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The study of online digitized specimens revalidates *Andersonglossum boreale* as a species different from *A. virginianum* (Boraginaceae)

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Abstract

Cynoglossum virginianum L., now transferred to the genus *Andersonglossum* as *A. virginianum* (L.) J.I.Cohen, has been traditionally considered to be formed by two infraspecific taxa: var. *virginianum*, and var. *boreale* (Fernald) Cooperr. The var. *boreale* was originally described as an independent species, *Cynoglossum boreale* Fernald, and remained treated as such until its combination as a variety of *C. virginianum*. However, no analysis exists that objectively compares both taxa in order to properly assess their taxonomic relationships. We performed a morphometric study to help elucidate their taxonomy. We found that both species are distinguishable using a few characters, despite slight overlap in nutlet length, corolla diameter, and calyx length, all traditionally considered to identify both taxa. The relatively large amount of variation in calyx dimensions seems to be the reason for most recent authors treating the two taxa at varietal rank. We provide the new combination *Andersonglossum boreale* (Fernald) Jim.Mejías, J.I.Cohen & Naczi to allow treating *Cynoglossum boreale* as a distinct species under its new generic circumscription.

Keywords: Amsinckiinae, Boraginales, Boraginaceae, Cynoglossoideae, North America

Introduction

Recent phylogenetic works have demonstrated that the genus *Cynoglossum* Linnaeus (1753: 134) as traditionally conceived was polyphyletic (Weigend *et al*. 2013, Cohen 2014, Otero *et al*. 2014, Chacón *et al.* 2016). The new genus *Andersonglossum* J.I.Cohen (2015: 618) was recently described to accommodate some of the native North American species of *Cynoglossum*. In the original publication, Cohen (2015) intended the combination of the names *Cynoglossum boreale* Fernald (1905: 250) and *Cynoglossum virginianum* Linnaeus (1753: 134) under *Andersonglossum*. Unfortunately, the combination of *A. boreale* was incorrectly made and, consequently, is invalid. In particular, the proposed new combination was contra the International Code of Botanical Nomenclature Art. 36 (see also example 1) (McNeill *et al*. 2012), since the author explicitly did not accept "*Andersonglossum boreale*" as a species distinct from *A. virginianum* (L.) J.I.Cohen (2016: 618), despite wanting others to have the opportunity to use the name if desired.

The circumscription of *Cynoglossum boreale* is indeed controversial. Until its combination under *C. virginianum*, most floristic works recorded both taxa as species: e.g., Fernald (1950), Gleason (1952), Gleason & Cronquist (1963), Scoggan (1979). After the former species was combined as *Cynoglossum virginianum* var. *boreale* (Fernald) Cooperr. (1984: 166), most authors have recorded it at varietal rank. In his combination, Cooperrider alleged that "it has been my experience that there is in fact extensive intergradation in all […] characters", and cited Fernald (1950), "there is considerable overlap in the ranges of the two taxa". Since then, not much has been discussed concerning the morphological limits between *C. boreale* and *C. virginianum*.

Considerable herbarium digitalization efforts have proceeded in recent years to make available information provided by museum specimens to a broader public. However, these materials are rarely used beyond mere comparison when identifying specimens or for the designation or recognition of type material.

During preparation of the *New Manual of Vascular Plants of Northeastern United States and Adjacent Canada* (Naczi *et al.* in prep., Naczi 2016), we noted the need to treat *C. boreale* under its new generic circumscription as either a species or a variety under *A. virginianum*. We perform a straightforward morphometric study using as the main

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source online data available—digitized specimens—in order to ascertain if both taxa are sufficiently distinct to be considered different species or, on the contrary, if they are part of a morphologic grade and, therefore, better considered as varieties of a single species.

Materials and methods

For the sake of simplicity and to avoid continued nomenclatural confusion, and according to our own results, we will refer to the two studied species as *Andersonglossum boreale* and *A. virginianum*, even if we are citing a work where the authors refer to the taxa under *Cynoglossum* or at varietal rank.

Fernald (1905) distinguished *A. boreale* from *A. virginianum* by four quantitative characters that have been considered in all subsequent works that recorded this taxon: the shorter calyx length at anthesis (reportedly 2–2.5 mm for *A. boreale* vs. 3.5–4.5 mm for *A. virginianum*), smaller corolla limb diameter (6–8 mm vs. 10–12 mm), maximum length of nutlets (4–5 mm vs. 7–9 mm), and maximum leaf width (3–8 cm vs. 5–11 cm).

We studied 170 digitized herbarium specimens (41 ascribable to *A. boreale*, including a lectotype and two paratypes, and 121 to *A. virginianum* s.s.; Table 1) available through the servers www.canadensys.net (accessed 15 Oct 2016), http://midwestherbaria.org/portal/collections/index.php (accessed 15 Oct 2016), http://intermountainbiota.org/portal/collections/index.php (accessed 15 Oct 2016), http://midatlanticherbaria.org/portal/collections/index.php (accessed 15 Oct 2016), and JSTOR Global Plants (https://plants.jstor.org/, accessed 15 Oct 2016). To these, we added 40 specimens (14 ascribable to *A. boreale*, and 26 to *A. virginianum* s.s.) from NY herbarium to fill geographic distribution gaps in the sampling from online specimen images.

In order to maximize the amount of useful images, we considered only four characters: calyx total length at anthesis, corolla diameter, calyx total length at fruit, and nutlet length. Interestingly, specimens of the studied species never bear flowers and ripe fruits at the same time. Subtler characters, such as corolla lobes/throat dimensions, were not considered, as they were much more difficult to observe in the digitized herbarium specimens and were not necessary to distinguish the two taxa. In addition, we did not consider the widest leaves in each specimen, as this character greatly depended on the way the specimens had been collected. We took one measurement for each character per specimen.

To graphically evaluate differences between the two taxa, we plotted the length of the calyx at anthesis against the corolla width as well as the length of the calyx in fruit against the nutlet total length. We performed a correlation analysis between all pairs of characters to consider the possibility of correlated, and thus genetically redundant, variation. Analyses were performed in Microsoft Excel 2016 MSO. Additionally, box plots and density comparisons were undertaken in JMP v12.1.

We tested statistically for differences in the four selected characters between the two groups. As most the variables did not fit a normal distribution, we performed a Mann-Whitney *U* test using SYSTAT 11 (Richmond, California), and Wilcoxon test with JMP. Given that sample sizes where large enough ($n > 20$), significance was tested with a *Z*-test.

Results

Nutlet length was the character that presented the least overlap between the two taxa, followed by calyx length at anthesis, calyx length in fruit, and corolla diameter (Table 2). Differences in the length of the calyx between anthesis and fructification in both taxa are inconclusive and seem to indicate that the calyx may or may be not slightly accrescent depending on each particular situation. When calyx length at anthesis was plotted against corolla diameter, samples of both taxa where arranged without overlap between individuals of the two taxa (Fig.1). When calyx length in fruit was plotted against nutlet length, not only the taxa did not overlap, but a visible gap is apparent (Fig. 1). The two pairs of characters plotted in each case did not present significant correlation ($r < 0.3$). Box plots and density comparisons of the four characters, for the two species, demonstrate some overlap between the two species. In general, the lower limit for the investigated morphological characters of *A. virginianum* is about the upper limit for *A. boreale* (Figs. 2 and 3). However, measurements of the diagnostic characters, in combination, separate the two species. Accordingly, the Mann-Whitney *U* test and the Wilcoxon test revealed significant differences in *Z*-test for the four paired comparisons for a $P < 0.001$.

TABLE 1. Studied specimens and measurements of *Andersonglossum virginianum* and *A. boreale*. Herbarium abbreviations provided are according to *Index herbariorum* (http://sweetgum.nybg.org/science/ih/, accessed 10 Nov 2016). Herbarium barcode numbers are provided; if barcode was not available, then collector and collection number or date are cited. Abbreviations of U.S. states and Canadian provinces follow standard postal codes. Measurements are provided in mm.

Andersonglossum boreale											
Flowering dataset						**Fruiting dataset**					
Herbarium	*Barcode number / Voucher*	*State/Prov*	*County*	*Calyx length*	*Corolla diameter*	*Herbarium*	*Barcode number / Voucher*	*State/ Prov*	*County*	*Calyx length*	*Fruit length*
ALBC	1728	MI	Emmet	1.9	7.6	A	96670 (Lectotype)	QC		2.4	4.8
MSC	201513	MI		1.5	3.1	A	96671 (Lectotype)	QC		2.1	4.6
MSC	201524	MI	Keweenaw	1.0	5.6	ALBC	1729	MI	Emmet	2.6	4.6
MSC	201525	MI	Crawford	1.5	4.6	MSC	201518	MI	Chippewa	2.6	4.6
MSC	201526	MI	Otsego	2.6	3.6	MSC	201522	MI	Ontonagon	2.3	3.9
MSC	201528	MI	Keweenaw	1.5	3.6	MSC	201523	MI	Keweenaw	2.0	3.8
MSC	201531	MI	Otsego	2.1	4.6	MT	14242	QC		2.0	3.5
MSC	201577	MI	Baraga	2.6	3.6	NY	Barnhart 1725	NY	Malborough	2.0	5.0
MT	2002	QC		1.8	3.6	NY	DeWitt Miller 1274	NJ	West Milford	2.0	4.0
MT	2008	QC		1.4	3.6	NY	DeWitt Miller 1276	NJ	West Milford	2.5	4.5
NY	Bumstead/ 5Jun1871	NY		2.0	4.0	NY	DeWitt Miller 1277	NJ	West Milford	1.9	4.5
NY	Merrill/ 5 Jun1898 (Paratype)	ME	Orono	2.5	4.0	NY	Gleason 9667	MI		1.9	4.5
NY	Nash 995	NJ	Sussex	1.5	4.2	NY	Grant 2715	MN	Clearwater	1.5	4.2
NY	Victorin 8406	QC		2.0	4.0	NY	Johnson/ 26Jun1921	NY		2.3	4.2

...Continued on next page

TABLE 1. (Continued)

Andersonglossum boreale											
Flowering dataset						**Fruiting dataset**					
Herbarium	*Barcode number / Voucher*	*State/Prov*	*County*	*Calyx length*	*Corolla diameter*	*Herbarium*	*Barcode number / Voucher*	*State/ Prov*	*County*	*Calyx length*	*Fruit length*
OAC	554	ON		2.0	4.5	NY	Shurtleff s.n.	ME	Harrison	2.6	4.5
OAC	13444	ON		1.0	4.0	NY	Vail/ 29Jun1897	MA	Berkshire	1.8	3.6
OAC	13457	ON	Lambton	1.5	4.0	OAC	555	ON		2.0	3.5
OAC	13458	ON		1.5	4.5	OAC	13459	ON		3.0	4.0
OAC	25604	ON	Lambton	2.0	2.5	OAC	28273	ON		1.5	3.5
OAC	28277	ON		1.5	4.0	OAC	35528	ON		2.0	4.0
OAC	35617	ON		1.5	6.0	WIN	17331	MB		2.0	4.0
OAC	51320	ON	Bruce	1.5	4.0	WIN	17333	MB		1.7	4.0
OAC	70823	ON		1.5	5.5	WIN	35225	MB		2.0	4.0
WIN	28829	MB		1.9	4.5	WIN	36218	MB		1.5	4.5
WIN	35736	MB		1.9	3.8	WIN	53326	MB		2.5	4.5
WIN	42980	MB		1.9	3.0						
WIN	47851	MB		1.9	6.0						
WIN	47852	MB		2.3	4.9						
WIN	54731	MB		1.1	4.5						

...Continued on next page

TABLE 1. (Continued)

Andersonglossum virginianum											
Flowering dataset						**Fruiting dataset**					
Herbarium	*Barcode number / Voucher*	*State/Prov*	*County*	*Calyx length*	*Corolla diameter*	*Herbarium*	*Barcode number / Voucher*	*State/ Prov*	*County*	*Calyx length*	*Fruit length*
BOON	11998	NC	Watauga	3.4	6.9	BOON	17398	NC	Ashe	3.1	6.6
BOON	11999	NC	Watauga	2.3	6.6	BOON	23491	NC	Alleghani	2.6	5.7
BOON	12006	GA	Walker	3.7	6.9	DES	13252	LA	Caldwell	3.3	7.1
BOON	17397	NC	Ashe	2.9	6.3	DSC	101909	MS	Yazoo	4.2	6.3
BOON	23490	NC	Alleghani	2.9	6.0	DSC	101911	AL	Convington	2.9	6.3
DSC	101912	MS	Grenada	3.3	7.5	DSC	101914	MS	Tallahatchie	3.8	6.7
EIU	15320	IL	Pope	2.9	6.7	DSC	101917	AL	Henry	3.9	6.1
GA	63791	GA	Bibb	4.4	10.9	EIU	15311	IL	Lawrence	4.2	6.1
GA	63803	GA	Bartow	2.2	8.0	EIU	15312	IL	Hamilton	3.9	6.8
GA	63809	GA	Houston	2.2	9.5	EIU	15314	IL	Crawford	4.2	6.5
GA	63825	GA	Murray	2.6	6.7	EIU	15319	IL	Johnson	3.5	5.5
GA	63827	GA	Clay	2.9	9.5	EIU	15324	IN	Lawrence	3.2	5.5
GA	63913	GA	Jones	3.0	7.8	EIU	15325	WV	Kanawha	5.8	7.7
GA	83823	GA	Floyd	2.5	7.3	EIU	15327	IN	Spencer	2.9	6.1
GA	84007	GA	Putnam	2.5	9.5	GA	63793	GA	Walker	3.5	6.8
GA	160306	GA	Houston	3.3	11.7	GA	63797	GA	Clay	4.3	7.7
GA	161112	GA	Houston	3.0	9.7	GA	63811	GA	Houston	3.7	7.3
GMUF	32155	VA	Fairfax	3.2	8.1	GA	63814	GA	Dade	2.6	7.4

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TABLE 1. (Continued)

Andersonglossum virginianum											
Flowering dataset						**Fruiting dataset**					
Herbarium	*Barcode number / Voucher*	*State/Prov*	*County*	*Calyx length*	*Corolla diameter*	*Herbarium*	*Barcode number / Voucher*	*State/ Prov*	*County*	*Calyx length*	*Fruit length*
GMUF	32156	VA	Dinwiddie	5.5	10.0	GA	63822	GA	Hall	3.0	6.5
GMUF	32159	VA	Culpeper	3.9	10.0	GA	63826	GA	Dawson	3.5	7.4
GMUF	32169	VA	Loudoun	3.5	7.4	GA	206685	GA	Cobb	2.6	7.0
GMUF	32179	VA	Warren	3.5	11.9	GMUF	32157	VA	Dickenson	3.2	7.4
GMUF	32180	VA	Westmoreland	3.5	8.1	GMUF	32163	VA	Orange	3.5	7.4
HX	1502	AR	Cleburne	3.0	11.3	GMUF	32168	VA	Louisa	4.5	6.5
LSU	34029	LA	Rapides	3.0	9.1	GMUF	32170	VA	Lee	3.0	7.4
LSU	34030	LA	West Feliciana	3.0	8.3	GMUF	32172	VA	Lee	4.3	6.5
LSU	34033	LA	West Feliciana	3.0	9.6	GMUF	32173	VA	James City	4.3	5.2
MISSA	6412	MS	Oktibbeha	3.5	9.6	GMUF	32181	VA	Stafford	3.9	7.8
MISSA	31944	MS	Oktibbeha	3.9	10.0	GMUF	32184	VA	Rappahannock	2.6	5.7
MUHW	19801	AR	Newton	3.5	10.3	HX	1501	AR	Phillips	3.5	6.1
MUHW	19803	WV	Cabell	2.9	7.7	HX	1503	AR	Lee	2.9	6.1
MUHW	19806	WV	Calhoun	4.2	10.6	KNK	21973000006700	AL	Russell	3.2	6.5
MUHW	19808	WV	Huntington	2.9	8.7	KNK	31973000006701	KY	Lewis	2.9	6.5
NCSC	20807	OH	Coshocton	2.4	7.1	KNK	31973000006702	KY	Pendleton	6.2	8.6
NCSC	20815	WV	Wirt	2.7	8.6	KNK	31973000006703	AR	Madison	3.8	7.6
NCSC	20817	TN	Shelby	2.7	9.4	LSU	34024	LA	East Baton Rouge	4.3	6.7
NY	Carey/ 4Jun1842	NJ	Fort Lee	3.0	10.0	LSU	34028	LA	Natchitoches	3.8	6.7

...*Continued on next page*

TABLE 1. (Continued)

Andersonglossum virginianum											
Flowering dataset						**Fruiting dataset**					
Herbarium	*Barcode number / Voucher*	*State/Prov*	*County*	*Calyx length*	*Corolla diameter*	*Herbarium*	*Barcode number / Voucher*	*State/ Prov*	*County*	*Calyx length*	*Fruit length*
NY	Coulter/ May1874	IN	Jefferson	2.5	7.5	LSU	34034	LA	West Feliciana	3.8	5.7
NY	Dawson 1193	IN	Lawrence	3.0	6.5	LSU	87261	MS	Tate	2.9	6.7
NY	Deam/ 25May1901	IN	Orange	3.0	7.0	MISSA	6411	MS	Grenada	2.9	6.7
NY	Kezer/ 16May1936	NJ	Union	3.5	8.5	MISSA	6413	AR	Saline	3.7	6.3
NY	Leggett/ May1860	NJ	Hudson	3.0	7.0	MISSA	6414	LA	Vernon	3.3	5.7
NY	Lupfer 2813	PA	Perry	2.5	6.0	MISSA	6418	NY	Tompkins	2.7	6.3
NY	McCoy/ 16May1934	IN	Franklin	3.5	6.5	MMNS	580	MS	Hinds	3.0	7.0
NY	McCoy/ 18May1934	IN	Brown	3.0	6.0	MUHW	19799	MS	Warren	4.0	6.7
NY	McCoy 3655	IN	Spencer	2.5	8.0	MUHW	19800	MS	Warren	2.7	7.0
NY	McCoy 3668	IN	Perry	3.0	9.0	MUHW	19807	NC	Haywood	2.3	7.0
NY	McCoy 5084	IN	Posey	4.0	8.0	NY	Blanchard/ 13Jul1892	DC		3.3	6.7
NY	Robbins 3229	OK	McCurtain	3.5	6.0	NY	Champan sn	FL		4.0	6.7
NY	Steven 13025	NJ	Steven	3.5	6.0	NY	Crowl/ 9Jul1937	OH	Ross	4.3	5.7
NY	Tweedy/ May1879	NJ	Plainfield	3.0	8.0	NY	Deam/ 11Jul1899	IN	Crawford	4.3	6.3
NY	Yuncker 1901	IN	Putnam	2.5	8.5	NY	DeWitt Miller 1273	NJ	Union	3.7	6.3

...*Continued on next page*

TABLE 1. (Continued)

Andersonglossum virginianum											
Flowering dataset						**Fruiting dataset**					
Herbarium	*Barcode number / Voucher*	*State/Prov*	*County*	*Calyx length*	*Corolla diameter*	*Herbarium*	*Barcode number / Voucher*	*State/ Prov*	*County*	*Calyx length*	*Fruit length*
NY	Yuncker et al. 10381	IN	Putnam	3.0	8.0	NY	Eggert/ 13Jun1879	MO	Eureka	4.7	8.7
UARK	14789	AR	Baxter	3.0	7.7	NY	French/ 26Jun1878	IL	Jackson	3.7	7.0
UARK	14802	AR	Cleburne	3.3	7.0	NY	Grimes/ 12Aug1911	IN	Owen	4.0	7.0
UARK	14805	AR	Conway	3.3	8.3	NY	Wilmintong sn	DE		3.3	6.0
UARK	14811	AR	Franklin	3.3	8.0	UARK	14792	AR	Boone	4.3	6.7
UARK	14812	AR	Garland	3.7	6.7	UARK	14793	AR	Boone	3.7	5.3
UARK	14818	AR	Independence	3.0	12.0	UARK	14799	AR	Clark	2.7	7.0
UARK	14831	AR	Logan	3.3	9.3	UARK	14800	AR	Clark	4.4	8.1
UARK	14836	AR	Monroe	3.3	10.0	UARK	14801	AR	Clay	5.2	7.0
UARK	14844	AR	Pike	2.7	8.0	UARK	14803	AR	Cleburne	4.1	5.9
UARK	14850	AR	Pope	2.3	7.7	UARK	14804	AR	Conway	4.8	5.2
UARK	14855	AR	Washington	4.3	10.0	UARK	14807	AR	Cross	3.3	6.7
UARK	14856	AR	Washington	3.0	8.7	UARK	14808	AR	Cross	3.6	8.0
UARK	48520	AR	Franklin	4.3	7.3	UARK	14815	AR	Hempstead	3.3	8.4
UCA	4489	AR	Montgomery	4.1	10.3	UARK	14817	AR	Howard	3.0	6.0
UCA	4490	AR	Montgomery	3.4	7.6	UARK	14821	AR	Jefferson	5.0	6.0

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TABLE 1. (Continued)

Andersonglossum virginianum											
Flowering dataset						**Fruiting dataset**					
Herbarium	*Barcode number / Voucher*	*State/Prov*	*County*	*Calyx length*	*Corolla diameter*	*Herbarium*	*Barcode number / Voucher*	*State/ Prov*	*County*	*Calyx length*	*Fruit length*
UCA	4571	AR	Montgomery	3.8	8.3	UARK	14824	AR	Johnson	2.0	5.0
USCS	7158	SC	Cherokee	2.7	8.7	UARK	14826	AR	Lee	2.7	5.5
USCS	7159	SC	Cherokee	3.3	7.7	UARK	14829	AR	Little River	3.5	6.7
VSC	2873	GA	Houston	2.4	11.0	UARK	14835	AR	Madison	3.9	6.7
VSC	17111	MS	Winston	3.1	8.6	UARK	14838	AR	Montgomery	3.5	6.0
VSC	61920	GA	Houston	2.7	9.0	UARK	14852	AR	Searcy	3.0	6.5
						UARK	14853	AR	Sevier	3.0	7.5
						USCS	7162	SC	Laurens	3.0	7.0
						USCS	7166	SC	York	3.0	7.0
						USMS	8179	MI	Alger	4.0	7.0
						VSC	17107	GA	Dawson	3.0	6.0
						VSC	17112	WV	Wetzel	3.0	8.0
						VSC	17117	LA	Caldwell	3.0	6.5

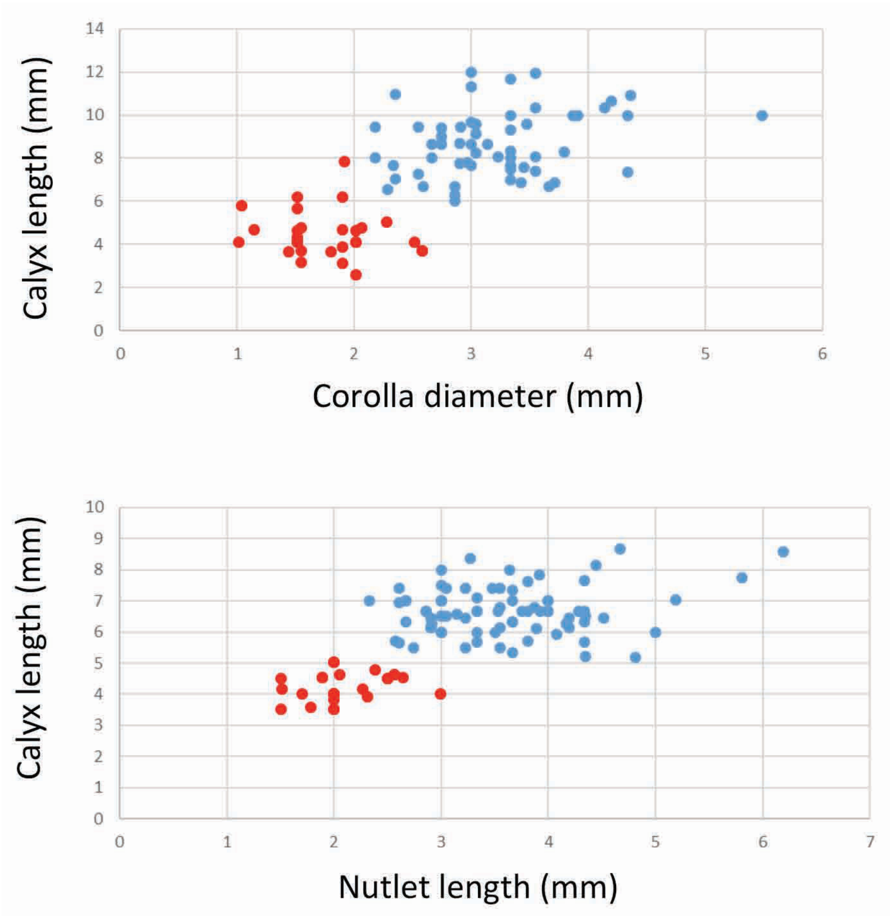

FIGURE 1. Scatter plot of the measurements of calyx length at anthesis vs. corolla diameter (upper graph), and calyx length in fruit vs. nutlet length (lower graph). Red dots represent *Andersonglossum boreale*, blue dots represent *Andersonglossum virginianum*.

TABLE 2. Summary statistics for measured characters of *Andersonglossum boreale* and *A. virginianum* [number of studied individuals *n*, mean ± SD (minimum–maximum)] from *A. boreale* and *A. virginianum*. Measurements are provided in mm.

Character	***Andersonglossum boreale***	***Andersonglossum virginianum***
Calyx length (anthesis)	*n* = 29 1.8 ± 0.4 (1.0–2.6)	*n* = 75 3.2 ± 0.6 (2.2–5.5)
Calyx length (fruit)	*n* = 26 2.1 ± 0.4 (1.5–3.0)	*n* = 80 3.6 ± 0.8 (2.0–6.2)
Corolla diameter	*n* = 29 4.3 ± 1.0 (2.5–7.6)	*n* = 75 8.3 ± 1.8 (6.0–12.0)
Nutlet length	*n* = 26 4.2 ± 0.4 (3.5–5.0)	*n* = 80 6.6 ± 0.8 (5.0–8.7)

Discussion

Our approach revealed clear differences between the two taxa. They do not present wide overlap in their diagnostic characters, as previously alleged (Cooperrider 1984). Since the measurements provided by Fernald (1950), no work has ever carefully evaluated the variation in the diagnostic characters for these two taxa. It seems that variation wider than expected regarding corolla diameter and sepal length at various stages of development may have misled authors, considering the two taxa to be overlapping in the overall diagnostic characters. However, our study reveals that the combination of the four considered features are sufficient to clearly distinguish the two species. Revisionism in the North American flora is rare outside the context of monographic works in the taxonomy of particular plant groups.

Local floras tend to accept taxonomy as reported in previous works, and many past floristic treatments present an inflation of taxa at varietal rank (Ellison *et al.* 2014). Straightforward analyses, such as the ones presented herein, would help to objectively evaluate the limits between taxa rather than just relying on opinions of floristic authors.

The value of digitized specimens for taxonomic purposes is revealed in this work, which uses a majority of online specimens for the evaluation of taxonomic limits. Indeed, without these online resources, our work would have necessitated loans of herbarium specimens. The opportunity to study the imaged materials housed at several repositories presents a valuable and convenient source of data that should be considered by researchers, enabling a faster way of conducting taxonomic work.

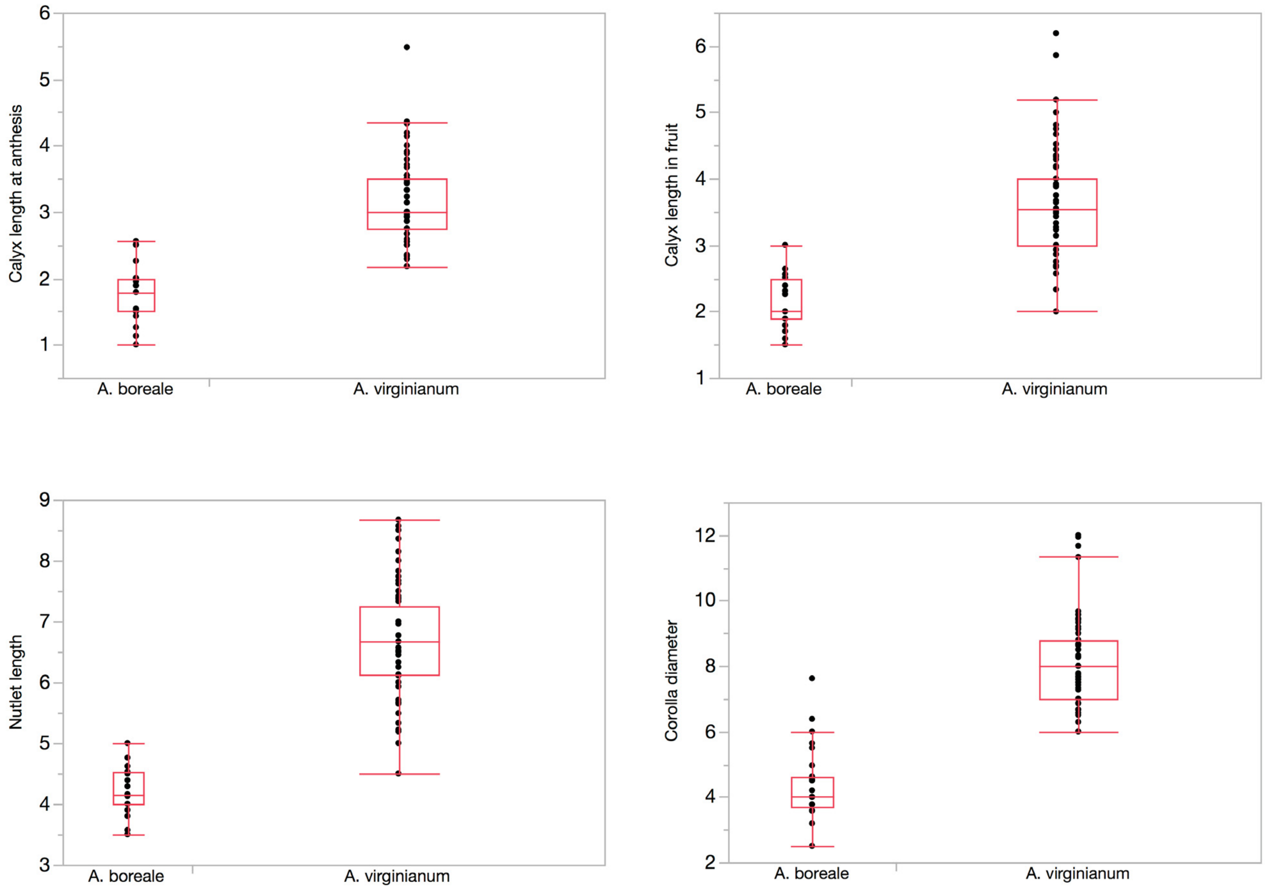

FIGURE 2. Box plots for two species for calyx length at anthesis (top-left), calyx length during fruiting (top-right), nutlet length (bottom-left), and corolla diameter (bottom-right), y-axis is in mm.

Taxonomic treatment

Andersonglossum boreale (Fernald) Jim.Mejías, J.I.Cohen & Naczi, *comb. nov*. Basionym:—*Cynoglossum boreale* Fernald (1905, Rhodora 7: 250).

Lectotype (designated by Cohen 2015: 618):—CANADA. Quebec: Little Cascapedia River, 17 July 1905, *E. F. Williams, J. F. Collins, & M. L. Fernald s. n.* (GH, photo!).

= *Cynoglossum virginianum* var. *boreale* (Fernald) Cooperrider (1984: 166).

= *Cynoglossum virginianum* subsp. *boreale* (Fernald) A.Haines (2010: 3).

- *Andersonglossum boreale* (Fernald) J.I.Cohen (2015: 618), *nom. inval*.

Observations:—*Andersonglossum boreale* is a species ecologically linked to boreal conifer forests and mixed northern forests. It is widespread in northern North America, with a transcontinental distribution (see http://plants.usda.gov/, accessed 15 Oct 2016), spreading in Canada from Nova Scotia to British Columbia and Yukon, and reaching its southernmost limit in the states of New Jersey, New York, Ohio, Indiana, Wisconsin, Iowa, and South Dakota, although many of these stations are believed to be extirpated (see http://explorer.natureserve.org/, accessed 15 Oct 2016). On the contrary, *A. virginianum* is a southeastern North American species, occurring in temperate broadleaf forests. It is known only from the U.S.A., spreading from Connecticut west to Illinois, Missouri and Oklahoma, south to Florida and Texas. It co-occurs (or co-occurred) with *A. boreale* through a narrow strip in the states of Connecticut, New Jersey, and New York across the Appalachians, and Ohio and Indiana south of the Great Lakes region.

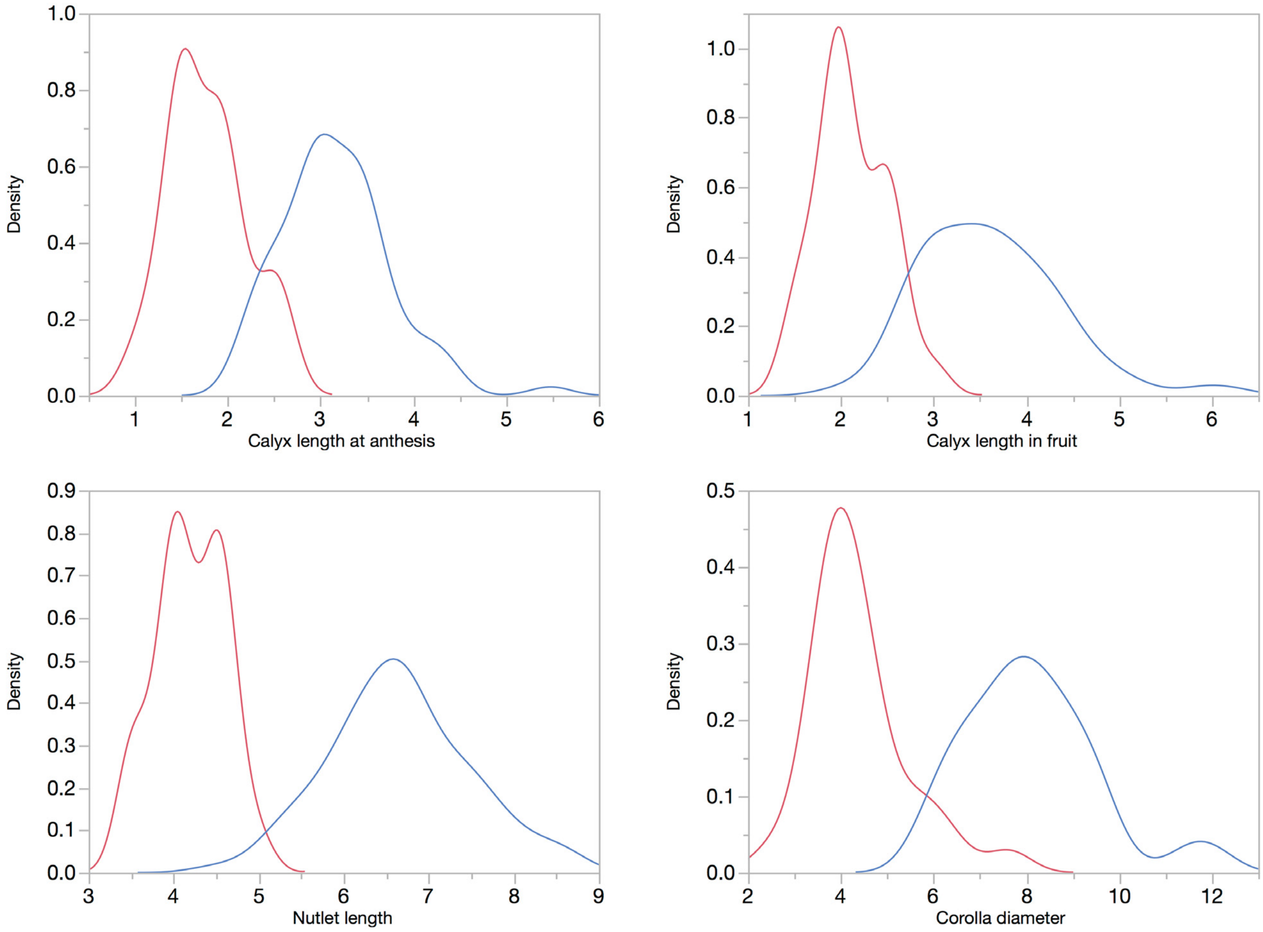

FIGURE 3. Density comparisons for two species for calyx length at anthesis (top-left), calyx length at fruiting (top-right), nutlet length (bottom-left), and corolla diameter (bottom right). Red is *Andersonglossum boreale*, and blue is *Andersonglossum virginianum*, x-axis is in mm.

Identification key

The following key allows the identification of the three species of the genus *Andersonglossum*.

1. Corolla purple to red; style > 4 mm..*A. occidentale*
1. Corolla blue to white; style < 3.5 mm..2.
2. Nutlets 3.5–5 mm long; calyx lobes 1.5–3 mm long (from the pedicel insertion point to the apices of the lobes); corolla 2.5–6.3(7.6) mm wide..*A. boreale*
2. Nutlets 5–8.7 mm long, calyx lobes 2–5 mm, slightly accrescent up to 6.2 mm in fruit; corolla 6–12(16) mm wide..*A. virginianum*

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