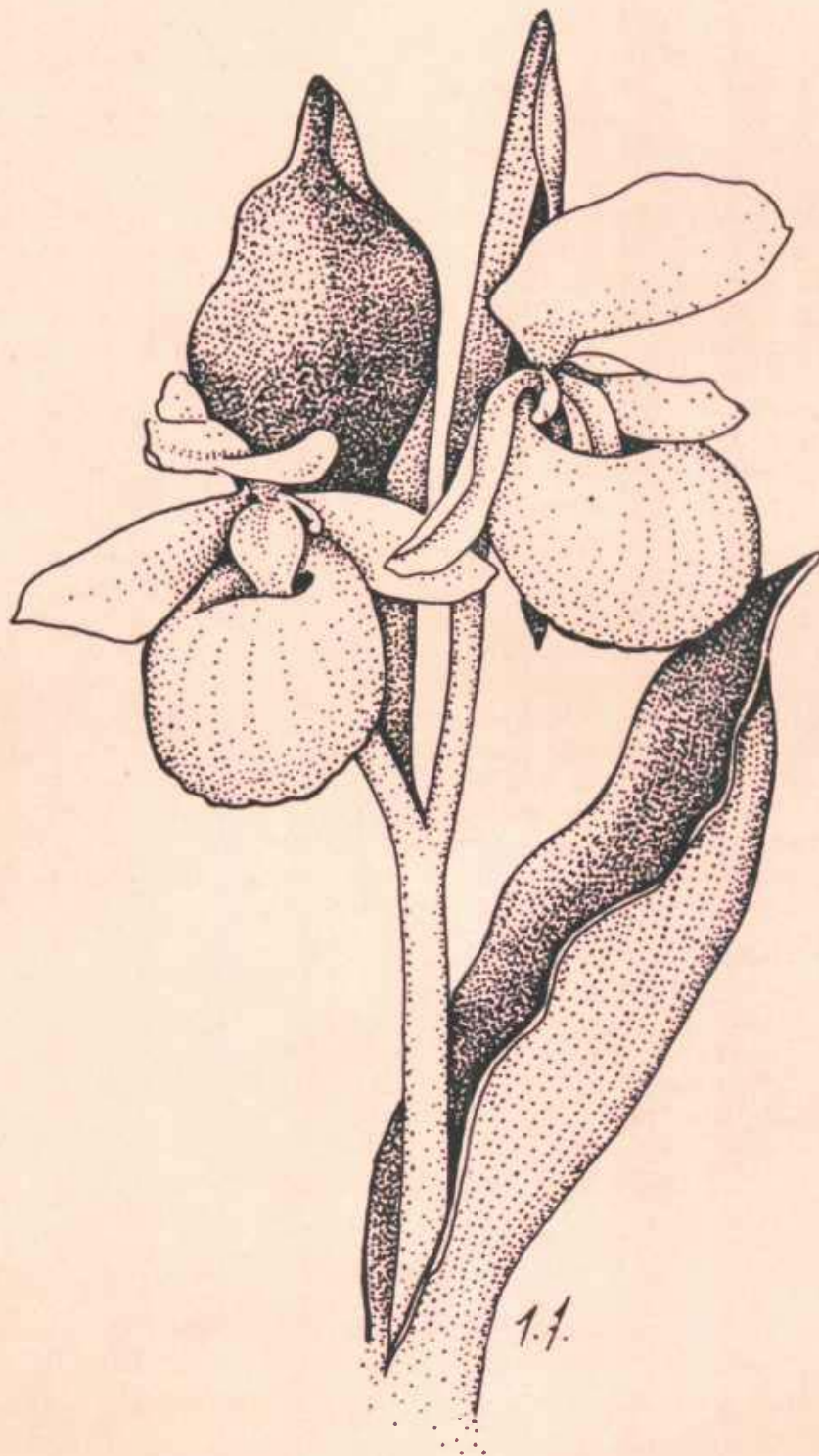


# Rhodora

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THE INTRODUCTION AND SPREAD OF  
*VERONICA BECCABUNGA* (SCROPHULARIACEAE)  
IN EASTERN NORTH AMERICA

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ABSTRACT

*Veronica beccabunga* L., indigenous to Eurasia, was introduced into North America toward the latter part of the nineteenth century. Originally confined to the East Coast of the United States, the range of the species has expanded to include seven states and two Canadian provinces. Historical evidence implicates ballast disposal in the initial introduction of the species, although multiple introductions may have occurred. Compared with other non-indigenous aquatic plants, the spread of *V. beccabunga* has been slower and less conspicuous. Interspecific competition with the native flora may have kept the progress of the species in check. The presently known distribution of *V. beccabunga* is mapped for North America. The species is dispersed mainly by plant fragments dislodged during periods of high water flow.

Key Words: *Veronica beccabunga*, European Brooklime, introduced aquatic, dispersal, North America

The European Brooklime, *Veronica beccabunga* L. (Scrophulariaceae), is one of about 12 aquatic species constituting section *Beccabunga* Dumort. of the genus (Cook, et al., 1974; Ozturk & Fischer, 1982). According to Smith (1823), the curious epithet "beccabunga" is derived from the German "Bach-pungen," Bach ("beck") meaning "rivulet" in English and referring to the usual habitat of the species. Fischer (1981) recognized three allopatric Eurasian subspecies of *V. beccabunga* [ssp. *beccabunga*, ssp. *abscondita* M. A. Fischer, and ssp. *muscosa* (Korsh.) A. Jelen], each occurring within a well-defined geographical region. *Veronica beccabunga* (Figure 1) is widespread in Europe (Pennell, 1921) where it commonly inhabits upper stream reaches of various substrate compositions (Haslam, 1978). Prior to 1870, European Brooklime (hereinafter E. Brooklime) was not known to occur in North America. The closely related native species *Veronica americana* (Raf.) Schwein., however, is as widespread in North America as *V. beccabunga* is in Europe (Pennell, 1921).

Specimens of *Veronica beccabunga* collected in New Jersey by Schrenk in 1876 provide the earliest evidence of the species in North America. Since that time, collections of E. Brooklime have been made throughout many parts of the eastern United States and

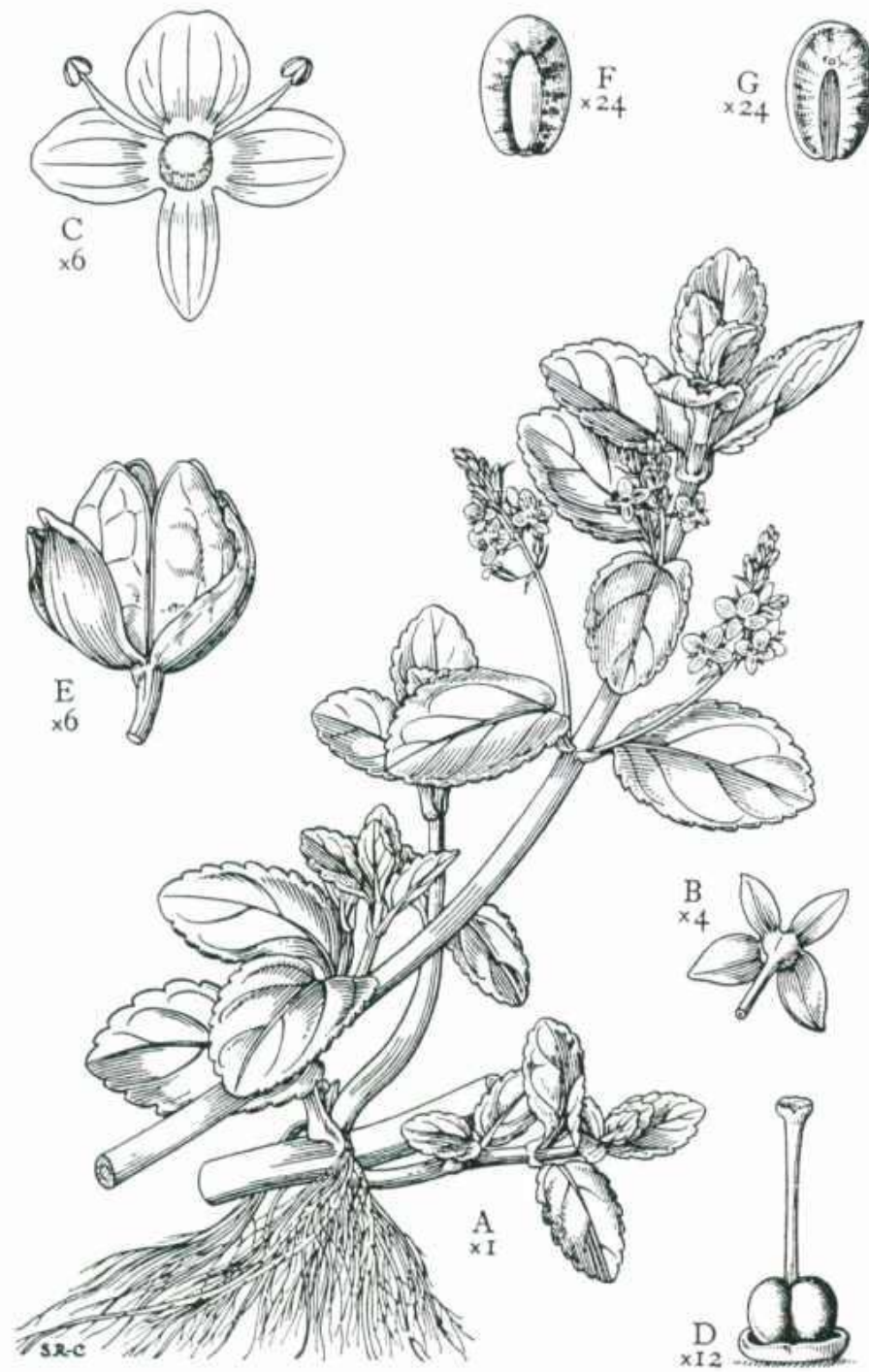


Figure 1. Habit of *Veronica beccabunga* L. A. lower and upper parts of a flowering stem—an internode and two branches cut out; B. calyx; C. corolla and stamens; D. gynoecium and disc; E. fruit; F-G. seed in two views. Figure and caption from Ross-Craig (1979); used with permission from Bell and Hyman, Ltd.

Canada. In 1982, the authors collected specimens of *V. beccabunga* at several localities in central Ohio; these specimens constituted the first state records of the species known at that time. Discovery of these new localities indicates that the range of E. Brooklime in North America is continuing to expand. This discovery provided the impetus for us to investigate further the distributional history of this species in North America.

#### MIGRATORY PATTERNS

Pennell (1921) listed *Veronica beccabunga* as occurring only in Quebec, New York, and New Jersey. Later works by Pennell (1935), Muenscher (1944), Groh (1946), Dore and Gillett (1955), Voss (1957), and Rosseau (1968) included additional records of the species in Ontario, Michigan, Pennsylvania and West Virginia. Mason (1957), Stodola (1967), and Sellers (pers. comm.) have recorded E. Brooklime (subsp. *beccabunga*) on the West Coast of North America (California and British Columbia), but these localities will not be considered in detail here. Using published reports as a guide, a list of the presently known localities for *V. beccabunga* was compiled. Voucher specimens for most sites reported in the literature were located in several regional herbaria (ALBC, CU, DAO, HAM, MICH, MO, NY, NYS, OS, PENN, PH) and constitute the sites listed on our maps. The verified localities were arranged chronologically (*see* Appendix) and then mapped for three time periods based upon dates of collection: 1) specimens collected before 1900, 2) specimens collected 1900–1940, and 3) specimens collected 1940–1985 (Figure 2). This technique provides an interpretation of the spread of the species in terms of time (years elapsed between new collection sites) and degree (number of new sites per time interval). The resulting pattern (Figure 2) is one of a general northward and westward movement from a point of origin near the harbor district of New York City. Similar patterns have been observed for several other foreign aquatic and wetland species such as *Lythrum salicaria*, *Lycopus europaeus*, and *Rorippa sylvestris* (Stuckey, 1966; Stuckey, 1980; Stuckey & Phillips, 1970). In the case of *V. beccabunga*, however, the spread has not been nearly as rapid or as conspicuous as that noted for “weedy” species such as *Lythrum salicaria*. Unlike many foreign aquatic weeds, *V. beccabunga* does not do well in lentic environments, but requires colder, more oxygen-rich waters of streams, brooks, and springs (Aichele, 1976; Stodola, 1967).

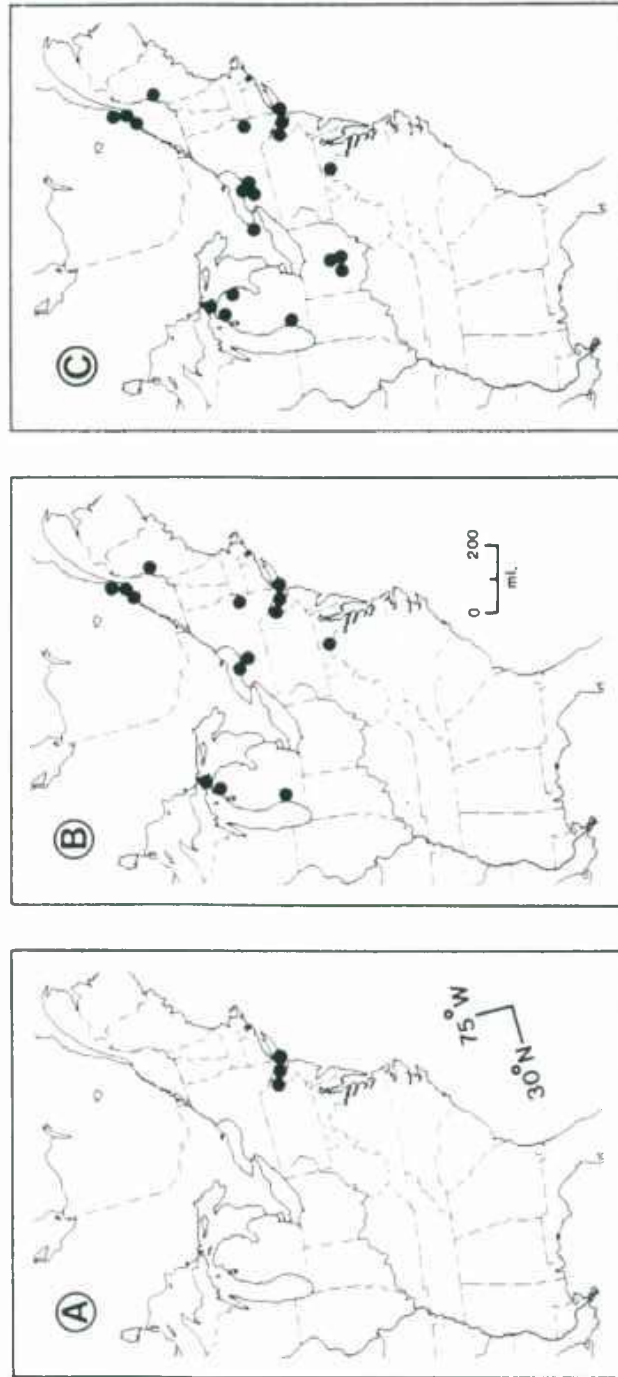


Figure 2. The distribution of *Veronica beccabunga* in eastern North America during three consecutive time intervals. A. distribution before 1900; B. distribution from 1900-1940; C. distribution from 1940-1985. Vouchers for mapped sites are listed in Appendix.

The slower migration of E. Brooklime may be due to its affinity for undisturbed habitats where native species such as *Veronica americana* are already established. Because both *V. americana* and *V. beccabunga* are essentially equivalent ecologically (Marie-Victorin, 1935), it would be difficult for E. Brooklime to become established under such circumstances. Our finding of *V. beccabunga* in two localities of undisturbed vegetation in Ohio supports this hypothesis; in both of these areas *V. americana* does not occur. Furthermore, *V. beccabunga* was found at three sites within Clark and Delaware counties, Ohio in which *V. americana* is not known to occur. (See map of *V. americana* in Bentz & Cooperrider, 1978.) The absence of the native species presumably opened a vacant niche in which invading plants of E. Brooklime could become established. It would be informative to carry out experiments to determine which of these two species is the better competitor for newly opened habitats, and whether there are differences in their relative dispersal efficiency. Observations regarding habitats occupied by *V. beccabunga* were made by Groh (1946, p. 47) who remarked, "like its nearest American ally, *V. americana* Schwein., it [*V. beccabunga*] is confined mostly to ditches and muddy shores where it is of little account as a weed." However, the species has been noted as weedy in Ontario by Dore and Gillett (1955, p. 82) who reported it to be "choking Hopple Creek" near Wales. If habitat competition is indeed a factor regulating the migration of E. Brooklime, then one would expect its progress to be as slow as our maps indicate. However, opportunistic establishment could eventually expand the range of *V. beccabunga* to equal that of *V. americana* (map in Muenscher, 1944, p. 318). Such has been the case with *V. anagallis-aquatica*, another non-indigenous Eurasian species (map in Muenscher, 1944, p. 318).

#### POSSIBLE MEANS AND SITES OF INTRODUCTION

Although the name *Veronica beccabunga* appears in several older manuals (e.g., Pursh, 1814), these records refer to *V. americana*, which was not regarded as distinct taxonomically from the European plants until 1830. The earliest records of bona fide *V. beccabunga* are from the East Coast of the United States (see Appendix). Propagules were probably first brought into this region in ship ballast as it was disposed of at ports. This method has been implicated

in the introduction of *Lycopus europaeus* into North America (Stuckey & Phillips, 1970). Evidence for a similar introduction of E. Brooklime is an early specimen [Schrenk, s.n. (NY)] collected in 1880 from a ballast site in New York. Brown (1879) discovered plants of *V. beccabunga* in such disposal sites in New York which had (p. 355) "undoubtedly sprung from seeds introduced with ballast." He also indicated that the species was not known to him previously as growing wild in the country.

Brown's (1879) account contained valuable information regarding the importance of ballast disposal as a method of plant introduction. He stated (p. 353) "Never before ... has so much [foreign vegetation] been brought to this country [USA] during the same period as in the past two years [1878-79]." He further commented (p. 353) "... on Gowanus Creek [the site where he first discovered *V. beccabunga*], vessels have for many months past been discharging [ballast] without cessation, night and day." The fact that the oldest collections of E. Brooklime were made within a 100 mile radius of Long Island, New York attests to the likelihood that ballast disposal was responsible for the earliest introduction of the species into North America.

Although plants and seeds of *Veronica beccabunga* were likely to have been dispersed to different sites from the New York City area, some populations of the species may have been established independently. A possibility exists that plants were brought in from Europe with fish stocks and carelessly discarded into watercourses. Mucnscher (1944, p. 318) noted that in the United States, *V. beccabunga* occurs locally "... in spring-fed ponds about fish hatcheries," and Bursche (1971, p. 78) reported that E. Brooklime is "specially valued in trout streams" in Europe. Fish hatcheries were responsible for much of the early spread of another aquatic plant, *Potamogeton crispus*, in North America (Stuckey, 1979).

Voss (1957, p. 29) related information noted on a specimen of *Veronica beccabunga* collected in Emmet Co., Michigan suggesting yet another means by which the species could have spread: "Its location ... is possibly due to seed having been washed in from Lake Michigan, but more likely to having been brought to the Tannery with hides." In any case, hides brought to that tannery would have originated in North America, and contaminating seeds would have effected dispersal of populations already established in the region.

There is also a possibility that whole plants were intentionally brought to North America for use in home aquaria. This explanation is reasonable in light of Muhlberg's (1982, p. 191) comments that "*V.[eronica] beccabunga* has often been used in cold-water aquaria, particularly in early days of aquarium plant cultivation." Because such introductions usually result from the careless disposal of specimens, actual incidents are very difficult to document. We have been unable to find evidence that any introductions of *E. Brooklime* occurred via this route.

We are not certain, therefore, whether the present distribution of *E. Brooklime* in North America is the result of one or of multiple introductions. Although there is fairly good documentation that the initial introduction of the species occurred around Long Island, New York by seeds disposed of in ballast, whole plants brought in with fish hatchery stocks may have been responsible for establishing some of the other sites at which the plant was subsequently found. The presence of disjunct populations on the Pacific Coast also indicates the likelihood of multiple introductions because of the relatively great distance (over 1700 miles) separating the eastern and western North American populations.

#### GEOGRAPHICAL ORIGIN OF NORTH AMERICAN POPULATIONS

In Eurasia, *Veronica beccabunga* is comprised of three vicarious subspecies, a factor which enabled us to trace the geographical origin of plants introduced into North America. Manfred Fischer (1981) and G. Fischer (1981) detailed these distributions, which we summarize as follows: subspecies *muscosa*—Asia, mainly east of Iran; subspecies *abscondita*—Mediterranean and Transcaucasian region; subspecies *beccabunga*—Europe and northwest Turkey. Brown (1879) noted that ballast-introduced species were most often natives of Europe (Britain and Germany) or the Mediterranean region. Specimens of *V. beccabunga* collected in British Columbia, New Jersey, Ohio, Pennsylvania, and Quebec were identified as subspecies *beccabunga* (by Roger Sellers, University of Oklahoma), placing the origin of our plants in Europe rather than in the Mediterranean region where subspecies *abscondita* occurs. Other subspecies of *V. beccabunga* have not yet been found in North America.

It may also be possible to use cytological data to assist in pinpointing actual sites of origin for North American plants. In con-

trast to the native *Veronica americana* which is tetraploid, *V. beccabunga* is usually diploid with the exception of several tetraploid populations of subspecies *beccabunga* in the northern part of its range (Ozturk & Fiseher, 1982). It would be informative to determine whether North American plants are diploid or tetraploid cytotypes. Such data might better clarify the region from which these plants originally came.

#### METHODS OF DISPERSAL

Little information has been published on the biology of *Veronica beccabunga*; in particular, its reproductive biology is not well known. The species is perennial and produces globose, flattened fruits in axillary racemes (Pennell, 1921). Two avenues of dispersal are possible, by seed or by entire plants. Van der Pijl (1982) includes *Veronica* with ombrohydrocharous (rain-wash) dispersed species and suggests that in *V. beccabunga* this method of dispersal may be enhanced by hygrochasy (capsule dehiscence in humid atmospheres). Although these factors may function to promote short-distance dispersal along stream banks, it is unlikely that long-distance dispersal occurs by actual water transport. The seeds of E. Brooklime are not buoyant (Guppy, 1906), and in most *Veronica* species they sink within one minute in fresh water (Praeger, 1913). Although the dynamics of seed movement in flowing waters have not been studied in detail, it is not likely that in *V. beccabunga* seed transport occurs over very great distances. Guppy (1906) observed that seeds of *V. beccabunga* were not represented in floating river drift as were those of characteristically water-dispersed species. In the Index to Ridley (1930), *V. beccabunga* is cited as an example of dispersal by adhesion. Guppy (1906) found that seeds of E. Brooklime form a mucilaginous coating when exposed to water, a feature not occurring in other species of the genus that he examined. The formation of mucilaginous seeds in E. Brooklime is circumstantial evidence for dispersal by adhesion.

Ridley (1930) referred to *Veronica beccabunga* as an example of a water-dispersed plant of riparian habitats that produces non-buoyant seeds. He accounted for the abundance of E. Brooklime along watercourses by its ability to grow rapidly from detached branches when stranded on river banks. Ridley observed this form

of dispersal in *V. beccabunga* in various English river systems. Plants of *V. beccabunga* are tolerant to drying apparently because of their ability to produce terrestrial forms along shores and other drying habitats (Stodola, 1967). Haslam (1978) remarked that *V. beccabunga* is a species characteristically uprooted during storm damage, and possesses the ability to recover quickly from such events. *Veronica* species can also exploit temporary habitats of silt deposition along stream banks where coarse substrates ordinarily prevent plant establishment (Haslam, 1978).

#### CONCLUSIONS

*Veronica beccabunga* was introduced into eastern North America near New York City in the late nineteenth century as a result of ballast disposal. The species spread westward through the dispersal of seeds and plant fragments. Separate introductions of plants from contaminated fish hatchery stocks may also have influenced the present distribution of the species. The rate by which E. Brooklime has spread in North America is slow in comparison to that of other non-indigenous aquatic plants and has probably been governed by competition with native plant species. Plants introduced into North America originated in Europe and belong to subspecies *beccabunga*. *Veronica beccabunga* is dispersed along rivers as fragments broken off from plants during storms or other periods of rapid current flow. Although the spread of E. Brooklime has not been as aggressive as that characteristic of weedy species, its distribution deserves further observation.

#### ACKNOWLEDGMENTS

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#### APPENDIX

A chronology of collections of *Veronica beccabunga* made in eastern North America from 1876-1985

#### Collections prior to 1900

NEW JERSEY: Hudson Co.: Bergen Tunnel, Aug., 1876. *Schrenk s.n.* (NY). NEW YORK: Kings Co.: A. Brown *In: Torr. Club Bull.* 6: 358. 1879 (actual specimen not seen). NEW YORK: Hunter's Point, L[ong] I[sland] (ballast), 17 July, 1880, *Schrenk s.n.* (MO). PENNSYLVANIA: Northampton Co.: In cold, shaded rivulets on the shore of the Delaware, 1 mi. above Easton, 5 Oct., 1891, *Porter s.n.* (NY).

#### Collections from 1900 to 1940

QUEBEC: wet ground, St. Lawrence River, 10 July, 1905, *Churchill* 72 (MO). NEW YORK: Monroe Co.: Irondequoit, wet meadow,

Sept., 1915, *Baxter s.n.* (NY). NEW YORK: Monroe Co.: Irondequoit, wet meadows, 5 Sept., 1916, *Baxter 13* (NYS). NEW YORK: Monroe Co.: moist fields near Rochester, Oct. 10, 1916, *Baxter s.n.* (NYS). NEW YORK: Monroe Co.: Densmore Creek, Sept., 1917, *Baxter s.n.* (NYS). QUEBEC: Greves intercotidales de Beauport, 8 Aug., 1922, *Rolland 16204* (NY). MICHIGAN: Emmet Co.: Tannery Creek where it empties into Little Traverse Bay, 1924, *Fallass s.n.* (ALBC). QUEBEC: Murray Bay [La Malbaie], 1929, *Groh s.n.* (DAO). WEST VIRGINIA: Jefferson Co.: Harper's Ferry, 20 Aug., 1931, *Core s.n.* (NY). QUEBEC: Quebec Co.: Sillery, lieux sourceux au pied des caps, 30 July, 1933, *Marie-Victorin, et al. 45243* (PH). QUEBEC: 1934, *Groh s.n.* (DAO). MICHIGAN: Mackinac Co.: in shallow water, beach of Lake Huron, Mackinac Island, 28 July, 1935, *Gleason s.n.* (MICH, NY). NEW YORK: Rensselaer Co.: springy bank N. of Rensselaer, 4 Sept., 1936, *House 24065* (NY). MAINE: Somerset Co.: in muddy place on trickle from cold spring roadside north of Macomber, Aug. 31, 1937, *True 4462* (PENN). MICHIGAN: Kent Co.: Crooked Lake, Grattan Twp. sec. 20, 18 May, 1939. *Marcelline 1351* (MICH).

#### Collections from 1940 to 1985

NEW YORK: Livingston Co.: in spring brook, Caledonia, 13 June, 1942, *Muenschler, et al. 20472* (CU). ONTARIO: Wentworth Co.: S. area 20, trampled bank of canal at bridge [Royal Botanic Gardens, Dundas], 7 Aug., 1954, *Tamsalu 5120* (HAM). MICHIGAN: Alcona Co.: T27N, R9E, sec. 24, 12 July, 1958, *Gehring s.n.* (MICH). OHIO: Clark Co.: Moorefield Twp., SE 1/4 sec. 5, uncommon along creek in floating mats; ca. 10 miles NE of Springfield at the intersection of St. Rt. 4 and Mumper Rd. (169), 24 October, 1970, *Roberts 902* (os). QUEBEC: Quebec Co.: Lorretteville, Rang St-Jacques, sur escarpement de la riviere pres du blvd Honore Mercier, 16 June, 1971, *Perras 71-156* (os). OHIO: Franklin Co.: infrequent on mudflat of small island in Olentangy River just SE of Fawcett Center, 29 Oct., 1982, *Les 331* (os). OHIO: Franklin Co.: infrequent in low depression between bicycle path and west bank of Olentangy River, just north of Bethel Rd., 31 Oct., 1982, *Les 332* (os). OHIO: Franklin Co.: infrequent in low depressions and along muddy banks of Olentangy River, due east of lake in Antrim Park, 3 Nov., 1982, *Les 333 & Stuckey s.n.* (os). OHIO: Clark Co.: Prairie Rd. fen, SE of

intersection of old SR-4 and Prairie Rd., 15 Oct., 1983, *Les 350* (os).  
OHIO: Delaware Co.: Blue Limestone Park, Delaware, occasional  
in spring flowing through park, 26 Feb., 1984, *Les 354* (os).