3–25.9)</td>
<td>44.6</td>
</tr>
<tr>
<td>Length capsule exceed inner tepals</td>
<td>1.2 ± 0.4 (0.8–1.6)</td>
<td>1.8 ± 0.4 (1.4–2.2)</td>
<td>26.2</td>
</tr>
<tr>
<td>Length capsule exceed outer tepals</td>
<td>0.5 ± 0.4 (0.1–0.9)</td>
<td>1 ± 0.3 (0.7–1.3)</td>
<td>22.8</td>
</tr>
</tbody>
</table>

TABLE 3. Earliest known specimen of *Juncus validus* from each State.

<table>
<thead>
<tr>
<th>Year</th>
<th>State</th>
<th>County</th>
<th>Collector, Collector number, (Herbarium)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1842</td>
<td>Texas</td>
<td>Harris</td>
<td>Lindheimer s.n. (MO)</td>
</tr>
<tr>
<td>1853</td>
<td>Arkansas</td>
<td>[none indicated]</td>
<td>Bigelow s.n. (US)</td>
</tr>
<tr>
<td>1868</td>
<td>Oklahoma</td>
<td>[none indicated]</td>
<td>Palmer 318 (US)</td>
</tr>
<tr>
<td>1890</td>
<td>Mississippi</td>
<td>Lee</td>
<td>Tracy 1587 (US)</td>
</tr>
<tr>
<td>1898</td>
<td>Louisiana</td>
<td>Bienville Parish</td>
<td>C. Ball 257 (US)</td>
</tr>
<tr>
<td>1909</td>
<td>Missouri</td>
<td>Jasper</td>
<td>Palmer 2300 (MO)</td>
</tr>
<tr>
<td>1912</td>
<td>Alabama</td>
<td>Mobile</td>
<td>Bartlett 3200 (BALT, NCU)</td>
</tr>
<tr>
<td>1913</td>
<td>Kansas</td>
<td>Cherokee</td>
<td>Leterman s.n. (US)</td>
</tr>
<tr>
<td>1937</td>
<td>Georgia</td>
<td>Heard</td>
<td>Pyron &amp; McVaugh 1748 (GA)</td>
</tr>
<tr>
<td>1956</td>
<td>Florida</td>
<td>Gadsden</td>
<td>Redfern 2192 (NY)</td>
</tr>
<tr>
<td>1956</td>
<td>South Carolina</td>
<td>Beaufort</td>
<td>Ahles 15620 (NCU)</td>
</tr>
<tr>
<td>1957</td>
<td>North Carolina</td>
<td>Onslow</td>
<td>Ahles 28143 (NCU)</td>
</tr>
<tr>
<td>1964</td>
<td>Maryland</td>
<td>Harford</td>
<td>Baltars 4433 (Cylburn, US)</td>
</tr>
<tr>
<td>1965</td>
<td>Tennessee</td>
<td>McNairy</td>
<td>Rogers 33627 (NCU)</td>
</tr>
<tr>
<td>1967</td>
<td>Virginia</td>
<td>Isle of Wright</td>
<td>Harvill 17062 (US)</td>
</tr>
<tr>
<td>2006</td>
<td>Illinois</td>
<td>Alexander</td>
<td>Mohlenbrock 18991 (MO)</td>
</tr>
<tr>
<td>2006</td>
<td>Delaware</td>
<td>Sussex</td>
<td>Longbottom et al. 7586 (DOV, PH)</td>
</tr>
</tbody>
</table>

*Juncus fascinatus* and *J. validus* are routinely confused with other morphologically similar species. To assist in correct identification, illustrations for *J. paludosus* (Fig. 6) and *J. polycephalos* (Fig. 7) are provided. The leaves of *J. polycephalos* are incompletely septate giving the leaf surface a wrinkled appearance (Fig. 7) whereas the other species have complete septa. *J. fascinatus* (Fig. 4) and *J. validus* (Fig. 5) have superficially inconspicuous septa whereas *J. paludosus* (Fig. 6) has conspicuous ring-like septa. I have also identified new auricle characters to assist in identification of species. The auricles of *J. polycephalos* are much shorter and poorly developed when compared to the long ligule present in *J. fascinatus* (Fig. 4), *J. paludosus* (Fig. 6), and *J. validus* (Fig. 5).

**Geographic distribution**

*Juncus fascinatus* is a narrow endemic to 25 counties of north-central and southeastern Texas (Fig. 8). This range is much smaller and restricted than *J. validus* (Fig. 9). Label data reveals *J. fascinatus* occurs along streams and seeps, whereas *J. validus* is a weedy species of wet roadsides, ditches, and power lines. The collection of *J. fascinatus* from Bowie County, Texas, appears out of range. It is based upon two Eggert collections with identical labels from “wet places N. Texarkana, 22 July1896, s.n.” (MO) and “9 June 1898, s.n.” (MO). Eggert also collected *J. validus* in 22
July 1896. The labels for the 22 July 1896 specimens of *J. fascinatus* and *J. validus* are identical, suggesting this could be the result of a labeling error.

The collection database compiled for *J. validus* contains data from 574 specimens. Mapping by date shows the range has expanded through the southeast and into the mid-Atlantic (Fig. 9, Table 3). The number of unique pre-1900 collections I have seen is 27; five from Arkansas, four from Louisiana, one from Mississippi, four from Oklahoma, and 13 from Texas. This suggests a natural range of the south-central United States and, possibly, into the southeastern United States. I compiled the earliest records per State to help illustrate the spread of this species (Table 3) and created individual maps showing the known range, over four time periods; pre-1900, pre-1930, pre-1970 and pre-2014 to help illustrate the changes in specimen documentation over time (Fig. 9). Searches of the Alabama Plant Atlas website (2014), the Thomas M. Pullen Herbarium website (2014) and physical searches by A. Floden at the University of Tennessee (UTENN) revealed no specimens earlier than those in Table 3.

**FIGURE 2.** Scatterplot of the factor scores of PCA loadings I and II of 55 specimens. Circles represent *J. fascinatus* (N = 22) and triangles represent *J. validus* (N = 33).
FIGURE 3. Cluster Analysis of the 55 specimens measured. *J. validus* = group 1, and *J. fascinatus* = group 2.

*New records of other species*

Examination of specimens as part of this study also resulted in the discovery of new records for *J. paludosus* from Alabama (C. Mohr s.n., US; S. Orzell & E. Bridges 20312, FLAS), Georgia (W. Duncan 1290, FLAS; R. Thorne 4709 NY, R. Thorne 4575, US; V. McNeilus 01–266, NY), Louisiana (G. Giltner 72, LSU; A. Dufrene & B. Rhodes 2887V60–4, LSU), and South Carolina (R. Godfrey & R. Tryon 484, NY). *Juncus polycephalos*, a species of the
FIGURE 4. Specimen of *Juncus fascinatus* (A) with inserts showing mature capsule (B), leaf ligule (C) and leaf septa (D). Specimen and leaf morphology image R. Fleetwood 10361 MO, ligule image D. Correll & I. Johnson 17284 FSU, capsule image B. Tharp 10559 FSU. Scale bar = 1 mm.
FIGURE 5. Specimen of *Juncus validus* (A) with inserts showing mature capsule (B), leaf ligule (C) and leaf septa (D). Specimen, ligule, and leaf morphology image *Knapp 1445 DOV* and capsule image *McNeilus 98-484 DOV*. Scale bar = 1 mm.
FIGURE 6. Specimen of *Juncus paludosus* (A) with inserts showing mature capsule (B), leaf ligule (C) and leaf septa (D). Specimen and leaf morphology image G. Giltner 72 LSU, capsule image S. Orzell & E. Bridges 20312 FLAS, and ligule image L. Anderson 10582 FSU. Scale bar = 1 mm.
FIGURE 7. Specimen of Juncus paludosus (A) with inserts showing mature capsule (B), leaf auricle (C) and leaf septa (D). Specimen photo R. Kral 96539B DOV, capsule and auricle A. Curtis 4940 DOV. Scale bar = 1 mm.
Discussion

Morphologic characters can easily and reliably distinguish *J. fascinatus* from *J. validus*. Given there is no overlap in morphology between taxa, *J. fascinatus* is best treated as a distinct species. Given how distinct *J. fascinatus* is from *J. validus* it is somewhat surprising it had not been recognized at the species level before. This is probably due to the confusion surrounding *J. polycephalos*. Most specimens of *J. fascinatus* were initially identified as *J. polycephalos*, presumably based upon similar capsule morphology. *Juncus polycephalos*, however, is classified in section *Iridifolii*, which is likely paraphyletic (Kirschner 2000), but circumscribed as having ensiform leaves with incomplete leaf-septa (Kirschner 2002). Confusion between *J. polycephalos* and members of section *Ozophyllum* (*J. fascinatus, J. paludosus* and *J. validus*) is common throughout the range of *J. validus*.

NatureServe (2014) gives S- (State) and G- (Global) ranks of S4/G4 (apparently secure) for *J. fascinatus [=J. validus var. fascinatus]*. This S-rank appears incorrect. Of seven botanists I polled who work in Texas only one was directly familiar with this species. Additionally, I have seen only three collections dated post-1980 (*W. Carr 7548 BRIT, W. Carr 23452 BRIT, & W. Carr 11994 TEX*). If the rank of S4/G4 is correct the populations that exist must be large and overlooked. I recommend this species be considered a priority for inventory in Texas so that accurate S- and G-ranks may be determined. Given the uncertainty of numbers and sizes of extant populations the IUCN Red List category of Data Deficient (DD) is most appropriate (IUCN 2012).

Inferring the geographic range of a species based on herbarium records can be risky. In this case, I believe it accurately documents a clear trend that *J. validus* has spread over time and its nativity should be questioned in much of its current range (Fig. 9). Currently, only the States of Delaware, Maryland, and Virginia consider *J. validus* non-native.
(NatureServe 2014, Knapp et al. 2011). The States of Kansas, Kentucky and Missouri list *J. validus* as S1 (critically imperiled) and North Carolina lists *J. validus* as S2 (imperiled, NatureServe 2014). I strongly advise the States of Kentucky and North Carolina to drop *J. validus* as a conservation priority. Given the very early collections of *J. validus* in eastern Kansas and western Missouri, it is likely native to these States; however, recent documentation in eastern Missouri and now its addition to the Illinois flora suggest its range is expanding here. Protection for this species should be weighed carefully in Missouri and Kansas. I believe the single pre-1900 collection from Mississippi is the first documentation of this species’ spread eastward. This hypothesis is further supported by the presence of only two specimens from east of the Mississippi River pre-1930 (Table 3, Fig. 9). The decades of most rapid range expansion appear to be the 1950s and 1960s when *J. validus* was first documented in Florida (eight locations), Maryland (one location), North Carolina (nine locations), South Carolina (four locations), Tennessee (two locations), and Virginia (one location, Table 3). Additionally, Mississippi had only two locations pre-1950, yet in the 1950s and 1960s an additional 12 locations were documented. *Juncus validus* has been reported from Kentucky, but no specimens could be located for this study (NatureServe 2014). A similar pattern of range expansion was published for *J. diffusissimus* (Lamont & Young 2005).

![FIGURE 9](image_url)  

The same confusion that clouded the proper taxonomic rank of *J. fascinatus* also surrounded *J. paludosus*, which was recently described as a Florida endemic (Bridges & Orzell 2008). Before its description, nearly all specimens of *J. paludosus* were identified as *J. polycephalos*. The discovery of *J. paludosus* specimens from Alabama, Georgia,
Louisiana, and South Carolina expand the known range of this species outside of Florida. *Juncus paludosus* is not considered rare in Florida (Bridges and Orzell 2008), but it seems rare outside of Florida having only been documented from the eight specimens cited above.

Manuals universally spell *J. polycephalos* with a –us ending (*J. polycephalus*; e.g., Gleason & Cronquist 1991, Brooks & Clemants 2000), but this spelling is incorrect. The genus name has a –us ending, but Michaux chose to use the –os ending for the species (1803). Although Michaux’s choice is not a preferred one, the epithet is not correctable (K. Gandhi pers. comm.). *Juncus polycephalos* is predominantly a species of the Atlantic Coastal Plain found from North Carolina south to Florida, and west to Texas. A single inland specimen from Kansas (Lamarck (1789: 267), suggesting it could be naturally occurring here (C. Morse pers. comm. Park, 4 August 1954, mi E of Cisco, 20 June 1946, *Juncus fascinatus*).

**Taxonomic treatment**


Perennials, 35–85 cm tall, rhizomatous or subcaespitose. Rhizomes short-creeping, 2 mm in diameter, not tuberous, horizontal, branched. Cataphylls absent; leaves flat, elliptical in cross section, laterally compressed, 2–4.5 mm wide, 11.5–25 mm long, tip acute, unitubular septa externally obscure to ±distinct in dry condition; auricles 0.8–1.3 mm long, acute, membranous. Lower bract leaf-like, green becoming castaneous, linear, 3–13 cm long, shorter than or surpassing than the inflorescence, erect or more commonly spreading to reflexed; other bracts castaneous, linear to lanceolate, 0.9–3 mm long. Inflorescence of 3–20 heads, 2.8–15(–20) cm long, 2–11 cm wide, relatively narrow and congested in appearance; heads spherical, 45–80 flowers per head, 12–15 mm in diameter. Tepals sub-equal, lanceolate-subulate, green to reddish, acuminate, inner tepals 2.4–3 mm long, outer tepals 3–4 mm long. Stamens 3, concealed by tepals; anthers 0.3–0.5 mm long; filaments 1.2–1.5 mm long; style ±absent, ca. 0.1 mm long; stigmas 0.3–0.4 mm long. Capsules unilocular, lanceolate in outline 3–4.5 mm long, tapering to a subulate beak of 0.5–1.4 mm long, stramineous, equaling to exceeding perianth; valves fused apically at dehiscence. Seeds ovoid to broadly ovoid, apiculate, 0.3–0.6 × 0.2–0.3 mm, pale brown, reticulate; appendages absent.


Perennials. 40–100 cm tall, rhizomatous or subcaespitose. Rhizomes short-creeping, 2 mm in diameter, not tuberous, horizontal, branched. Cataphylls absent; leaves flat, elliptical in cross section, laterally compressed, 3–5 mm wide, 11.5–25 cm long, unitubular septa externally obscure to distinct in dry condition; tip acute; auricles 1–3 mm long, acute, membranous. Lower bract leaf-like, green becoming castaneous, linear, 5–13 cm long, shorter than or surpassing than the inflorescence, erect or more commonly spreading to reflexed; other bracts castaneous, linear to lanceolate, 1–3 mm long. Inflorescence of 9–48 heads, 10–39–45 cm long, and (6–9)–27 cm wide, wide and loose in appearance; heads spherical, 45–80 flowers per head, 12–15 mm in diameter. Tepals sub-equal, lanceolate-subulate, green to reddish, acuminate, inner tepals 3–3.9 mm long, outer tepals 3.8–5 mm long. Stamens 3, concealed by tepals; anthers 0.5–0.6 mm long; filaments 1.2–1.8 mm long; style ± absent, ca. 0.1 mm long; stigmas 0.3–0.4 mm long. Capsules reddish, acuminate, inner tepals 3–3.9 mm long, outer tepals 3.8–5 mm long. Stamens 3, concealed by tepals; anthers 0.5–0.6 mm long; filaments 1.2–1.8 mm long; style ± absent, ca. 0.1 mm long; stigmas 0.3–0.4 mm long. Capsules unilocular, lanceolate in outline 4.4–6 mm long, stramineous, obviously exceeding perianth; valves completely separating at dehiscence. Seeds ovoid to broadly ovoid, apiculate, 0.4–0.6 × 0.2–0.3 mm, pale brown, reticulate; appendages absent.

Key to morphologically similar species of Juncus sect. Ozophyllum and J. polycephalos (sect. Iridifoliis) of North America, north of Mexico.

1. Leaves with incomplete septate bands; auricles poorly developed, <0.5 mm……………………………………………………………..Juncus polycephalos Michaux
2. Leaves with complete septate bands; auricles well developed, >0.5 mm, forming a distinct ligule………………………………………………………2
3. Capsules remaining united at apex at maturity, forming a prominent beak of >0.5 mm…………………………………………………………………………5
4. Largest tepals 4–5 mm long; leaves laterally compressed………………………………………………………………………………………………………………………Juncus validus Coville
5. Capsules 3.5–5 mm long, exceeding tepals; culms 0.4–3 dm……………………………………Juncus nodosus Linnaeus (1762: 466)
6. Capsules 3–3.5 mm long, slightly included within or equaling tepals; culms 2.5–8.5 dm………………Juncus fascinatus (M.C. Johnston) W. Knapp

Juncus bolanderi Engelmann (1868: 470) leaves strictly terete, rounded or channeled, circular in cross-section, septate bands of leaves often prominent and ring-like……6
7. Culms 4–8 mm in diameter near base, usually > 80 cm tall; inflorescence usually >15 cm tall with > 25 heads; longest leaf blade >25 cm long and >3 mm wide…………………………………………………………Juncus paludosus E.L. Bridges & Orzell
8. Culms 1–3 mm in diameter near base, usually <80 cm tall; infl. usually <10 cm tall, with <25 heads; longest leaf blades <25 cm long and <2 mm in diameter…………………………………………………………………………………………Juncus scirpoideus Lamark
9. Uppermost leaf blade well developed, equaling to longer than its sheath; heads spherical to lobed; tepals green to straw-colored, nearly equal in length; basal leaf sheaths and cataphylls straw-colored to brown…………………………Juncus scirpoideus Lamark
10. Uppermost leaf blade poorly developed, much shorter than its sheath; heads strictly spherical; tepals reddish to reddish brown, the inner tepals somewhat shorter than outer; basal leaf sheaths and cataphylls deep reddish purple………………………………………………Juncus megacephalus Curtis (1835:132)

Representative specimens examined of J. paludosus and J. polycephalos

Juncus paludosus E.L. Bridges & Orzell

**Juncus polycephalos** Michaux


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**References**


Curtis, M.A. (1835) Enumeration of plants growing spontaneously around Wilmington, North Carolina, with remarks on some new and obscure species. _Boston Journal of Natural History_ 2: 82–141.


Dumortier, B.C. (1827) _Florula belgica_. Tomaci Nerviorum.


