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Asarum rosei (Aristolochiaceae), a new species from the Blue Ridge Escarpment of North Carolina, USA

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Abstract

Hundreds of years of botanical exploration in heavily populated and highly accessible eastern North America have not exhausted taxonomic prospects in the region. Here, I describe a new species of *Asarum* (Aristolochiaceae), *Asarum rosei* B.T.Sinn, from North Carolina, USA. This species is characterized and contrasted with species in *Asarum* subgenus *Heterotropa* section *Hexastylis*, and a revised artificial taxonomic key to the similar species in the section is provided.

Key words: *Asarum*, *Hexastylis*, magnoliids, Piperales, Wild Ginger

Introduction

Asarum (Aristolochiaceae) comprises approximately 110 species (Cheng and Yang, 1983; Huang *et al*., 1995; Kelly, 2001; Sinn *et al*., 2015a) whose reproductive biology and diversity is more poorly known (Kelly, 1997; Sinn *et al*., 2015b) than would be expected given the charismatic and attractive flowers, broad geographical distribution, and use in horticulture. During 1998, Mark Rose discovered a population of *Asarum* plants along Wilson Creek in Caldwell County, North Carolina, USA that were unassignable to any known species. He collected several plants which were transplanted into his garden, and their morphology has remained consistent with that of his first observation while in this garden setting for over 18 years. Below, I describe this species, compare it to and provide a taxonomic key to morphologically similar species in *Asarum* section *Hexastylis*, and present observations that suggest its mode of pollination.

Recent work on the phylogenetic relationships, character-associated diversification, and taxonomy of *Asarum* (Gaddy, 2011; Sinn, 2015; Sinn *et al*., 2015a, 2015b) have sparked a renewed regional interest (Keener and Davenport, 2015; Weakley, 2015; Diamond, 2016) in the rank-level designations of the infrageneric categories established by Araki (1937, 1953), Cheng and Yang (1983), Kelly (1997, 1998, 2001), Sugawara (2006), and Sinn *et al.* (2015a). A discussion of the perspective of these authors is warranted here, not simply to provide historical background but also to provide context for why this new species is named in *Asarum*, rather than in the Rafinesque genus *Hexastylis* (1825).

The recognition of *Hexastylis* by Small (1903) in his influential flora marked the beginning of what has become a botanical tradition in the southeastern United States. A comparison of the general morphology of *Asarum canadense* L. with any taxon in *Hexastylis* provides the observer with differences in the temporal persistence of leaves, connation of the sepals, sepal and leaf vestiture, and the presence of herkogamy or stamen movement or both (see Blomquist 1957). However, through the establishment of the phylogenetic systematic (Hennig, 1966) paradigm, the majority of contemporary systematists recognize genera and more elevated ranks upon the basis of shared, derived character states that support monophyletic groups rather than on the magnitude of perceived differences.

The morphological characteristics that make taxa commonly segregated from *Asarum* into *Hexastylis* so easily discriminated in the southeastern United States are only unique in light of the strong regional contrast provided through the comparison with *Asarum canadense* L. The sculpturing on the adaxial surface of the sepals, the lack of vestiture on the abaxial surface of the sepals, the presence of herkogamy, and the single leaf produced per node are not unique to *Hexastylis*—all of these character states are plesiomorphic with respect to *Asarum* subgenus *Heterotropa*, found throughout southeastern China and Japan (more than 50 species have been recognized as occupying the latter). Despite

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perceived novelty of these features for species comprising section *Hexastylis*, their overall morphology is characteristic of the majority of *Asarum* species worldwide.

The phylogenetic investigations of Sinn *et al.* (2015a, 2015b) fail to unequivocally support the monophyly of section *Hexastylis*, and suggest that a unique combination of plesiomorphic character states and phylogenetic signal encapsulated in the plastid genome, rather than the presence of any single synapomorphic character state, support what has been designated as *Asarum* subgenus *Heterotropa* section *Hexastylis* (See Sinn *et al.* 2015a for discussion and appendix 3 for a key to *Asarum* sub-generic ranks). While rank-level taxonomic designations are arbitrary, with the exception of the condition of monophyly, I propose that in order to make a strong case for the recognition of *Hexastylis*, the presence of at least a single morphological synapomorphy and unequivocal molecular support for a single evolutionary origin of the genus should be reported. At present, the placement of this new taxon in *Asarum* provides the most evidenced and taxonomically-stable framework upon which to study and further our understanding of the evolution of these plants, which share common vegetative and floral *baupläne* and vary most strongly only in the connation, shape, and vestiture of their floral organs.

Materials and Methods

Photographs were taken with a Nikon SMZ 1500 stereoscope and Nikon DS-Ri1 camera. Images and Z-stacks were prepared using NIS Elements BR (version 4.30.01) software.

Photographs of previously borrowed viewed or loaned specimens from BOON, CLEMS, FLAS, GA, GH, MO, MICH, NCSC, NY, PH, TENN, US, WCUH, WVA, and YUO were surveyed for unidentified specimens of *Asarum rosei* B.T.Sinn. Keys and descriptions published by Blomquist (1957), Gaddy (1987, 2011), Whittemore and Gaddy (1997), and Weakley (2012) were compared.

Mark Rose maintained plants from the topotype in cultivation at Flannery Fork Botanical Garden in Boone, NC for the past 18 years to observe variation and control for habitat-related influence on morphology or timing of anthesis.

The species hypothesis presented herein was guided by clarified forms of the Evolutionary (Simpson, 1951, 1961) and Ecological Species Concepts (Van Valen, 1976) which comprise the "phenophyletic" view of Freudenstein *et al.* (2016), "*A species is a lineage or group of connected lineages with a distinct role*."

Taxonomy

Asarum rosei* B.T.Sinn, *sp. nov. (Fig. 1)

Diagnosis:—Similar to *A. heterophyllum* Ashe, though notable for flowers with pale yellow-white (rarely green-white) sepal lobes covered in exclusively white multicellular trichomes which transition to entirely red within the calyx tube, and flowering period of late-May through June. Leaves are of similar shape to those of *A. shuttleworthii* Britten & Baker though not variegated, and with conspicuously undulating-crenulate margins.

Type:—UNITED STATES. North Carolina: Caldwell County, growing on the West (East facing) sloped road bank of Brown Mountain Beach Road (CR 1328) 0.5 km south of the junction with Harper's Creek. Latitude 35 58.07N, longitude 081 45.49W, elevation 445 m. Growing along the roadside from just north of Harpers Creek south for approximately 1.2 km. 13 June 2016 R. Mark Rose collection # 2016-06-13CA-A (Holotype: NY (FAA-fixed, ethanol-stored leaves and flower, and a living individual also accessioned into The New York Botanical Garden), isotypes distributed to: NCU, MO, US)).

Description:—*Perennial herb*, clumped growth habit with short rhizome. *Petioles* glabrous, over 18 cm in length. *Leaf blades* glabrous and entire, (7.4–) 8.2–11.2 cm long from base of lobe to the apex of the acute leaf tip and (6.8–) 8.5–11 cm wide, roundly- to oblong-cordate in shape, variegation not observed, the minutely revolute and entire leaf margins conspicuously undulate-crenulate; *leaf lobes* 2.1–3.7 cm long and 2.9–4.4 cm wide; *calyx tube* 1–1.5 cm long, (0.5) 0.9–1.2 cm wide at the orifice, with a pronounced protuberance distending the tube to (0.9) 1.1–1.5 cm in width at its broadest point which lies at approximately 2/3 of the distance from the base of the tube to the apex, the base white to pale yellow, sharply transitioning to a deep maroon above, trichomes villous with those inside the tube red and those of the sepal lobes entirely white; *calyx reticulations* composed of highly developed transverse and

FIGURE 1. A) Habit of mature *A. rosei* individual at anthesis. B) Flowers of *A. rosei* showcasing entirely white trichomes covering sepal lobes. Photographs taken by Mark Rose.

longitudinal lines of equal height, the height of the strongest of these reticulations surpasses the thickness of the calyx wall, and anastomosing to form deep irregular pits; *sepal lobes* (0.7) 1–1.2 cm long, weakly spreading, pale yellow-green (rarely green-white), somewhat shorter or as long as they are wide at the base, with long-tomentose covering of uniformly white trichomes over the adaxial surface; *stamens* extrorse, thecae ~2 mm long and 0.5 mm wide, the broad filaments red and shorter than the styles, ~3 mm long tapering and surpassing the thecae by approximately 1 mm or less, the distal apex of the thecae slightly nearer to one another than proximally; *ovary* approximately 2/3 superior; *styles* gradually transitioning from white at the base to deep red at the apices of the highly developed, deeply cleft style extensions that surpass the ovoid, overhanging stigmas by >2 mm; stigmas approximately 1 mm long and 0.5 mm wide. Fruit and seeds not seen.

Phenology:—Flowering late May–late June, fruits not seen by author.

Distribution:—Caldwell, Co., NC—The population occurs along a stretch of Brown Mountain Beach Road from just north of Harpers Creek south for approximately 0.8 of a mile to just above the K C Killian Camp property, and comprises approximately 600 individuals.

Habitat:—Acidic Cove Forest (Typic Subtype) per the Guide to the Natural Communities of North Carolina, Fourth Approximation (Schafale, 2012).

Associates:—*Rhododendron maximum*, *Kalmia latifolia*, *Tsuga canadensis*, *Betula alleghaniensis*, *Betula lenta*, *Liriodendron tulipifera*, *Leucothoe fontanesiana*, *Hydrangea arborescens*, *Euonymus americanus*, *Parthenocissus quinquefolia*, *Toxicodendron radicans*, *Aristolochia macrophylla*, *Xanthorhiza simplicissima*, *Mitchella repens*, *Asarum shuttleworthii*, *Polystichum acrostichoides*, *Parathelypteris noveboracensis*, *Actaea racemosa*, *Eutrochium* sp., and *Laportea canadensis*.

Conservation:—To-date, *A. rosei* is known from only a single locality. It is recommended that this species be evaluated for protection at the state level, at minimum.

Etymology:—Named for Mark Rose, a respected plant collector, horticulturalist, orchid breeder, and naturalist who discovered and documented the species that is here named in his honor. Mr. Rose ensured the recognition of this new species by way of his skilled observations, patient documentation, and curiosity for the natural world.

Other specimens examined:—No pre-existing specimens are known.

Discussion

With regard to floral morphology, especially calyx tube reticulations and gynostemium morphology, *Asarum rosei* B.T.Sinn (Figure 1) is most similar to *A. heterophyllum* Ashe, and I suspect that if it had been collected prior to this description, it was most likely mistaken for that species. Both *A. heterophyllum* and *A. rosei* have highly developed style extensions, broad stamen filaments, extrorse thecae (Figure 2A), adaxial sepal sculpturing with the longitudinal components more highly developed than the horizontal components, sepal lobes whose length equals or exceeds the width at the base, and a calyx tube that is broadest below the opening (Figure 2B). The white-yellow sepal lobes covered in pure white multicellular trichomes, the latter of which is a characteristic of pure white multicellular trichomes (Figures 1B & 3) are a combination of traits that is highly consistent in the known population—these distinctive calyx characteristics, combined with the unique crenulate leaf margins, makes identification of *A. rosei* quite straightforward. Unlike *A. heterophyllum*, or other section *Hexastylis* species with the exception of *A. shuttleworthii* Britton & Baker, *A. rosei* flowers from late May to late June. The late flowering of this species, coupled with its extremely restricted geographic distribution, could account for how this species evaded description. Since the blooming of *A. rosei* coincides with that of *A. shuttleworthii*, which grows throughout the only known locality of *A. rosei* (Figure 4A), it is likely that if this population of plants were encountered by an individual with a knowledge of section *Hexastylis* species in early Spring, these plants could have been overlooked as *A. shuttleworthii* individuals with odd leaves.

The undulate-crenulate leaf margins of *A. rosei* are highly distinctive (Figure 4B), and represent the only consistent, species-level diagnostic vegetative feature yet described for a species of section *Hexastylis*. Contrastingly, leaf morphology of section *Hexastylis* species can often be used to narrow a species identification to a few potential species, but the most accurate identification cannot be made in the section without a combination of vegetative and reproductive characters, especially those provided by flowers at anthesis. The distinctive leaf morphology of *A. rosei* allows one to confidently identify individuals when in vegetative condition; this may help parties interested in surveying lands for conservation purposes or other botanists to identify new populations of this species throughout the year.

FIGURE 2. A) Gynostemium with extrorse thecae, broad stamen filaments, and well-developed style extensions. B) Calyx tube typical of the species. Note that the tube is broadest above its midpoint.

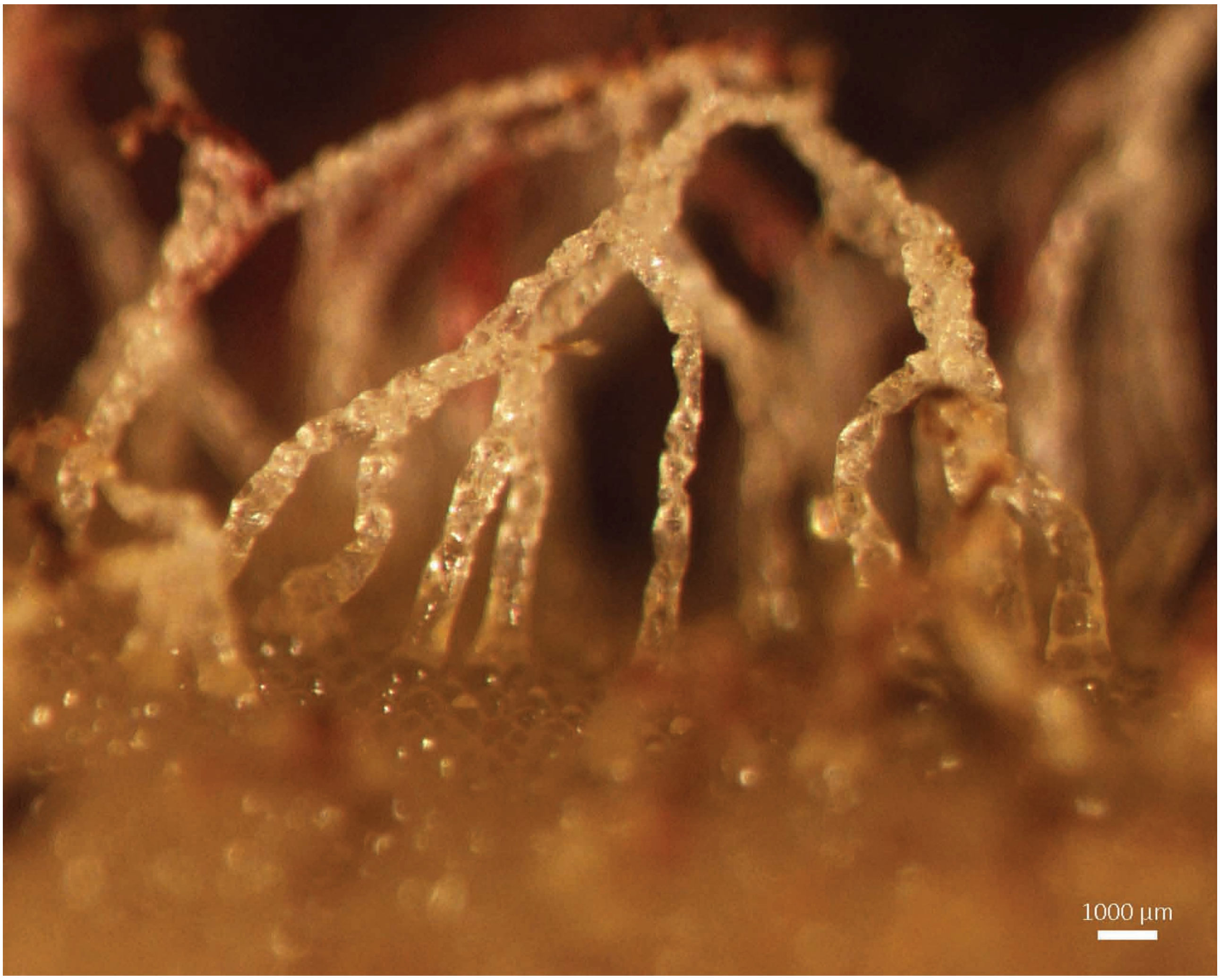

FIGURE 3. White multicellular trichomes of sepal lobes. Note the transition to red trichomes that occurs in the background of the photograph, as the frame progresses into the calyx tube.

The flowers of section *Hexastylis* species have been hypothesized to mimic fungal brood sites for fungus gnats (see Sinn *et al.*, 2015b), and the adaxial calyx sculpturing of *A. rosei* flowers has been photographed with dipteran larvae present throughout (Figure 5). Sympatry between *A. rosei* and *A. shuttleworthii* represents another similarity to some populations of *A. heterophyllum* in South Carolina and Georgia where I have found those two species, often along with *A. arifolium* Michx., in mixed populations with segregated flowering periods (Sinn, 2015). Contrastingly, this population of *A. rosei* represents what I believe to be the first example of a mixed section *Hexastylis* population where anthesis overlaps between *A. shuttleworthii* and another species of the section. *A. shuttleworthii* plants can produce the largest, most aromatic flowers of section *Hexastylis* species. This, coupled with the later flowering period when potential pollinators are more active, suggests that this species is more likely to receive pollinator services. The presence of dipteran larvae in the calyx reticulations of *A. rosei* co-occurring with *A. shuttleworthii*, but lacking the larger and aromatic flowers, suggests that visitation by putatively-effective pollinators might be most influenced by flowering period rather than by floral features such as odor and floral orifice ornamentation that have been interpreted as pollinator-attractive.

FIGURE 4. A) Photograph depicting type locality and associate species. Photograph taken by Mark Rose. B) Leaf of *A. rosei.* Note the conspicuously crenulate margins.

FIGURE 5. Dipteran larvae found within calyx tube reticulations.

Artificial Key to species of Blomquist's informal Virginica Group

1A. Trichomes of sepals and floral orifice pilose and exclusively white 2
2A. Leaf scars widely spaced and internodes long, plants forming mats; leaves broadly hastate; sepal lobes red, often with white mottling; leaves with entire margins .... ***A. lewisii*** Fernald.

2B. Internodes short, plants clumping and not forming mats; sepal lobes yellow-white, without mottling; leaves with undulate-crenulate margins .... ***A. rosei*** B.T.Sinn.

1B. Trichomes of sepals and floral orifice comprised of red or red and white cells **3**
3A. Calyx tube 3 cm or less in length, thick-walled and relatively robust, often odorless; ovary often somewhat inferior, the point of stamen insertion on the gynostemium no further from the base of the calyx tube than the height of the thecae **4**
4A. Stamen filaments broad and strap-like; thecae extrorse **5**
5A. Flower orifice not often highly constricted, or if constricted the orifice is not more than 5 mm from the widest portion of the calyx tube **6**
6A. Calyx tube greatly flared at the midpoint or higher, the floral orifice only slightly more constricted than the widest portion of the calyx tube; sepal lobes much broader than long; leaves usually variegated **7**

7A. Floral orifice nearly as wide as the interior of the calyx tube flare; calyx tube reticulations forming irregularly-shaped distally-facing pits, the longitudinal components only equaling the thickness of the calyx tube in height distally, if ever; leaves often heavily variegated. .... ***A. minus*** Ashe.

7B. Plants as above but with weakly variegated leaves and of frequently disturbed areas in the Sandhills region of North and South Carolina .... ***A. sorriei*** (Gaddy) B.T.Sinn.

6B. Calyx tube often flared above the middle, the floral orifice is of approximately the same width as the unflared portion of the calyx tube; sepal lobes as long or longer than their width at base; leaves often not variegated **8**

8A. Calyx lobes ± erect, much broader than long; leaves reniform to obovate-cordate, rarely variegated. Longitudinal and transverse components of the calyx tube sculpturing of approximately equal relief, the transverse components anastomosing and often not spanning the longitudinal portions forming irregularly shaped pits …. ....***A. virginicum*** L.

8B. Longitudinal components of the calyx tube sculpturing of greater relief than the transverse components **9**

9A. Style extensions longer than the width of the stigmatic surfaces; stigmas dorsal and overhanging; calyx tube at least 1 cm in length, cylindrical, and sometimes broadly so, usually encircled by a flare distally (except in the SE portion of the range); sculpturing of the calyx tube highly developed, especially the longitudinal components; some large-flowered southern populations with slight odor...***A. heterophyllum*** Ashe.

9B. Style extensions as long as or shorter than the width of the stigmatic surfaces; stigmas nearly terminal and in notched recess; flowers extremely small, calyx tube often approximately 1 cm or less in length, cylindrical and slightly tapering or expanding toward orifice; interior sculpturing of the calyx tube poorly developed, often only the longitudinal components present................ ....***A. naniflorum*** (H.L.Blomq.) B.T.Sinn.

5B. Floral orifice highly constricted, greater than 5 mm from widest point of calyx tube...............***A. rhombiformis*** (Gaddy) B.T.Sinn.

4B. Stamen filaments cylindrical; thecae latrorse or nearly so **10**

10A. Stamen filaments not strongly tapering distally, proximal and distal portion of the thecae about equally spaced; calyx tube broadest below the middle. ....***A. contractum*** (H.L.Blomq.) Barringer.

10B. Stamen filaments strongly tapering distally, thecae touching or nearly so distally; calyx fusiform and broadest at the midpoint ....***A. chueyi*** B.T.Sinn.

3B. Calyx tube greater than 3 cm in length, thin-walled and relatively brittle, often with rancid odor; the point of stamen insertion on the gynostemium as far or further from the base of the calyx tube than the height of the thecae **11**

11A. Internodes short and leaf scars crowded on stem, plants not forming mats. ....***A. shuttleworthii*** Britten & Baker.

11B. Internodes long and leaf scars widely spaced on stem, plants forming mats.......................................***A. harperi*** (Gaddy) Diamond.

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References

Araki, Y. (1937) The species of *Asarum* in the Santan District. *Acta Phytotaxonomica et Geobotanica* VI: 122–135.

Araki, Y. (1953) Systema generis Asari. *Acta Phytotaaxonomica et Geobotanica* XV: 33–36.

Barringer, K. (1993) New Combinations in North American *Asarum* (Aristolochiaceae). *Novon* 3(3): 225–227. https://doi.org/10.2307/3391458

Cheng, C.Y. & Yang, C.S. (1983) A synopsis of the Chinese species of *Asarum* (Aristolochiaceae). *Journal of the Arnold Arboretum* 64: 565–597.

Diamond, A.R. (2016) *Asarum harperi*: a new combination for a *Hexastylis* (Aristolochiaceae) taxon. *Phytoneuron* 2016(9): 1–2.

Freudenstein, J.V., Broe, M.B., Folk, R.A. & Sinn, B.T. (2016) Biodiversity and the Species Concept – Lineages are not Enough. *Systematic Biology*. [published online 26 October 2016] https://doi.org/10.1093/sysbio/syw098

Gaddy, L.L. (1987) A Review of the Taxonomy and Biogeography of *Hexastylis* (Aristolochiaceae). *Castanea* 52(3): 186–196.

Gaddy, L.L. (2011) A new species of *Hexastylis* (Aristolochiaceae) from the Sandhills of North and South Carolina. *Phytoneuron* 2011(47): 1–5.

Hennig, W. (1966) *Phylogenetic Systematics*. University of Illinois Press, Champaign, IL.

Huang, S.-F., Hsieh, T.-H. & Huang, T.-C. (1995) Notes on the Flora of Taiwan (21)—The Genus *Asarum* L. (Aristolochiaceae). *Taiwania* 40(2): 91–120.

Keener, B.R. & Davenport, L.J. (2015) Change in taxonomic rank for a *Hexastylis* (Aristolochiaceae) taxon of the southeastern United States. *Journal of the Botanical Research Institute of Texas* 9(2): 317–318.

Kelly, L.M. (1997) A Cladistic Analysis of *Asarum* (Aristolochiaceae) and Implications for the Evolution of Herkogamy. *American Journal of Botany* 84(12): 1752–1765.
https://doi.org/10.2307/2446475

Kelly, L.M. (1998) Phylogenetic Relationships in *Asarum* (Aristolochiaceae) Based on Morphology and ITS Sequences. *American Journal of Botany* 85(10): 1454–1467.
https://doi.org/10.2307/2446402

Kelly, L.M. (2001) Taxonomy of *Asarum* section *Asarum* (Aristolochiaceae). *Systematic Botany* 26: 17–53.
http://dx.doi.org/10.1043/0363-6445-26.1.17

Schafale, M.P. (2012) *Guide to the natural communities of North Carolina: Fourth Approximation.* North Carolina Natural Heritage Program, Department of Natural Resources.

Simpson, G.G. (1951) The species concept. *Evolution* 5: 285–298.
https://doi.org/10.2307/2405675

Simpson, G.G. (1961) *Principles of animal taxonomy.* Columbus University Press, New York.

Sinn, B.T. (2015) *Asarum chueyi* (Aristolochiaceae), a new species from the foothills of the Blue Ridge Mountains of Tennessee and Virginia, USA. *Phytotaxa* 224(1): 85–95.
https://doi.org/10.11646/phytotaxa.224.1.6

Sinn, B.T., Kelly, L.M. & Freudenstein, J.V. (2015a) Phylogenetic relationships in *Asarum*: partitioning-dependent topologies and a revised classification. *American Journal of Botany* 102(5): 765–779.
https://doi.org/10.3732/ajb.1400316

Sinn, B.T., Kelly, L.M. & Freudenstein, J.V. (2015b) Putative floral brood-site mimicry, loss of autonomous selfing, and reduced vegetative growth are significantly correlated with increased diversification in *Asarum* (Aristolochiaceae). *Molecular Phylogenetics and Evolution* 89: 194–204.
https://doi.org/10.1016/j.ympev.2015.04.019

Sugawara, T. (2006) *Asarum*. *In*: Iwatsuki, K., Yamazaki, T., Boufford, D. & Ohba, H. (Eds.) *Floral of Japan*, vol. IIa. Kodansha, Toyko, Japan, pp. 368–386.

Van Valen, L. (1976) Ecological species, multispecies, and oaks. *Taxon* 25(2/3): 233–239.
https://doi.org/10.2307/1219444

Weakley, A.S. (2015) *Flora of the Southern and Mid-Atlantic States* (Draft – 21 May 2015). 1225 pp. Available from: http://herbarium.unc.edu/FloraArchives/WeakleyFlora_2012-Nov.pdf (accessed 1 July 2016)

Whittemore, A.T. & Gaddy, L.L. (1997) *Hexastylis*. *In:* Flora of North America Editorial Committee (Eds.) *Flora of North America North of Mexico*. Oxford University Press, New York, pp. 54–58.