

THREE REMARKABLY DISJUNCT FERN SPECIES DISCOVERED IN PICKENS COUNTY, SOUTH CAROLINA

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ABSTRACT

Three species of fern in the family Pteridaceae are reported as new to South Carolina: *Astrolepis sinuata* (Lag. ex Sw.) Benham & Windham subsp. *sinuata*, *Bommeria hispida* (Mett. ex Kuhn) Underw., and *Pellaea wrightiana* Hook. One of these, *Bommeria hispida*, is the first record for eastern North America. All three occur in a cliff habitat in Pickens County created in 1968-1971 by quarrying of granite to build the adjacent Jocassee Dam. All three are native to the western USA and are hypothesized to have colonized this site along the leading edge of the Blue Ridge Escarpment as winds from the Southwest continue to bring in spores.

In 2017 Ms. Kay Wade located a large population of a strange fern growing on outcrops near the Jocassee Dam in Pickens Co., South Carolina. She brought this population to the attention of local native plant enthusiast and South Carolina Native Plant Society member Mr. Dan Whitten. Dan visited the site with Kay and confirmed that the plants were a species of *Pellaea*, possibly *Pellaea atropurpurea* (L.) Link. Mr. Whitten was aware that *Pellaea atropurpurea* was found on calcareous or mafic substrata and thus sent a photograph of the fern to retired University of South Carolina, Upstate professor Gillian Newberry. Dr. Newberry suggested the species was a western species, likely *Pellaea wrightiana*, not *Pellaea atropurpurea*.

Wade took McMillan to the site on December 3, 2017 and McMillan immediately recognized the plant as *Pellaea wrightiana* Hook., a species with which he was intimately familiar from his work in western Texas and North Carolina. McMillan managed to scale up the rock face to secure a sample of the fronds and confirmed this identification upon returning to Clemson University. A return visit with Kay Wade, Edward Pivorun and Richard Porcher on December 6, 2017 allowed a more thorough

examination of the cliff with binoculars. The group identified two additional species: *Astrolepis sinuata* (Lag. ex Sw.) Benham & Windham subsp. *sinuata* and *Bommeria hispida* (Mett. ex Kuhn) Underw. (this determination was suggested by Alan Weakley of the University of North Carolina after examining photographs). McMillan collected one frond from each of these species but most of the cliff was outside the range of hands and binoculars. The team returned to the site on 13 December 2017 with a member of McMillan's staff, Mr. Cody Davis, an expert climber. Mr. Davis secured fronds of all three species and thoroughly explored the extent of the cliff for other oddities that might be encountered.

All determinations were confirmed by George Yatskievych via a loan of specimens to the University of Texas at Austin. Taxonomy follows Weakley (2015). Vouchers are as follow.

ASTROLEPIS SINUATA (Lag. ex Sw.) Benham & Windham subsp. *sinuata*

South Carolina. Pickens Co.: Approximately 300-400 vigorous clumps growing along approximately 50 meters of shoreline of Lake Jocassee on exposed granitic outcrops created during the construction of Lake Jocassee dam; plants located in vegetation mats and fissures in the rock face on west and southwest-facing exposures, with *Pellaea wrightiana*, *Bommeria hispida*, *Woodsia obtusa*, *Asplenium platyneuron*, *Andropogon virginicus*, *Chrysopsis mariana*, *Solidago canadensis*, and various bryophytes, 34°58'11.59" N 82°54'45.27" W, 6 Dec 2017, *McMillan s.n.* with Wade, Porcher, and Pivorun (CLEMS); same location, 14 Dec 2017, *McMillan s.n.* with Davis, Maddox, Pivorun, and Huffman (CLEMS, NCU).

BOMMERIA HISPIDA (Mett. ex Kuhn) Underw.

South Carolina. Pickens Co.: Two clumps located shoreline of Lake Jocassee on exposed granitic outcrops created during the construction of Lake Jocassee dam; plants found in fissures in the rock face on south and southwest-facing exposures, with *Astrolepis sinuata*, *Pellaea wrightiana*, *Woodsia obtusa*, *Asplenium platyneuron*, *Andropogon virginicus*, *Chrysopsis mariana*, *Solidago canadensis*, and various bryophytes, 34°58'11.59" N 82°54'45.27" W, 14 Dec 2017, *McMillan s.n.* with Davis, Maddox, Pivorun, and Huffman (CLEMS, NCU).

PELLAEA WRIGHTIANA Hook.

South Carolina. Pickens Co.: Over 2000 vigorous clumps growing along approximately 150 meters (0.1 mile) of shoreline of Lake Jocassee on exposed granitic outcrops created during the construction of Lake Jocassee dam; plants dominant in fissures in the rock face on south, southwest and west-facing exposures, with *Astrolepis sinuata*, *Bommeria hispida*, *Woodsia obtusa*, *Asplenium platyneuron*, *Andropogon virginicus*, *Chrysopsis mariana*, *Solidago canadensis*, and various bryophytes, 34°58'11.59" N 82°54'45.27" W, 3 Dec 2017, *McMillan s.n.* with Wade and Whitten (CLEMS); same location, 14 Dec 2017, *McMillan s.n.* with Davis, Maddox, Pivorun, and Huffman (CLEMS, NCU).

Discussion

All three of these species typically occur far to the west of Lake Jocassee. These discoveries add three species to the flora of South Carolina as well as the first record for *Bommeria hispida* in eastern North America.

The occurrence of ferns in the Southeast with a much more western distribution is not without precedent. *Pellaea wrightiana* is known from two locations in the piedmont of North Carolina, *Myriopteris rufa* Fée from Virginia and West Virginia, *Myriopteris gracilis* Fée from Virginia, *Astrolepis sinuata* subsp. *sinuata* from a single location in Georgia, *Astrolepis integerrima* (Hook.) D.M. Benham & Windham from Alabama, and most remarkably *Pellaea ternifolia* (Cav.) Link subsp. *arizonica* Windham from approximately 7.25 miles northeast of the Lake Jocassee site in Pickens County (Wagner 1965; Knobloch & Lellinger 1969; Wiebolt & Bentley 1982; Mellichamp et al. 1987;

Benham & Windham 1993; Allison & Stevens 1999; Heafner 2001). The Jocassee Gorges region has long been known for the remarkable diversity of ferns found there. One species, the mostly tropical *Hymenophyllum tunbrigense* (L.) J.E. Smith, which was located during surveys of the nearby Eastatooe River gorge (approximately 6.7 miles northeast of the Lake Jocassee site), is still known from only this single metapopulation in the continental USA (Taylor 1938). *Asplenium monanthes* L., another species with a mostly tropical distribution, is present at many locations in the Jocassee Gorges region. A review of published records and herbarium specimens, combined with field work for the preparation of this article indicates that the area of Pickens/Oconee counties now hosts 68 species of fern and fern relatives. Pickens County alone is home to 65 species. The discovery of three additional species certainly places this small region into a category of extremely high regional pteridophyte diversity.

Most, if not all, of the locations of fern species that are far disjunct to the east from more western ranges are reports of a single species per locale. The Jocassee site is remarkable for the presence of three species displaying such a pattern.

Pellaea wrightiana is a common species found on acidic-reaction outcrops in Texas, Oklahoma, New Mexico, Arizona, southern Colorado, and southern Utah and was formerly known from only two other populations east of Texas. It was erroneously reported for South Carolina by Platt and Townsend (1996). The plants originally thought to be *P. wrightiana* from Pickens County were found to be the first record of *Pellaea ternifolia* Link subsp. *arizonica* in eastern North America (Heafner 2001). The population reported here is the first record for South Carolina and is the most extensive population in eastern North America. The closest populations to the Lake Jocassee site are in Alexander Co., North Carolina (roughly 120 miles northeast), with an initially reported population of approximately 100 clumps growing on granite and Stanly Co., North Carolina (roughly 140 miles east-northeast), with an initially reported population of approximately 500 plants. Since their initial discovery, both of the North Carolina populations have apparently declined. Heafner (2001) found the Alexander County population had dropped to only around 25 clumps while the Stanly County population had also declined by half. The Lake Jocassee site is estimated to consist of no less than 2000 clumps. The discovery of the South Carolina population indicates that this species should be searched for on other acidic-reaction rock outcrops throughout the southern Appalachian region. Heafner (2001) reported that there was very little variation in the allozymes between the two North Carolina populations and they were likely to represent dispersal from a single eastward immigration event. Among the populations sampled from the western range, he found that plants in North Carolina were most similar to those sampled from Jeff Davis Co., Texas.

Astrolepis sinuata subsp. *sinuata* is also a common species on acidic-reaction outcrops in Arizona and New Mexico east to central Texas. The species is remarkably disjunct from central Texas to a bridge piling in Beauregard Par., Louisiana, and Merriweather Co., Georgia, where it was found on a granite flatrock next to a natural gas distribution station (Benham & Windham 1993; McMillan et al. 2013; L.L. Gaddy, pers. comm. 2017). The Pickens County location is the first for South Carolina and only the second report from east of the Mississippi River; it is the largest population east of central Texas.

The Pickens County location represents the first known station in the eastern USA for *Bommeria hispida*. This species is remarkably disjunct from the nearest known populations in Brewster Co., Texas (more than 1200 miles to the southwest). This staggering distance might at first seem unique but it is identical to the disjunction in range found in the nearby population of *Pellaea ternifolia* subsp. *arizonica*.

Establishment at the Pickens County site

The site at which all of the observations were made is a human-created habitat. The cliff habitat was created in 1968-1971 by quarrying activity for the material to build the adjacent Jocassee

Dam. The area is known as "The Wall" and is a 10–40 meter high quarry of granitic rock. The entire hill and face of the mountain was denuded with no natural vegetation left during construction. For a better idea of the scale of disturbance, the construction of the site can be seen on video during the opening minutes of the movie *Deliverance*. The habitat these ferns have colonized was barren, newly exposed rock during the construction of the dam.

The resulting cliff forms a horseshoe shape with the upstream portion facing south and ranging to southwest, west, and northwest exposures as it proceeds downstream. All three of the species are limited to southwest and west-facing faces. The base of the cliff extends to the water for the entire length and is well over 150 feet tall along a large portion of its length. This shape, in addition to the fact that the widest portion of the lake extends from the cliff habitat, has created conditions that receive the full impact of the predominant southwest winds that dominate the region. The winds eddy and swirl in this cove and may provide the opportunity for enhanced settling of the spores that brought these ferns to the cliff.

Astrolepis sinuata subsp. *sinuata* ($2n = 87$, triploid) relies on apogamous reproduction while *Pellaea wrightiana* ($2n = 116$, allotetraploid) and *Bommeria hispida* ($2n = 60$) both reproduce sexually (Benham & Windham 1993; Gastony & Haufler 1976). Spore resiliency and longevity has been shown to be high in members of the family Pteridaceae, with spores preserved on herbarium sheets remaining viable for over 40 years (Windham, Wolf, & Ranker 1986). It is hypothesized that spores were transported along prevailing southwest winds and settled on the newly exposed cliff face where competition with local species was reduced or absent due to the disturbance. The site is along the leading edge of the Blue Ridge Escarpment.

An alternative hypothesis is that nearby populations of these species provided spores for colonization of the newly exposed habitat, but we searched thoroughly along the entire shoreline outcrop habitats of Lake Jocassee and located no other populations. We also searched the exposed rock outcrops above the cliff. The area above the cliff was completely denuded during dam construction.

An alternative hypothesis could include the introduction of spores via machinery used in the construction. Several factors argue against this, notably the absence of any non-pteridophyte species from farther west on the site or nearby. Weed seeds would seem to just as easily be moved. Finally, the presence of another nearby species of fern with a similar distribution (*Pellaea ternifolia* subsp. *arizonica*) and the presence of *Pellaea wrightiana* at two sites in North Carolina, where they are assumed to have naturally colonized their habitats, supports the fact that spores must travel these distances and be able to successfully colonize new habitats.

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