

**REASSESSMENT OF VARIATION
WITHIN *POLYGALA CRUCIATA* SENSU LATO (POLYGALACEAE)**

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ABSTRACT

Herbarium research confirms the presence of two distinct entities within *Polygala cruciata* sensu lato, each of which we treat as species. *Polygala cruciata* is nearly endemic to the Coastal Plain, with local disjunctions inland, whereas *P. aquilonia* is northern with populations southward in the Appalachian Mountains and southward along the coast to Virginia.

Several eastern North American floras have distinguished two intraspecific entities within *Polygala cruciata* L. Fernald (1950) and Weakley (2015) have recognized these as varieties — *P. cruciata* var. *cruciata* and var. *aquilonia* Fernald & Schubert. A few other floras (e.g., Mohlenbrock 2014), in the range of only one of the varieties, specify that variety but do not provide a rationale. Haines (2011) treated two entities at subspecific rank (a *nom. illeg.* because of failure to cite the basionym publication). The characters used by Fernald & Schubert (1948) are leaf width, width of the inflorescence, and length of the peduncle. These treatments appear to rely strictly on Fernald & Schubert (1948), with no evidence of new and independent assessments of the characters used in the original segregation of var. *aquilonia* or of the introduction of new characters — Fernald (1950) and Weakley (2015) essentially repeated the characters from Fernald & Schubert (1948), while Haines (2010, 2011) mentioned the same characters generally [“the northern taxon (*aquilonia*) has broader leaf blades, shorter peduncles, and narrower racemes compared with the southern taxon (*cruciata*)”] and asserted that “recognition of these taxa as geographic subspecies is appropriate.” Other floras covering portions of the distribution of *P. cruciata* (Gleason 1952; Gleason & Cronquist 1990; Weakley, Ludwig, & Townsend 2012; Tennessee Flora Committee 2015) do not recognize two taxonomic entities but are tacit in their reasoning, not providing a rationale or evidence.

Weakley's Flora of the Southern and Mid-Atlantic States (2015) has recognized *Polygala cruciata* var. *cruciata* and *P. cruciata* var. *aquilonia*. In general terms, var. *cruciata* has been considered to be southern in distribution and occurs mostly on the Coastal Plain, whereas var. *aquilonia* is northern and occurs inland as well as coastally. As noted by Fernald and Schubert (1948), there appears to be a zone of overlap in eastern Virginia. A taxonomic assessment seems long overdue (nearly 70 years after their initial recognition): should two taxa be recognized (and at what taxonomic rank), by what characters might they be recognized, and what are their detailed distributions (including areas of overlap)?

METHODS

We reviewed all specimens at NCU, ODU, VPI, and WILLI, concentrating our research in the area of geographical overlap of the two varieties. Bill McAvoy examined specimens from Delaware at DOV and PH and Wes Knapp provided records from Maryland. Other distribution records came from state floras and vascular plant atlases. We assessed the morphological characters used by Weakley (2015) in order to find those most effective.



Figure 1. Specimen of *Polygala aquilonia* from the southern Appalachian Mountains. Note short floral axis.



Figure 2. Specimen of *Polygala cruciata* from the Coastal Plain of North Carolina. Note elongate floral axis.



Figure 3. *Polygala cruciata*, not fully developed, from the Coastal Plain of North Carolina. Note short floral axis.

Leaf width. Measurements of 23 leaves from as many specimens yielded a mean width of 2.1 mm for var. *cruciata*, with a range of 1.0-3.5 (-5) mm; a mean width of 2.9 mm for var. *aquilonia*, with a range of 1.5-4.5 mm. While a somewhat useful character, leaf width overlaps considerably and we excluded it from our key.

Raceme width. Measurements of 22 racemes yielded a mean for var. *cruciata* of 12.0 mm, with a range 10-15 mm; a mean for var. *aquilonia* of 9.9 mm, with a range of 8.5-12 mm. Contrary to Weakley's key, we found that no racemes of var. *cruciata* exceeded 15 mm; at least there are none on specimens at the herbaria searched. Visually, racemes of the more southern specimens certainly appeared to be broader than northern specimens.

Corolla wing length. Fernald and Schubert (1948) stated that the corolla wings of var. *cruciata* are longer than broad, 3.5-5.5 mm long, while in var. *aquilonia* wings are about as wide as long, 2.5-4 mm long. Measurements of 24 wings (without subulate tips) yielded a mean length for var. *cruciata* of 3.7 mm, with a range of 3.1-4.2 mm; a mean length for var. *aquilonia* of 3.3 mm, with a range of 3.0-3.7 mm.

Peduncle length. We assumed that "peduncle" meant the distance from the uppermost leaf to the first flower or flower bract, this being the customary use of the term. This may be the wrong interpretation, for Weakley (2015), Fernald and Schubert (1948), and Haines (2010, 2011) did not define the term as they used it in *Polygala cruciata*. They give peduncle lengths up to 40 mm for var. *cruciata*, whereas we measured none greater than 9 mm. We then re-measured peduncles to include the entire floral axis from the uppermost leaf to the tip of the inflorescence (20 specimens each variety). Thus measured, "peduncle" length ranged from 10-23 mm for var. *aquilonia*, with a mean of 16 mm (Fig. 1). For var. *cruciata*, "peduncle" length ranged from 11-96 mm (Fig. 2). In specimens solely from the state of North Carolina, the range was 11-64 mm, with a mean of 35 mm. It seems clear that southern and Coastal Plain plants develop long "peduncles" due to the continued growth of the inflorescence. This produces a markedly long axis that bears many persistent bracts along its length as corollas fall off. Based on specimens examined, inflorescences of northern and inland plants do not continue to elongate (or very little), and therefore appear to be sessile or subsessile. In this paper we use the term "floral axis" to describe the combined peduncle and inflorescence rachis. Note: specimens of var. *cruciata* collected early in the flowering period (Fig. 3) will show minimal elongation of the floral axis and thus mimic var. *aquilonia* in that character; however, raceme width will point towards var. *cruciata*.

RESULTS

By using a combination of raceme width and peduncle length, we were able to effectively distinguish two taxa; see the following key. Note: early in its flowering period var. *cruciata* will show minimal elongation of the floral axis and plants may key to var. *aquilonia*. Be sure to also measure raceme width as supporting evidence.

- 1. Floral axis length 11–64 (–96) mm, mean 35; raceme width 10–15 mm, mean 12; corolla wing length mean 3.7 mm **Polygala cruciata**
- 1. Floral axis length 10–23 mm, mean 16; raceme width 8.5–11 (–12) mm, mean 9.9; corolla wing length mean 3.3 mm **Polygala aquilonia**

TAXONOMIC TREATMENT

Polygala cruciata L., Sp. Pl., 706. 1753. **TYPE: Virginia**, without locality, *J. Clayton 157* (lectotype BM), designated by Reveal in Jarvis (2007, p. 755). Fernald & Schubert (1948) made a reasoned argument that *Clayton 157* represents the southern entity and not the northern, and we concur.

Polygala aquilonia (Fern. & B.G. Schub.) Sorrie & Weakley, **comb. et stat. nov.** *Polygala cruciata* var. *aquilonia* Fern. & B.G. Schub., *Rhodora* 50: 163, pl. 1100. 1948. **TYPE: Connecticut.** [Fairfield Co.]: Stratford, inner edge of salt-marsh, 30 Aug 1896, *E.H. Eames s.n.* (holotype: GH).

Polygala cruciata subsp. *aquilonia* (Fern. & B.G. Schub.) A. Haines [nom. illeg., without citation of basionym publication], *Stantec Bot. Notes* 13: 5. 2010.

Our reasoning is based on the following points. (1) The vast majority of specimens are clearly separated morphologically, using the characters in our key. We had little trouble in assigning specimens to one or the other species, which indicates that the characters are consistent. While equivocal specimens occur, they represent a small percentage of the hundreds of sheets we examined from throughout the ranges of the two species. A list of equivocal specimens is included in the following section. (2) The ranges of the two species are largely allopatric, with relatively small areas of overlap (Fig. 4 and Fig. 5, below). (3) Within the two overlap zones the species maintain their morphological distinction, with the exception of a small number of "intermediates." Based on existing evidence, we conclude that these two entities are separate evolutionary lineages at this time, satisfying criteria for species rank under modern species concepts, including the evolutionary species concept and de Queiroz's (1998, 2007) general lineage species concept.

Examples of equivocal specimens

- (1) Clay Co., North Carolina (*Radford & Duke 6436*, NCU). Racemes are 12 mm wide, leaves 4.0-4.5 mm wide. The peduncles vary from 18-35 mm long and with few or no exposed bracts.
- (2) Montgomery Co., Kentucky (*Wharton 408*, NCU). Racemes are 8-10 mm wide, peduncles 17-35 mm long, leaves 2-5 mm wide. Flower bracts are numerous on one plant, absent on another.
- (3) Fentress Co., Tennessee (*Rock 987*, NCU). Leaves <3 mm wide, racemes 10-12 mm wide, peduncles vary from 18-22 mm long. Some flower bracts are exposed.
- (4) Lincoln Co., Tennessee (*Sharp et al. 4876*, VPI). Racemes measure up to 12 mm wide, peduncles up to 28 mm long.
- (5) Polk Co., Tennessee (*Rogers 31402*, NCU). Racemes are up to 14 mm wide but sessile.
- (6) Brunswick County, Virginia (*Mikula 3467*, WILLI). Racemes are up to 12 mm wide but peduncles up to 22 mm long.
- (7) In addition, Bill McAvoy (pers. comm.) has measured several equivocal specimens from Delaware.

Other taxonomic considerations

The Coastal Plain of the Delmarva Peninsula and southeastern Virginia constitutes the primary overlap area for the two species, although the extent of the overlap zone has only now been worked out in detail. Fernald and Schubert (1948) stated that "...in eastern Virginia typical *Polygala cruciata* and var. *aquilonia* obviously merge..." The online atlas of Virginia plants (Digital Atlas 2016) does not distinguish between taxa. The online atlas of Maryland plants (Maryland 2016) lists only var. *cruciata* for the state (Wicomico Co.); however, the photo accompanying the text shows sessile racemes and relatively broad leaves, suggestive of *P. aquilonia*. In Delaware, McAvoy and Bennett (2001) included only var. *aquilonia*. As a result of our research, we now know that both species occur in eastern Virginia, Maryland, and Delaware. Moreover, we extend the area of overlap to southern New Jersey, with a specimen of *P. cruciata* from Cumberland Co.: 1 mi NW of Bennetts Mill, clay-bottomed pond-hole, 25 Sep 1938, *Long 53141* (VPI). On this specimen, the raceme width is 15 mm and the floral axis is 31 mm.

A secondary area of overlap is in the Eastern Highland Rim and Cumberland Plateau of central Tennessee (Fentress Co. south to Coffee and Grundy counties). This region also includes

plants of equivocal identity (examples listed above) in close proximity to typical plants, which maintain clear identity.

Haines (2010) suggested that the two taxa occupy somewhat different habitat types, based on Fernald and Schubert (1948), who stated that "... the generally more northern or inland var. *aquilonia* is a plant of usually less saturated wet habitats and from Delaware northward it is partial to the outer coastal or coastwise region, even the upper borders of salt-marshes." As examples of "saturatedly wet," Fernald and Schubert cited "wet pineland," "low pineland," "boggy savannas," "swamps," and "pine-barren swamps." While we agree that there appears to be a shift from seasonally saturated habitats northward to more or less permanently saturated habitats southward, we wish to clear up some misinterpretations regarding older specimen label data. For decades we have studied plant communities of the Southeast and assessed specimen label data from collectors such as Curtiss, Chapman, Harper, and Tracy. In the 1800s and early 1900s collectors routinely wrote "swamp" or "bog" not to mean a permanently wet to inundated forest or a peat bog in the sense of northern botanists but to cover a diverse array of permanently to seasonally saturated, fire-prone habitats. Critical to the southern habitats is seepage from adjacent low slopes, or a permanently high water table, but no standing water as "swamp" would suggest, nor accumulation of peat as "bog" would suggest. Graminoids and low shrubs dominate beneath a canopy of moderately dense to very sparse pines, the whole kept free of dense shrubs and saplings by recurring fires.

Range of *Polygala cruciata* (Figure 4)

Coastal Plain from southern New Jersey to southern Florida, eastern Texas, southeastern Oklahoma, and central Arkansas. It is a rare disjunct in Bartow Co., Georgia (sinkhole pond), Greenville Co., South Carolina (montane seepage bog), Coffee and Bledsoe counties, Tennessee (Manchester Prairie, etc.) — all areas known for Coastal Plain disjuncts. Fernald and Schubert (1948) also cited specimens from Grundy and Van Buren counties, Tennessee (GH); Gentry et al. (2013) have mapped it disjunctly in Benton Co., Arkansas.

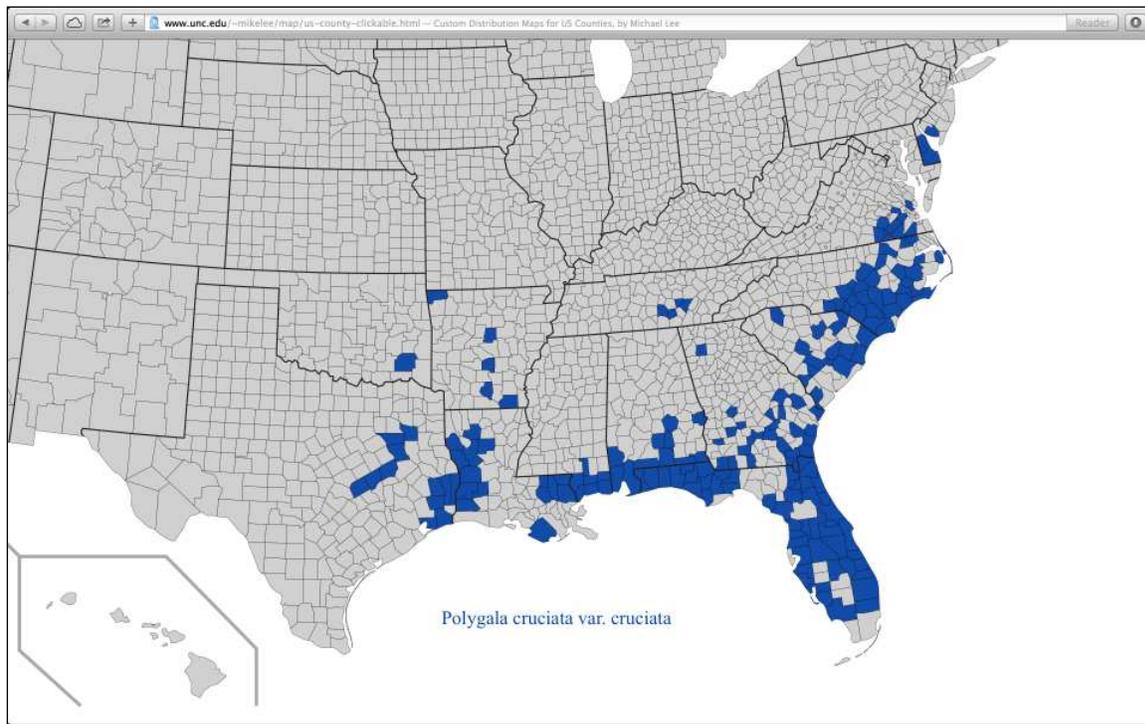


Figure 4. Range of *Polygala cruciata*.

A check of additional specimens from other herbaria will improve the range maps, and perhaps increase the number of disjunct localities. At the present, *P. cruciata* is treated as a Coastal Plain endemic with a few disjunctions.

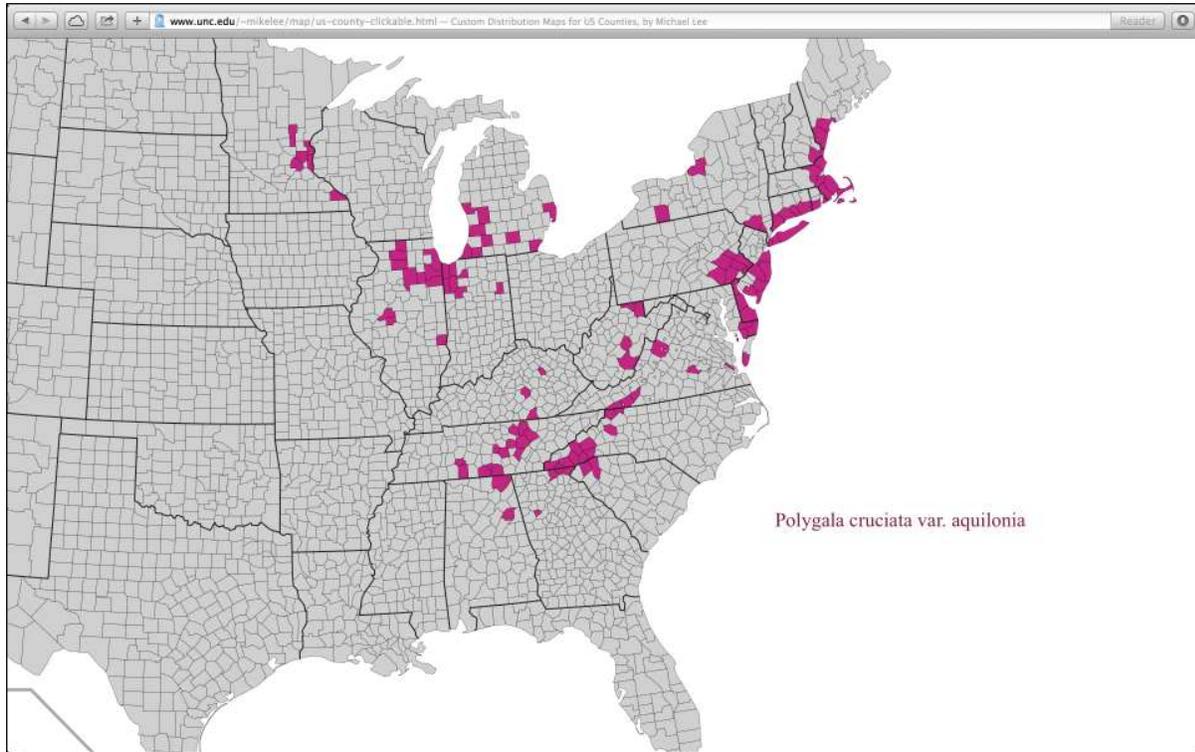


Figure 5. Range of *Polygala aquilonia*.

Range of *Polygala aquilonia* (Figure 5)

Southern Maine to southeastern Minnesota, south to southeastern Virginia, and upland regions of central Kentucky and Tennessee. Also Southern Appalachian Mountains from Virginia and West Virginia to northeastern Alabama. The PLANTS database maps it in Ohio, Wisconsin, and Ontario, Canada. This variety occurs in coastal counties southward to Northampton County, Virginia. On the mainland of Virginia (excluding the mountains) *Polygala aquilonia* is apparently rare: York County (*Wright s.n.*, WILLI) and Powhatan County (*Wieboldt et al. 1161*, VPI).

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