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THLASPI ALLIACEUM (BRASSICACEAE) NATURALIZED IN GEORGIA, MISSOURI, AND NORTH CAROLINA

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ABSTRACT

Thlaspi alliaceum L. (roadside penny-cress/garlic penny-cress), an exotic European annual in the Brassicaceae, is rapidly becoming naturalized to the point of invasiveness in the east-central and mid-Atlantic USA. We have documented its occurrence for the first time in Georgia and have documented range extensions for two Missouri counties and six North Carolina counties. Associated species found with roadside penny-cress are discussed from collection vouchers.

KEY WORDS: Brassicaceae, *Thlaspi alliaceum*, naturalized, Georgia, Missouri, North Carolina

Thlaspi alliaceum L. (roadside penny-cress/garlic penny-cress) is a naturalized, fast-growing European annual in the Brassicaceae of the Order Capparales (Figure 1). It typically occupies highway corridors and other roadside ruderal habitats; hence, its most used vernacular name. The genus, *Thlaspi*, a Greek derivative, *thalo, thals-* "to compress", refers to its flattened silicles. The other vernacular name, garlic penny-cress, signifies its specific epithet, *alliaceum*, the garlic-like odor of fresh, bruised, or crushed foliage (Al-Shehbaz 2010). *Thlaspi alliaceum* should not to be confused with *Alliaria petiolata* (M. Bieb.) Cavara & Grande (garlic mustard), a related European invasive annual with petiolate, non-auriculate, cordate-reniform, and broad dentate-margined leaves, and curved torulose, 4-angled siliques, and a stronger garlic odor.

Roadside penny-cress plants (Figures 1-5) have a simple taproot with one to several erect stems 20-60+ cm tall with sparse pilose trichomes at the base which become glabrate at maturity. The sessile, glabrous, and glaucous leaves 2.0-3.0 x 1.0-1.5 cm are auriculate-clasping, lanceolate to oblong-obovate with sinuate-repand margins. Basal leaves are shed early to be followed progressively by withered middle and upper cauline leaves as senescence occurs. Terminal and

lateral racemes have numerous flowers with four green sepals 1.5-2.5 x 0.8-1.2 mm and four white petals 2.5-3.5 x 1.0-1.5 mm on slightly recurved pedicels 10-15 mm. Convex obovate-oblong silicles are 5.0-7.0 x 3.0-4.5 mm, slightly winged with a very shallow apical notch. Each silicle typically encloses 5-8 dark brown, alveolate, obovate seeds, 1.4-1.6 x 0.9-1.0 mm (Al-Shehbaz 2010). Phenology of *Thlaspi alliaceum* extends for a very short time period with flowering in early-to-mid March and senescence by mid-to-late May. $2n = 14$.

Thlaspi alliaceum may be readily separated from two other widely naturalized European Brassicaceous annuals in the eastern USA, *Microthlaspi perfoliatum* (L.) F.K. Meyer (clasp-leaved or perfoliate penny-cress; formerly *Thlaspi perfoliatum* L.) and *Thlaspi arvense* L. (field penny-cress) by diagnostic keys (e.g., Thieret & Baird 1985; Rollins 1993; Yatskievych 2006; Al-Shehbaz 2010; Weakley 2012; Weakley et al. 2012).

1. Plants < 35 cm tall; bruised plant without garlic odor; silicles 4–6 x 2–4 mm; seed coat smooth, yellowish tan; cauline leaf margins entire ..... **Microthlaspi perfoliatum**
1. Plants > 35 cm tall; bruised plants with or without garlic odor; silicles 6–20 x 3–20 mm; seed coat concentric striate or alveolate, grayish brown to brownish black; cauline leaf margins dentate-repand.

2. Silicles convex, oblong, 6–8 x 4–5 mm, apex notch 0.5 mm, wing 1 mm wide; seeds alveolate brownish black; lower stems with pilose hairs; bruised plant with garlic odor ... **Thlaspi alliaceum**
2. Silicles compressed, obovate to oval, 10–20 x 8–20 mm, apex notch 5 mm, wing 4 mm wide; seeds concentric striate, grayish brown; lower stems glabrous; bruised plant without garlic odor ..... **Thlaspi arvense**

The native geographical distribution of *Thlaspi alliaceum* includes central Europe (Austria, Germany, Hungary, Poland, Switzerland), southeastern Europe (Bosnia, Bulgaria, Croatia, Herzegovina, Italy, Macedonia, Romania, Serbia, Slovenia, Turkey), southwestern Europe (France, Spain), and tropical Africa (Ethiopia, Kenya, Tanzania). Roadside pennycress is naturalized in northern Europe (United Kingdom), eastern Europe (Ukraine), and the eastern USA (USDA, ARS 2013).

Roadside penny-cress seeds are characteristically dispersed along interstates, parkways, and paved road corridors on grassy road medians, shoulders, slopes, and ditches. Plants are often present in fallow and cultivated fields, pastures, woodland edges, and other ruderal habitats. Culturally disturbed roadside habitats generally have been created for *Thlaspi alliaceum* by increased high volume of vehicle traffic, extensive roadside mowing programs, and wayside disturbances from highway construction and general maintenance projects.

Dispersal of many naturalized species with small, light seeds has been typically accomplished through “slipstreaming,” a phenomenon of low pressure drag created by the velocity wake or turbulence of passing motor vehicles (Eskridge & Hunt 1979; von der Lippe et al. 2013) and train locomotives and freight cars (Thompson & Abbott 2013). Mowing machinery scatters seeds, and the slurry deposited under the mowers disseminates seeds during mowing at other sites, while highway and general construction provides ruderal or disturbed habitats for seed migration and establishment.

Thlaspi alliaceum has rapidly been dispersed throughout the east-central and mid-Atlantic USA during the last 30-40 years. It was first collected in North America by Harry E. Ahles in March 1956 from an adjacent roadside and field in Rockingham County, North Carolina (Radford et al. 1968). The distribution of garlic penny-cress is currently listed in 10 eastern states (DE, IN, KY, LA, MD, NC, OH, PA, TN, and VA) by USDA, NCRS (2013). New Jersey has been included in the geographical range with three counties documented by voucher specimens (Lamont & Young 2006).

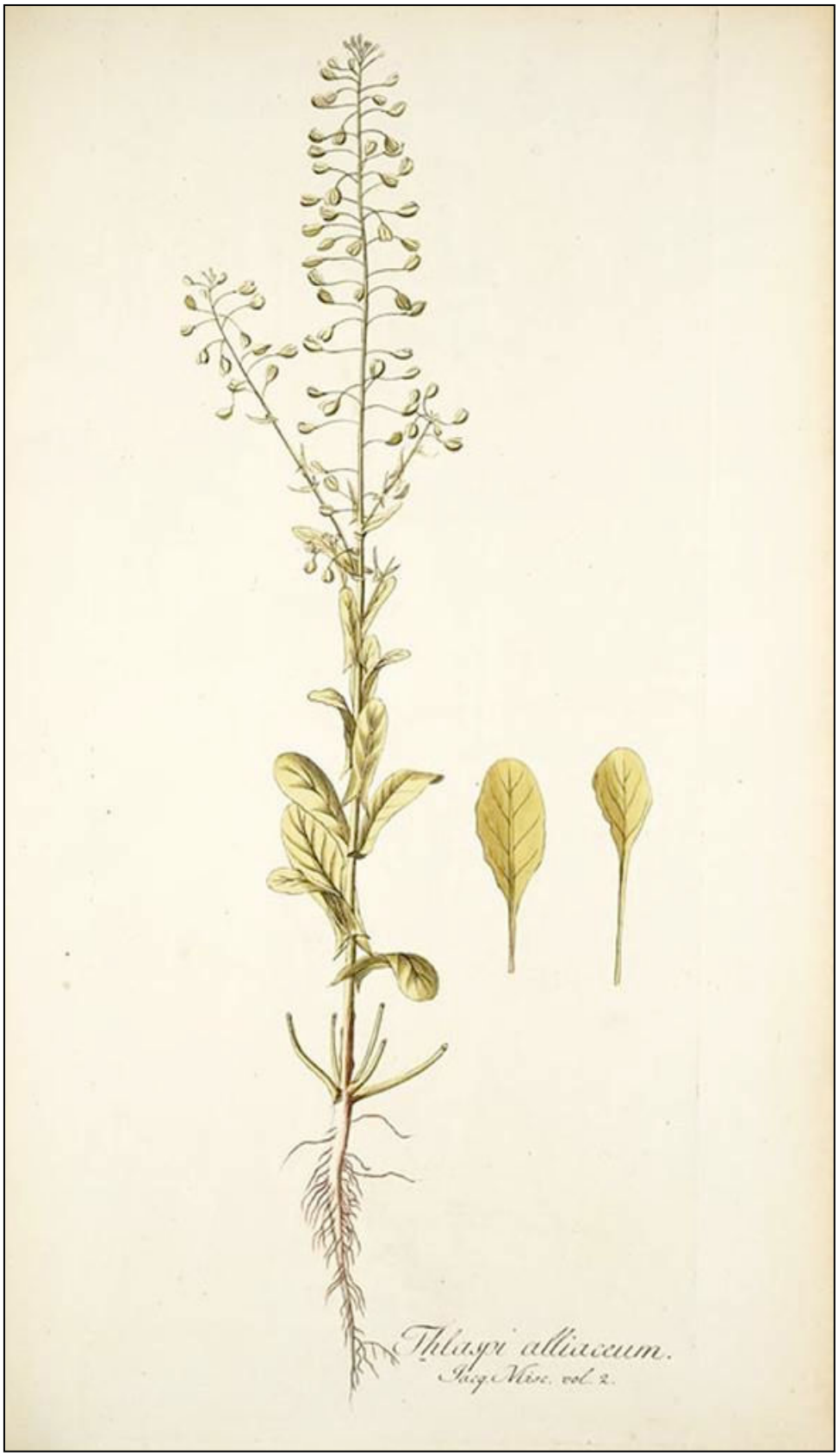

Figure 1. *Thlaspi alliaceum* L. in *Icones Plantarum Rariorum*, Vol. I., Plate 121 (Jacquin 1781-1786).

Figure 2. *Thlaspi alliaceum* in Murray Co., Georgia (*Thompson & Threadgill 13-114*, NCU).

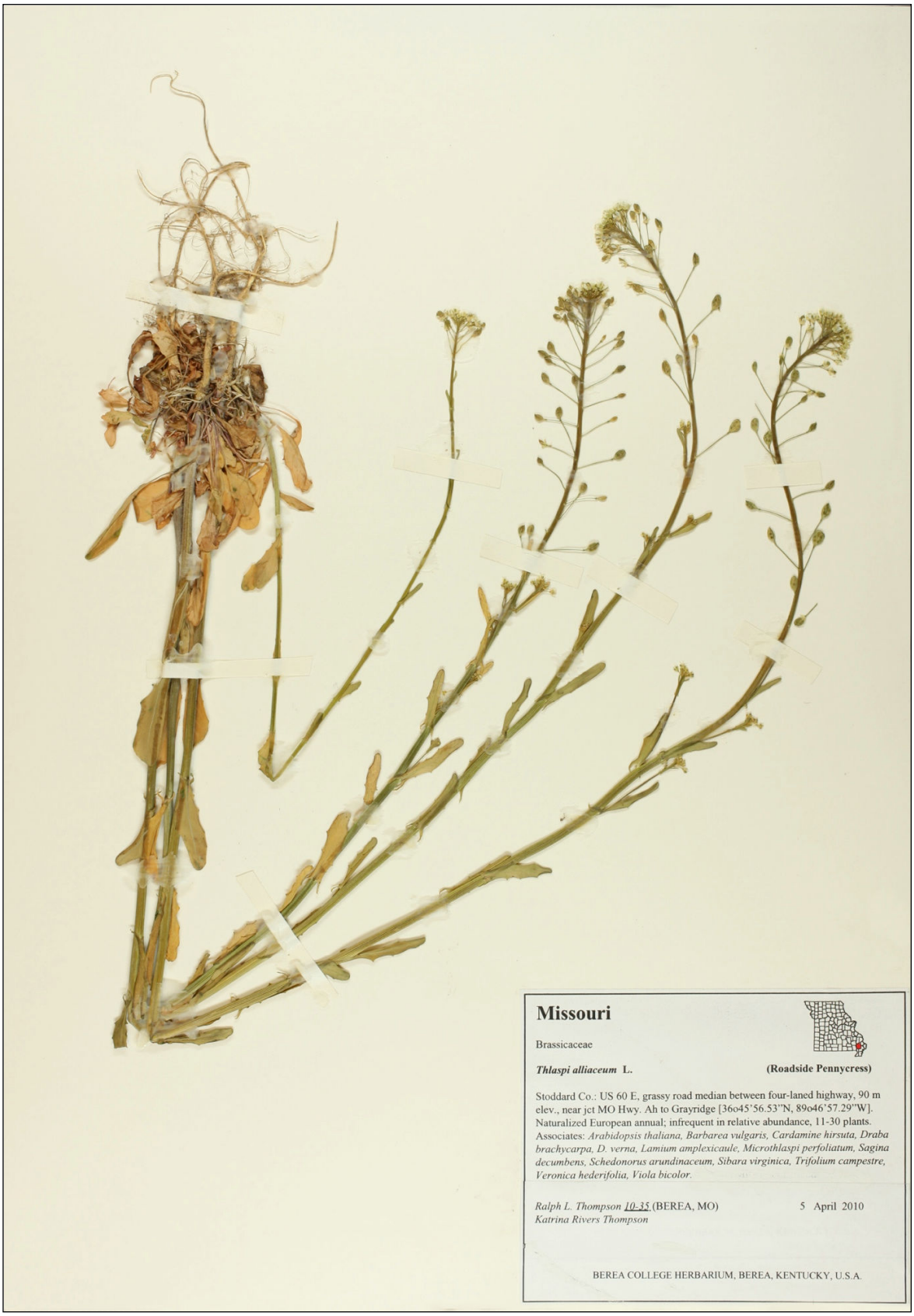

Figure 3. *Thlaspi alliaceum* in Stoddard Co., Missouri (*Thompson & Rivers Thompson 10-35*, NCU).

Figure 4. *Thlaspi alliaceum*, the North American record in Rockingham Co., North Carolina (*Ahles 10757*, NCU).

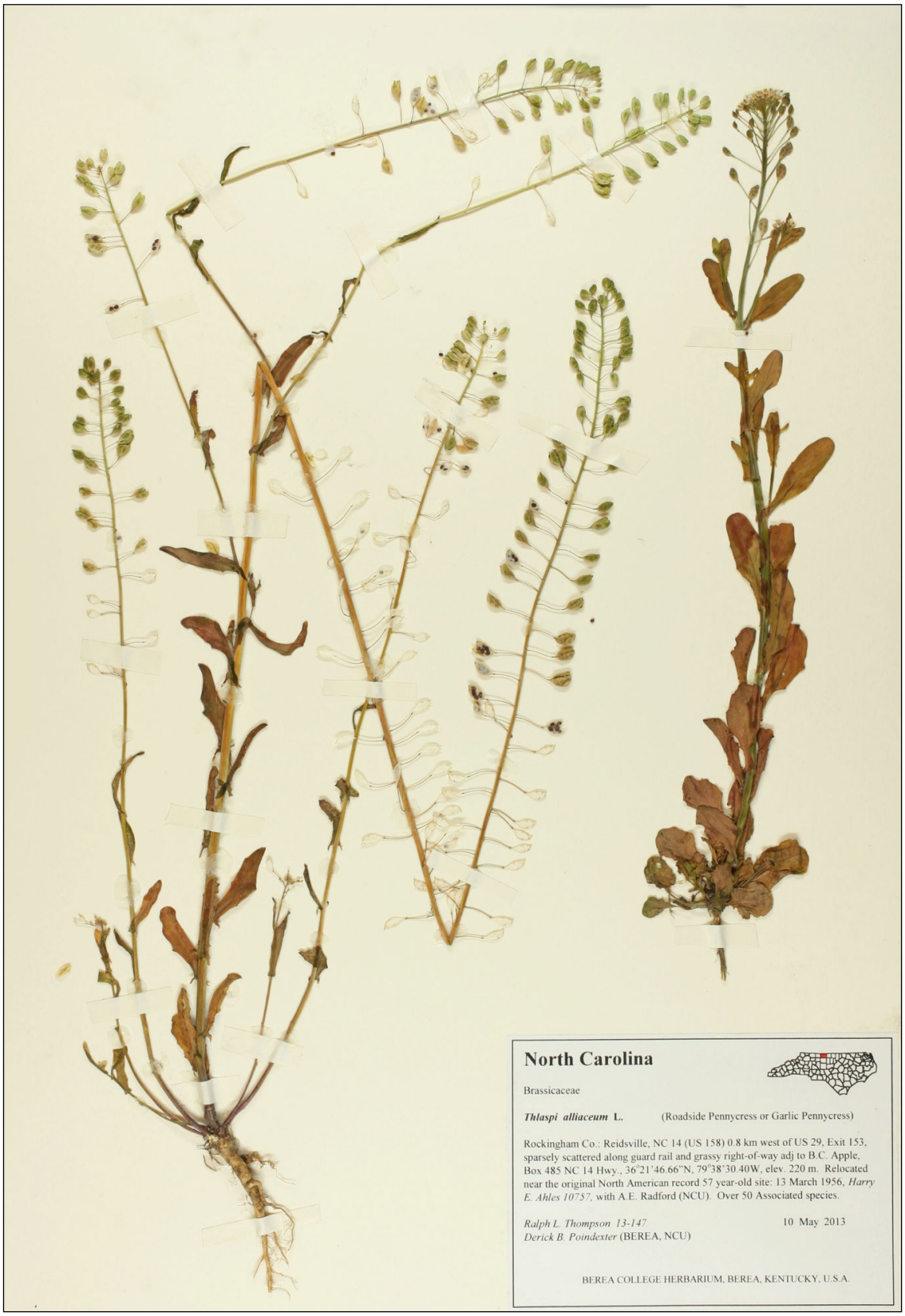

Figure 5. *Thlaspi alliaceum*, rediscovered in Rockingham Co., North Carolina (*Thompson & Poindexter 13-147*, NCU).

Al-Shehbaz (2010) added West Virginia from voucher specimens collected in seven West Virginia counties dot-mapped by Harmon et al. (2006). The distribution is mapped for all 12 states by BONAP (2013).

Kentucky provides an excellent example of the rapid spread of roadside penny-cress. In 1982, John W. Thieret documented the first Kentucky records in Pike and Harrison counties (Thieret & Baird 1985). Thompson and Rivers Thompson (2009) surveyed all 120 Kentucky counties for *Thlaspi alliaceum* during 2005-2009 and collected vouchers in 116/120 counties. Seventy-eight associated species (a characteristic assemblage of taxa with similar habit and habitats) were recorded among the 116 counties. Fifty-nine were naturalized exotics, of which 24 were Kentucky-listed invasive species at the time. Roadside penny-cress should be monitored as an invasive pest plant based upon its rapid spread in the eastern USA (Thompson & Rivers Thompson 2009). The plant was recently classified as a "significant threat" invasive exotic pest plant in Kentucky (KY-EPPC 2013).

From an ongoing study, *Thlaspi alliaceum* has also been discovered in Georgia as a state distribution record and as range extensions in two additional counties in Missouri, plus six more counties from North Carolina as well as vouchers near the original North American site. Roadside penny-cress populations are described from each of these collection sites, including the occurrence of associated species from relevant label information. Nomenclature for all associated species is based on Weakley (2012). Herbarium acronyms follow *Index Herbariorum* from Thiers (2013).

Georgia *Thlaspi alliaceum* record

The new Georgia state distribution record for *Thlaspi alliaceum* was discovered in Eton, Murray County, in northwestern Georgia, a part of the Southern Appalachian Ridge and Valley Province bordering extreme southeastern Polk County, Tennessee. The Georgia habitat was at the edge of a grass-dominated fallow field adjacent to the road shoulder of US 411 (GA 61). Very few young spindly plants were present among 22 associated species comprising 21 naturalized annual and perennial herbs and one native violet. Label data for the Georgia site (Figure 2) are as follows:

Vouchers. **Georgia.** Murray Co.: Eton, 70 mi S of Eton southern city limits welcome sign, on left side of US 411 N (GA 61), across from Orion Carpets. Elev. 220 m, 39°49'3.18"N, 84°45'55.55"W. In a grassy fallow field at road shoulder edge, naturalized European annual, rare; only spindly plants found. Associated species mainly of naturalized annual taxa and a few native weeds: *Allium vineale, Cardamine hirsuta, Cerastium glomeratum, Dactylis glomerata, Galium aparine, G. pedemontanum, Lamium amplexicaule, L. purpureum, Plantago lanceolata, Poa pratensis, Schedonorus arundinaceus, Sherardia arvensis, Stellaria media, Taraxacum officinale, Thlaspi arvensis, Trifolium pratense, T. repens, Veronica arvensis, V. hederifolia, V. persica, Vicia sativa* ssp. *nigra, Viola bicolor*. *Georgia distribution record, 7 Apr 2013, *R.L. Thompson* & *P.F. Threadgill 13-114* (BEREA, GA, NCU).

The Georgia seed source may have possibly spread and colonized the Murray County site from an extant population in adjacent Polk County, Tennessee. The ruderal habitats and associates from Georgia and the Tennessee site were quite similar with 11/21 common taxa. It is conceivable slipstreaming migration of diaspores could have occurred along US 411 (GA 61-TN 33). Label data from the Polk County collection are included below:

Vouchers. **Tennessee**. Polk Co.: US 411 N (TN 33) on left road shoulder edge and shallow ditch by telephone pole entangled with *Lonicera japonica*, 30 mi S of Busted Creek Road, at mile marker 1, N of boundary to Murray Co., Georgia. Elev. 254 m, 35°0'15.75N, 84°43'55.38"W. Naturalized European annual, occasional, ca. 30-40 plants in various phenological flowering phases.

Associates: *Allium vineale*, *Brassica rapa, Buglossoides arvensis, Capsella bursa-pastoris, Cardamine hirsuta, Chaerophyllum tainturieri, Galium aparine, G. pedemontanum, Geranium carolinianum, Lamium amplexicaule, L. purpureum, Microthlaspi perfoliatum, Sherardia arvensis, Taraxacum officinale, Veronica persica*, and *Viola bicolor* interspersed among *Schedonorus arundinaceus*, 7 Apr 2013, *R.L. Thompson & P.F. Threadgill 13-108* (BEREA, GA, MO, NCU, TENN).

Missouri *Thlaspi alliaceum* records

Thlaspi alliaceum was first documented as a Missouri distribution record in 2001 on a floodplain near St. Joseph in the Dissected Till Plain of Platte County in WNW Missouri (Tenaglia & Yatskievych 2002). In 2007, a second collection of roadside penny-cress was made from a grassland in Andrew County, the second Missouri county to the north of Platte County. Yatskievych (2006) remarked that roadside penny-cress was to be expected at other Missouri sites in the future. These two previous Missouri databased collections (Tropicos 2013) are as follows:

Vouchers. **Missouri**. Andrew Co.: Found in CRP (Conservation Reserve Program) grassland in large clumps, ca. 4.5 mi N of Savannah on County Highway C, 28 Apr 2007, *N.W. Cole 10* (UMO!). Platte Co.: Dr. Frederick Marshall Conservation Area, on W side of Platte River ca. 2 air mi E of East Leavenworth, abundant in flat open floodplain area; corollas white, mostly past flowering, 6 May 2001, *D. Tenaglia s.n.* (MO!).

The third (Figure 3) and fourth Missouri counties in the Bootheel Region were documented during the spring of 2010 along US 60 E within the Southeastern Lowlands of the Mississippi Alluvial Coastal Plain. Label data are included below:

Vouchers. **Missouri**. New Madrid Co.: US 60 E, grassy road median in shallow ditch between four-laned highway adjacent to gravel-asphalted turn-around area between MO Hwy E and MO Hwy F, past Morehouse. Elev. 91 m, 36°50'18.57"N, 89°39'42.67"W. Naturalized European annual in full flower and silicles; infrequent in relative abundance, ca. 11-30 plants. Associates: *Arabidopsis thaliana, Barbarea vulgaris, Brassica rapa, Bromus commutatus, B. tectorum, Capsella bursa-pastoris, Cardamine hirsuta, Draba verna, Lamium amplexicaule, L. purpureum, Medicago lupulina, Microthlaspi perfoliatum, Viola bicolor*. *Fourth Missouri voucher, 5 Apr 2010, *R.L. Thompson & K. Rivers Thompson 10-56* (BEREA, MO, NCU). Stoddard Co.: US 60 E, grassy road median between four-laned highway near junction MO Hwy Ah, to Grayridge. Elev. 90 m, 36°45'56.53"N, 89°46'57.29"W. Naturalized European annual; infrequent in relative abundance, 11-30 plants. Associates: *Arabidopsis thaliana, Barbarea vulgaris, Cardamine hirsuta, Draba brachycarpa, D. verna, Lamium amplexicaule, Microthlaspi perfoliatum, Sagina decumbens, Schedonorus arundinaceus, Sibara virginica, Trifolium campestre, Veronica hederifolia, Viola bicolor*. *Third Missouri voucher, 5 Apr 2010, *R.L. Thompson & K. Rivers Thompson 10-35* (BEREA, MO, NCU).

North Carolina *Thlaspi alliaceum* records

The first North American distribution record of roadside penny-cress was a collection by Harry E. Ahles in Rockingham County, North Carolina (Figure 4), and it remained the only documented North Carolina county for *Thlaspi alliaceum* until our survey. The voucher listed in Radford et al. (1968) is represented by the following data:

Voucher. **North Carolina.** Rockingham Co.: Weed in field and adjacent roadside, 3.1 mi N of Reidsville on NC Rt. 14, 13 Mar 1956, *H.E. Ahles 10757 with A.E. Radford* (NCU!).

Reconnaissances were focused along interstate highways and paved roads in the Blue Ridge Mountains and the Piedmont Regions of North Carolina during April 2012 and May 2013. Seven North Carolina counties in sequence of roadside penny-cress collections were Haywood, Buncombe, Alleghany, Orange, Yadkin, Madison, and Rockingham. Poindexter (2013) included his Alleghany collection voucher in the annotated checklist of the recent Alleghany County flora. The special effort to document roadside penny-cress at or near the original 1956 collection site near Reidsville in Rockingham County was successful (Figure 5). Label data for specimens from these seven counties are these:

Vouchers. **North Carolina**. Alleghany Co.: Piney Creek Township, Piney Creek. Located along NC 93, ca. 0.1 mi S of the Virginia border. Only a few individuals were noted growing along the roadside margin. Apparently introduced from mowing operations, and more prominently established along VA 58 to the north of this site. This species will undoubtedly become an agricultural nuisance in the county with time. Associates: *Anthoxanthum odoratum, Poa annua, P. pratensis, Polygonum aviculare, Schedonorus arundinaceus, Stellaria media, Taraxacum officinale, Trifolium repens*, rare, exotic annual forb/herb. GPS: 36.573677°N; 81.307237W°, elev. 804 m, 28 Apr 2012, *D.B. Poindexter 12-15 with A.T., A.B., and C.T. Poindexter* (BEREA, BOON, NCU). Buncombe Co.: Ashville, I-40 W, at mile marker 47.5 just E of Exit 47, a scattered colony along unmowed grassy road shoulder adjacent and under NC Arboretum and Farmers Market green information sign. Elev. 652 m, 35°31'59.00"N, 82°35'0.50"W. Naturalized European annual, infrequent, 11-25 scattered colonies. Associates: *Alliaria petiolata, Allium vineale, Anthoxanthum odoratum, Barbarea vulgaris, Dactylis glomerata, Geranium carolinianum, Lamium purpureum, Lepidium campestre, L. virginicum, Lonicera japonica, Poa annua, P. pratensis, Rumex crispus, Schedonorus arundinaceus, Senecio vulgaris, Taraxacum officinale*. Garlic penny-cress found also at Exit 44. *Buncombe County voucher, 8 Apr 2012, *R.L. Thompson & K. Rivers Thompson 12-133* (BEREA, MO, NCU). Buncombe Co.: Ashville, I-40 W, at mile marker 47.5, a scattered along unmowed grassy road shoulder and woodland edge by NC Arboretum and Farmers Market green information sign. Elev. 652 m, 35°31'59.00"N, 82°35'0.50"W. *Second collection from 2012 site, now occasional, 70-100 senescing plants. Associates: *Anthoxanthum odoratum, Barbarea vulgaris, Bromus commutatus, Buglossoides arvensis, Dactylis glomerata, Geranium carolinianum, Hordeum pusillum, Lamium purpureum, Lonicera japonica, Oxalis dillenii, Phytolacca americana, Poa annua, P. pratensis, Ranunculus bulbosus, Schedonorus arundinaceus, Vicia sativa* ssp. *nigra*. Roadside pennycress also present at Exit 37 roadside toward Luther, 13 May 2013, *R.L. Thompson & K. Rivers Thompson 13-158* (BEREA, NCU). Haywood Co.: I-40 E, mile marker 30, 1.6 km to Exit 31 NC 215 to Canton. Elev. 811 m, 35°32'59.80" N; 82°52"48.16" W. Scattered along road margin and road shoulder in grassy road ballast by guard railing. Naturalized European annual, infrequent, 15-20 scattered plants. Associates: *Allium vineale, Bromus commutatus, Cardamine hirsuta, Geranium carolinianum, Lamium purpureum, Lepidium virginicum, Plantago lanceolata, Poa annua, Schedonorus arundinaceus, Senecio vulgaris, Stellaria media, Taraxacum officinale.* *Haywood Co. voucher, 6 Apr 2012, *R.L. Thompson & K. Rivers Thompson 12-128* (BEREA, MO, NCU). Haywood Co.: I-40 W, Exit 20 along interstate shoulder right-of-way to Maggie Valley by Jonathan Creek Road (NC 276). Elev. 842 m, 35°35'58.44"N, 83°0'14.39"W. Naturalized European annual, occasional, 40-60 individual plants. Associates: *Allium vineale, Anthoxanthum odoratum, Barbarea vulgaris, Capsella bursa-pastoris, Cerastium glomeratum, Dactylis glomerata, Daucus carota, Galium aparine, Geranium carolinianum, Lamium purpureum, Lepidium campestre, Leucanthemum vulgare, Plantago lanceolata, P. rugelii, Poa pratensis, Schedonorus arundinaceus, Senecio vulgaris, Stellaria media, Taraxacum officinale.* *Second Haywood Co. voucher, 8 Apr 2012, *R.L. Thompson & K. Rivers Thompson 12-141* (BEREA, NCU). Madison Co.: I-26 E, 2.0 km south of North Carolina Welcome Center, ca. mile marker 7, overpass embankment of Higgins Branch Road junction Jaruis Branch Road to Mars Hill and interstate road shoulder behind guard railing. Elev. 693 m, 35°50'51.54"N, 82°31'34.69W. Scattered, occasional, ca. 80-100 senescing plants. Associates:

Anthoxanthum odoratum, Barbarea vulgaris, Cerastium glomeratum, Dactylis glomerata, Galium aparine, Holcus lanatus, Lamium purpureum, Poa pratensis, Rumex crispus, Schedonorus arundinaceus, Securigera varia, Sonchus asper, Valerianella radiata, Verbascum thapsus, Vicia sativa ssp. *nigra*. *Madison Co. voucher, 9 May 2013, *R.L. Thompson & K. Rivers Thompson 13-133* (BEREA, MO, NCU). Orange Co.: Along US 40, at Exit 263 (New Hope Church Rd.), growing along interstate near guardrails and in intervening areas, uncommon and patchy between Exits 262 and 263. Associates: *Cardamine hirsuta, Trifolium campestre, Medicago lupulina, Nuttallanthus canadensis, Schedonorus arundinaceus,* and *Vicia sativa* ssp. *nigra*. GPS: 36.014189°N, 79.086022°W, elev. 160 m, Naturalized exotic, 5 Apr 2013, *D.B. Poindexter 13-09* (BEREA, NCU). Rockingham Co.: Reidsville, NC 14 (US 158) 0.8 km W of US 29, Exit 153, sparsely scattered along guard rail and grassy right-of-way adjacent to residence of B.C. Apple, 485 NC 14 Hwy. Elev. 220 m, 36°21'46.66"N, 79°38'30.40W. *Located near the original 57-year-old site with 51 associated species, 10 May 2013, *R.L. Thompson & D.B. Poindexter 13-147* (BEREA, MO, NCU). Yadkin Co.: Along US 77, ca. 2.3 mi N of the junction with NC 421, growing along mowed interstate roadsides. Occasional, naturalized exotic. Associates: *Cardamine hirsuta, Trifolium dubium, Schedonorus arundinaceus, Securigera varia,* and *Vicia villosa*. GPS: 36.15605531°N, 80.8078265°W, elev. 328 m, 7 Apr 2013, *D.B. Poindexter 13-10* (BEREA, NCU).

The 51 associated species at the Rockingham County collection site were as follows: *Allium vineale, Ambrosia artemisiifolia, Anthoxanthum odoratum, Aphanes microcarpa, Artemisia vulgare, Barbarea verna, Bidens frondosa, Bromus hordeaceus, Cerastium brachypetalum, C. glomeratum, Chamaecrista nictitans, Cirsium arvense, Cyperus* sp., *Dactylis glomerata, Erigeron annuus, Eupatorium capillifolium, Galium pedamontanum, Geranium carolinianum, Holcus lanatus, Hordeum pusillum, Hypochoeris radicata, Lactuca* sp., *Lamium purpureum, Lepidium virginicum, Lespedeza cuneata, Leucanthemum vulgare, Myosotis verna, Nuttallanthus canadensis, Oenothera biennis, O. laciniata, Plantago lanceolata, P. virginica, Poa annua, P. pratensis, Ranunculus bulbosus, R. parviflorus, Raphanus raphanistrum, Rumex acetosella, R. obtusifolius, Schedonorus arundinaceus, Senecio vulgaris, Sonchus asper, Taraxacum officinale, Trifolium campestre, T. dubium, Triodanis perfoliata, Triticum aestivum, Valerianella radiata, Veronica arvensis, Vicia sativa* ssp. *nigra,* and *Vulpia myuros*.

A total of 24 associated species present at Rockingham County were found among the six other North Carolina counties. In addition, 20 herbaceous associates from the other six North Carolina counties were not present at the Rockingham County site. These 20 taxa were *Alliaria petiolata, Barbarea vulgaris, Bromus commutatus, Buglossoides arvensis, Capsella bursa-pastoris, Cardamine hirsuta, Daucus carota, Galium aparine, Lepidium campestre, Medicago lupulina, Oxalis dillenii, Phytolacca americana, Plantago rugelii, Polygonum aviculare, Rumex crispus, Securigera varia, Stellaria media, Trifolium repens, Verbascum thapsus,* and *Vicia villosa*.

The top 10 associates or characteristic species extant among these seven counties (Alleghany, Buncombe, Haywood, Madison, Orange, Rockingham, and Yadkin) were all naturalized taxa: *Schedonorus arundinaceus* (6/7 counties), *Anthoxanthum odoratum, Poa pratensis,* and *Taraxacum officinale* (5/7 counties), and *Allium vineale, Cardamine hirsuta, Dactylis glomerata, Lamium purpureum, Poa annua,* and *Vicia sativa* subsp. *nigra* (4/7 counties).

More associated species in common would undoubtedly have been listed for specimens from these seven counties if only April collection periods had been made. Several earlier flowering associates at Rockingham and Madison counties had disappeared when *Thlaspi alliaceum* was collected in May. Conversely, later spring flowering taxa in May were not noted in April. Moreover, taxonomists are rather subjective in their choice of listing associated species over any given conditions in time.

The new record of *Thlaspi alliaceum* in Georgia, two more counties in Missouri, and six additional counties in North Carolina are confirmation of the continual spread of this naturalized European annual. Based on its present range in the eastern USA, other county and state reports will be forthcoming in the near future. *Thlaspi alliaceum* is more prominent in certain ruderal and culturally derived habitats and is expected to be associated with certain other non-native and native species with similar phenological life cycles and ecological adaptations. The presence of certain associated or characteristic species, especially in the Asteraceae, Brassicaceae, Fabaceae, and Poaceae, served as important indicators for the *T. alliaceum* populations among other naturalized species.

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