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Management of the Viburnum Leaf Beetle at the Morris Arboretum

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An independent study project report by The John J. Willaman & Martha Haas Valentine Endowed Plant Protection Intern (2016-2017)

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Abstract
Pyrrhalta viburni (Coleoptera: Chrysomelidae), or the viburnum leaf beetle (VLB), is an invasive pest on viburnums in North America, where native species of the plant have little natural resistance. Resistance can be conferred by leaf texture, leaf chemistry, or a wound response that crushes VLB eggs. The beetle does not immediately kill host plants, but repeated defoliation is fatal after several years. Because viburnum is a common forest and landscape plant in the eastern United States, VLB is a serious concern.

The Morris Arboretum has a large collection of viburnums, including many native and non-native species. While VLB had already been observed in passing, this project included a thorough baseline survey of VLB damage throughout the Arboretum. Data were collected for the number of twigs infested with VLB, the number of cavities on each twig, and whether a wound response had been produced. This information was compared to existing evaluations of viburnum susceptibility based on defoliation, and previously unlisted species were evaluated.

In the future, VLB populations should be managed by annually clipping and destroying infested twigs between October and March. If this window is missed, young larvae can be sprayed with horticultural oil, and adults shaken off plants into soapy water. However, if regional VLB populations become denser in coming years, pest pressure will still continue to increase at the Arboretum, as beetles come from surrounding properties. Therefore, highly susceptible viburnums should be avoided in new plantings, and the understory of natural areas should be diversified. Pest pressure should be reevaluated every 3-5 years, with a repetition of the survey in this project.

Disciplines
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Comments
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DATE: **March 2017**

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Pyrrhalta viburni (Coleoptera: Chrysomelidae), or the viburnum leaf beetle (VLB), is an invasive pest on viburnums in North America, where native species of the plant have little natural resistance. Resistance can be conferred by leaf texture, leaf chemistry, or a wound response that crushes VLB eggs. The beetle does not immediately kill host plants, but repeated defoliation is fatal after several years. Because viburnum is a common forest and landscape plant in the eastern United States, VLB is a serious concern.

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BACKGROUND INFORMATION

Plants within the genus *Viburnum* are common in both landscapes and natural areas in eastern North America, and they are being threatened by the invasive viburnum leaf beetle, *Pyrrhalta viburni* (Coleoptera: Chrysomelidae). The beetle was first identified in North America in Nova Scotia in 1924, where it was introduced from its native Palearctic range through imported nursery stock or other trans-Atlantic commerce. Maine was the first state to confirm presence of the viburnum leaf beetle (VLB) in 1994, followed by New York in 1996, Vermont in 2000, Pennsylvania in 2000, Ohio in 2002, and then throughout New England (Majka and LeSage 2007). The beetle was confirmed in New York City in 2008, and soon afterwards in Northern New Jersey ("Viburnum" 2009). The ultimate distribution of VLB may be limited by a chilling requirement of 5˚C (41˚F) for four months in order for eggs to complete diapause, and successfully hatch (Weston and Diaz 2005).

Both VLB larvae and adults feed on viburnum leaves, and in high density populations can cause defoliation. Often the larvae will eat the first flush of leaves, and the adults will eat the second. This exhausts the plant's resources, and within three years it can die. Feeding damage of the two VLB life stages can be distinguished by the pattern of holes in the leaf; larvae produce irregularly shaped holes, often along vein edges, while adults produce oblong holes with rounded edges, sometimes crossing over veins (Weston, Desurmont, and Hoebeke 2007).

While VLB only eat viburnums, they do exhibit feeding preferences between viburnum species. Factors that reduce susceptibility to VLB defoliation include thick or hairy leaves, and potentially some aspect of the leaf chemistry. Based on observations at the highly-infested Highland Park Arboretum in Rochester, NY, the species most resistant to defoliation include *V. burkwoodii, V.* × *carlcephalum, V. carlesii, V.* × *juddii, V. plicatum* var. *tomentosum, V.* × *rhytidophylloides, V. rhytidophyllum, V. setigerum,* and *V. sieboldii*. Moderately susceptible species include *V. acerifolium, V. dilatatum, V. lantana, V. lentago, V.* × *pragense*, and *V. prunifolium*. The most susceptible species, with heavy feeding and frequent brown, shriveled foliage, include *V. dentatum, V. opulus, V. rafinesquianum, V. sargentii*, and *V. trilobum* (Weston, Eshenaur, and McNiel, 2000). Further observations revealed a positive correlation between exposure to sunlight and higher feeding damage, resulting in some flexibility within the susceptibility lists (Weston, Desurmont, and Hoebeke 2007).

The life cycle of VLB is univoltine, with spring egg hatch occurring close to the leafing out of *V. dentatum*. The larvae go through three instars, changing their black and yellow color pattern with each step, and growing from 1 mm to 10 mm long. First instar VLB can only eat the bottom layer of the leaf, while the two larger instars chew holes all the way through. After three to four weeks, the larvae crawl down the viburnum stems and pupate a few centimeters under the soil. Adults emerge in late June to early July, depending on the accumulated growing degrees. Adults are greenish-brown, 4.5 to 6 mm long, and tend to stay on the same shrubs as the larvae, unless the population becomes too dense (Weston, Desurmont, and Hoebeke 2007).

The oviposition behavior of VLB has been the subject of several studies. Researchers in New York observed that female VLB have aggregative oviposition, meaning they prefer to lay eggs on twigs that already have VLB egg clusters from other females. Females chew a 1-2 mm cavity in a terminal twig, lay an average of eight eggs inside, and then cover it with a protective cap made of chewed bark and frass. It was determined that this aggregative behavior can help overcome plant defenses and aid egg survival. Twigs with fewer egg clusters are more likely to produce a wound response of undifferentiated tissue that grows into the cavities, crushing or expelling the eggs (Desurmont and Weston 2011).

Strength of a viburnum species' wound response is an additional factor that contributes to resistance to VLB. One study compared the wound response of three European viburnums (*V. lantana*, *V. opulus*, and *V. tinus*), which evolved in the presence of VLB, with three North American species (*V. trilobum*, *V. dentatum,* and *V. nudum*). The European species had much higher wound response, meaning they are less likely to be overcome by aggregative oviposition. This study also included three Asian species (*V. plicatum, V. rhytidophyllum,* and *V. sieboldii*), but not enough beetles could be induced to lay eggs in the twigs in order to evaluate wound response (Desurmont, Donoghue, Clement, and Agrawal 2011).

Two additional benefits of aggregative oviposition are that females spend less time searching for ideal egg sites, and larvae in high densities feed more and gain more mass (Desurmont, Weston, and Agrawal 2014). Aggregative oviposition is less common late in the oviposition season, close to October, as viburnum wound response is already weakened (Desurmont, Hajek, and Agrawal 2014).

In light of VLB's life cycle and behavior, several methods have been recommended for control. The method with the largest window for effectiveness is clipping the egg-infested twig tips off, any time after oviposition is complete in October, until egg hatch in April. If eggs hatch before clipping takes place, larvae can be sprayed with horticultural oil or spinosad. However, there is a short, 2-4 week window for this, and it is difficult to get adequate coverage on the underside of the leaves (Weston, Desurmont, and Hoebeke 2007). Some reports from New York State suggest using glue bands around the base of viburnum stems to trap final instar larvae as they crawl down to pupate in the soil, but this has not been tested for efficacy (Brewer 2016). Chemical insecticides can be used against larvae or adults, but require repeated applications and can affect non-target organisms. In its native range, VLB has several natural predators that help control its population, and these predators are being studied for potential classical biocontrol, but with no definitive results so far (Weston, Desurmont, and Hoebeke 2007).

METHODS

There were several goals for this project, relating to the management of viburnum leaf beetle at the Morris Arboretum. The first goal was to conduct thorough research on the pest, and to help make this information available to Arboretum staff. This includes a written review of literature on VLB's distribution, the damage it causes, its life cycle, susceptible viburnum species, and general management recommendations. Since journal publications are not up to date with VLB's spread across the northeast, plant health managers in the greater Philadelphia region were contacted to clarify the current distribution of the pest.

The second goal of the project was to conduct a baseline survey of the viburnums at the Morris Arboretum, recording details of VLB infestation throughout the collection. This was done in January 2017, after the oviposition period was complete, and infested twigs were easy to see because of leaf fall. The survey linked each plant's accession number (with corresponding information on species, age, etc) to the number of twigs with egg cavities, the number of cavities on each of those twigs, and the presence or absence of a wound response. All cultivars within a species were considered as one group, to evaluate the overall susceptibility of that species to VLB, based on wound response. Although nine species had previously been evaluated in this way, the survey at the Arboretum provided the opportunity to study wound response in many more species. The survey data were compared with the existing lists of VLB susceptibility based on both defoliation and wound response. The plant's size, general health, and non-VLB pest damage was also recorded. After recording information, infested twigs were clipped, double-bagged, and thrown out.

Finally, in accordance with the background information and current conditions of viburnum at the Arboretum, a management program for VLB at the Morris Arboretum was developed.

RESULTS

For a literature review on VLB, see "Background Information" of this report.

Previously VLB was reported throughout New England, New York, and parts of Pennsylvania, Ohio, and New Jersey (Majka and LeSage 2007; "Viburnum" 2009). Reports from regional plant health managers revealed that the beetle has spread further, through southeastern Pennsylvania, and into northern Maryland, and northern Delaware. Liz McDowell, of the Maryland Native Plant Society, reported that in 2014 VLB was confirmed in the state's two western-most counties, Garrett and Allegany, and Mary Kay Malinoski, extension specialist at the University of Maryland, has heard reports of VLB as far east as Harford county (personal communication, January, 2017). Jimmy Testa, Horticulturalist and Plant Health Care Specialist at Mt. Cuba Center in Hockessin, DE, reported that he has seen low populations of VLB for two or three years, but overall viburnum health has not yet been affected (personal communication, March, 2017). These reports suggest that VLB has spread throughout the greater Philadelphia region and beyond. As populations continue to spread through Maryland and further south, the Philadelphia region may start to see its existing beetle infestation increase in intensity.

In the baseline survey of viburnums at the Morris Arboretum, plants were excluded if they had very poor health for non-VLB reasons, or if many plants had already been checked within the species. A total of 150 accessioned plants were evaluated, which encompasses 75% of the total viburnum collection and includes 32 species or hybrids (see Table 1).

Of the 32 species surveyed, four were previously listed as susceptible in the defoliation study, four listed as moderately-susceptible, six listed as resistant, and 18 that were not listed (see Table 2). Overall, the 14 species whose susceptibility was previously described based on defoliation matched the susceptibility at the Arboretum, based on the percent of plants affected by the species, and percent wound response. One possible exception was *V. lentago*, which was listed as moderately-susceptible to defoliation, but showed signs of high susceptibility because of a lack of wound response (see Table 3). Of the 18 species whose susceptibility was not previously described, two were susceptible, two were moderately-susceptible, and 14 were resistant (see Table 4). As expected, both of these susceptible species are native to North America (*V. nudum* and *recognitum*), and one of the two moderately-resistant species is as well (*V. cassinoides*, but not *V. erosum*). Only one of the 14 resistant species is native to North

America (*V. rufidulum*), and the rest are native to Europe or Asia, where they would have co-evolved with VLB.

Of the nine species in the previous wound response study, only 6 were included in the survey at the Arboretum: three North American species (*V. tilobum, V. nudum,* and *V. dentatum*), two Asian species (*V. plicatum* and *V. rhytidophyllum*), and one European species (*V. opulus*). The three North American species in the survey matched the previous study by exhibiting poor wound response. The two Asian species were also similar; VLB did not infest the twigs at all, so wound response could not be evaluated. However, the European species in the previous study showed good wound response, while the one plant of *V. opulus* at the Arboretum had four infested twigs with an average of 6.75 cavities in each, and no wound response was visible (see Table 2).

Several cases of non-VLB damage were observed on viburnum during the survey. Most notably, there were many egg sites from the two-marked treehopper (*Enchenopa binotata*) on *V. prunifolium, V. nudum,* and *V. rufidulum.* These are similar to VLB egg sites in that the eggs are inserted into slits along the twig, but instead of a frass cap, they are covered with a mass of sticky, white froth. These insects feed on several other genera of plants as well, and rarely cause noticeable damage on any of them (Matausch 1912). Several *V.* × *rhytidophylloides* had European wasp chewing damage on the trunk, but this rarely girdles stems (Day 2014). Mealybugs were observed under dry bark of one *V. plicatum*, and katydid eggs were observed on several *V. utile* twigs. Neither of these are noted for severe damage on viburnums.

CONCLUSION AND MANAGEMENT RECOMMENDATIONS

The survey of VLB at the Morris Arboretum conducted in January 2017 will give Arboretum staff baseline information with which to compare VLB populations in the future. Horticulturalists should continue to observe viburnum health for extreme changes, and every 3-5 years the Plant Protection Intern should conduct the same survey to help quantify the rate of VLB population growth. The survey should be conducted between late October and February, to ensure that oviposition is complete, and hatching has not begun. While the initial survey was helpful for comparing the Arboretum's VLB infestation with trends elsewhere, future survey work should not be used for overall conclusions about VLB behavior and plant response, due to the high level of management at the Arboretum.

To manage the damage from VLB, infested twigs should be clipped annually, by the horticulturalists in each section of the Arboretum. The natural areas will have the most plants to check, primarily *V. dentatum*, so it could be a potential volunteer activity in the late fall. Clipped twigs should be double-bagged and thrown out. If the window for clipping is missed, and eggs hatch, first-instar larvae can be managed with horticultural oil sprays on the underside of leaves, although it is difficult to get adequate coverage. Adults are more difficult to manage because of their mobility, but some may be shaken off the plant into a bucket of soapy water.

As populations of VLB rise, viburnum shrubs may get more severely damaged and killed. It is uncertain when the infestation will reach this level, but even with careful management at the Arboretum, VLB will always be able to re-enter Morris Arboretum from surrounding properties.

For this reason, it is best to plant less susceptible species of viburnums, or at least diversify plantings in the natural areas.

Viburnum leaf beetle is an invasive species that has been in the United States for over 20 years, and yet it received little attention compared to pests like emerald ash borer and Asian long-horned beetle. While no one has to worry about dead viburnums falling on a house, or costing thousands of dollars to remove, the ecological damage of VLB may be severe (Weston, Desurmont, and Hoebeke 2007). The ultimate distribution of VLB may be limited by its overwintering requirements, but where it does occur, it should continue to be monitored and managed as best possible.

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Table 1- Entire data set from VLB survey at the Morris Arboretum. For accessions with multiple plants or a mass, only the plant with the accession tag was evaluated. There was no wound response unless otherwise noted.

Accession #	Species	Infested Twigs	Cavities/Twig & Wound Response
1996-393*B	Viburnum betulifolium	3	1, 3, 4 (all wr)
1996-393*D	Viburnum betulifolium	0	–
1996-492*A	Viburnum betulifolium	0	–
1986-052*G	Viburnum bitchiuense	0	–
1986-052*H	Viburnum bitchiuense	0	–
1986-069*C	Viburnum bitchiuense	0	–
1986-069*G	Viburnum bitchiuense	0	–
1986-037*C	Viburnum bitchiuense	0	–
1986-052*A	Viburnum bitchiuense	0	–
1983-026*A	Viburnum buddleifolium	0	–
1983-026*B	Viburnum buddleifolium	0	–
2007-077*B	Viburnum cassinoides	4	2 wr, 1, 1, 1
2000-337*A	Viburnum cassinoides	3	7, 8, 6 (all wr)
2000-337*B	Viburnum cassinoides	5	1, 4, 1, 2, 1 (all wr)
2000-337*C	Viburnum cassinoides	4	1 wr, 2 wr, 6, 10
1983-074*A	Viburnum dentatum	7	1, 12, 5, 14, 7, 5, 1
1993-174*D	Viburnum dentatum	10+	4, 7, 25, 28, 4, 10, 12, 14, 15, 4
1992-495*F	Viburnum dentatum	10+	26, 40, 15, 6, 16, 14, 20, 18, 4, 8

2002-365*A	Viburnum dentatum	3	1, 1, 1
2013-080*A	Viburnum dentatum	1	14
2013-080*B	Viburnum dentatum	0	–
2013-080*C	Viburnum dentatum	0	–
2013-080*D	Viburnum dentatum	0	–
2013-080*E	Viburnum dentatum	0	–
2013-084*B	Viburnum dentatum	0	–
1998-243*E	Viburnum dentatum	3	1 wr, 4, 4
1998-243*F	Viburnum dentatum	4	2, 5, 2, 2
2004-133*A	Viburnum dentatum 'Christom'	4	1, 2, 2, 1
2013-083*A	Viburnum dentatum 'Christom'	4	3, 6, 1, 9
2004-146*A	Viburnum dentatum 'J.N. Select'	9	2 wr, 4, 3, 2, 1, 3, 1, 7, 4
2004-146*B	Viburnum dentatum 'J.N. Select'	10	2 wr, 2 wr, 2 wr, 4, 1, 6, 4, 1, 3, 3
2004-134*A	Viburnum dentatum 'Moon-Glo' (mass)	0	–
2004-105*A	Viburnum dentatum 'Ralph Senior'	10+	did not count cavities
1995-041*A	Viburnum dentatum 'Synnestvedt'	10+	11, 11, 4, 6, 7, 19, 14, 11, 24, 3
2004-132*A	Viburnum dentatum 'Synnestvedt'	0	–
1942-032*A	Viburnum dilatatum	0	–
1984-142*B	Viburnum dilatatum	0	–
1984-142*C	Viburnum dilatatum	0	–
1984-142*E	Viburnum dilatatum	0	–

1984-142*G	Viburnum dilatatum	0	–
1984-142*H	Viburnum dilatatum	0	–
1984-142*I	Viburnum dilatatum	0	–
1986-075*L	Viburnum dilatatum f. pilosulum	0	–
1996-247*A	Viburnum dilatatum 'Michael Dodge'	0	–
1994-367*A	Viburnum erosum	2	2 wr, 3
1998-184*A	Viburnum erosum	0	–
1998-184*B	Viburnum erosum	0	–
1998-184*C	Viburnum erosum	0	–
1996-466*B	Viburnum henryi	0	–
2014-023*A	Viburnum henryi	0	–
1996-466*C	Viburnum henryi	0	–
2004-106*B	Viburnum lentago	3	2, 2, 1
2014-187*A	Viburnum lentago	5	2 wr, 1 wr, 8, 10, 6
1994-573*A	Viburnum mongolicum	0	–
2010-107*A	Viburnum nervosum	9	3, 7, 15, 14, 5, 4, 11, 8, 10 (all wr)
2010-107*B	Viburnum nervosum	7	9 (no wr, rest w/wr), 3, 9, 7, 7, 5, 10
2013-077*A	Viburnum nudum	2	10, 4
1996-643*A	Viburnum nudum (mass)	0	–
2004-107*A	Viburnum nudum 'Earth Shade'	0	–
2004-107*B	Viburnum nudum 'Earth Shade'	0	–

2004-107*C	Viburnum nudum 'Earth Shade'	0	—
2006-150*A	Viburnum nudum 'Longwood'	0	—
2006-150*C	Viburnum nudum 'Longwood'	0	—
1983-028*B	Viburnum opulus 'Aureum'	4	10, 8, 5, 4
1932-1927*A	Viburnum plicatum	0	—
1932-1927*C	Viburnum plicatum	0	—
1932-1928*A	Viburnum plicatum	0	—
1932-1928*C	Viburnum plicatum	0	—
1983-029*A	Viburnum plicatum f. tomentosum 'Lanarth'	0	—
1983-029*C	Viburnum plicatum f. tomentosum 'Lanarth'	0	—
1993-140*B	Viburnum plicatum f. tomentosum 'Shasta'	0	—
1993-140*C	Viburnum plicatum f. tomentosum 'Shasta'	0	—
1993-140*G	Viburnum plicatum f. tomentosum 'Shasta'	0	—
1993-140*I	Viburnum plicatum f. tomentosum 'Shasta'	0	—
2015-056*A	Viburnum plicatum f. tomentosum 'Shasta'	0	—
2015-056*B	Viburnum plicatum f. tomentosum 'Shasta'	0	—
1993-140*Q	Viburnum plicatum f. tomentosum 'Shasta'	0	—
1996-067*A	Viburnum plicatum f. tomentosum 'Shasta'	0	—
2015-056*C	Viburnum plicatum f. tomentosum 'Shasta'	0	—
2001-057*A	Viburnum plicatum f. tomentosum 'Watanabe'	0	—
2001-057*B	Viburnum plicatum f. tomentosum 'Watanabe'	0	—

1932-0514*C	Viburnum prunifolium	0	–
1983-068*A	Viburnum prunifolium	0	–
1983-068*B	Viburnum prunifolium	0	–
1983-068*D	Viburnum prunifolium	0	–
1983-068*E	Viburnum prunifolium	0	–
1983-068*F	Viburnum prunifolium	0	–
1992-539*B	Viburnum prunifolium	0	–
1996-604*A	Viburnum prunifolium (3 plants)	0	–
2009-098*B	Viburnum recognitum	10+	3, 1, 14, 4, 15, 11, 6, 3, 1, 6
2009-098*A	Viburnum recognitum	6	3, 4, 1, 6, 3, 7
2009-098*C	Viburnum recognitum (3 plants)	10+	5, 6, 5, 2, 18, 23, 16, 11, 10, 7
2004-086*A	Viburnum rhytidophyllum 'Cree'	0	–
2004-086*B	Viburnum rhytidophyllum 'Cree'	0	–
2004-086*C	Viburnum rhytidophyllum 'Cree'	0	–
2003-053*A	Viburnum rufidulum	0	–
2003-053*B	Viburnum rufidulum	0	–
2003-169*A	Viburnum rufidulum (5 plants)	0	–
2005-116*A	Viburnum rufidulum 'Morton' (3 plants)	2	1 wr, 1 wr
2003-052*A	Viburnum rufidulum 'Royal Guard'	0	–
2003-052*D	Viburnum rufidulum 'Royal Guard'	0	–
2003-052*E	Viburnum rufidulum 'Royal Guard'	0	–

1994-605*A	Viburnum sargentii	3	2, 2, 3 (all wr)
1994-605*B	Viburnum sargentii	2	1 wr, 3
1994-605*C	Viburnum sargentii	1	3 wr
1983-030*B	Viburnum sargentii	4	13 wr, 2, 1, 1
1983-031*A	Viburnum sargentii var. calvescens	7	5, 1, 7, 5, 1, 5, 2
1983-031*B	Viburnum sargentii var. calvescens	8	1 wr, 5, 6, 7, 9, 2, 5, 14
1996-501*A	Viburnum schensianum	1	1 wr
1996-501*B	Viburnum schensianum	0	–
1996-501*C	Viburnum schensianum	0	–
1983-033*B	Viburnum setigerum	0	–
2013-048*A	Viburnum setigerum 'Aurantiacum'	0	–
1932-0012*A	Viburnum setigerum 'Aurantiacum'	0	–
2013-049*A	Viburnum setigerum 'Aurantiacum'	0	–
1983-035*A	Viburnum trilobum 'Andrews' (mass)	5	4 wr, 1 wr, 6, 11, 6
1994-316*A	Viburnum utile	0	–
1994-316*C	Viburnum utile	0	–
1994-316*E	Viburnum utile	0	–
1994-421*B	Viburnum utile	0	–
1994-421*C	Viburnum utile	0	–
1983-107*A	Viburnum veitchii	0	–
1992-186*B	Viburnum wrightii	0	–

2003-182*A	Viburnum wrightii 'C.A. Hildebrant's'	0	—
2003-182*B	Viburnum wrightii 'C.A. Hildebrant's'	0	—
2003-182*C	Viburnum wrightii 'C.A. Hildebrant's'	0	—
2003-182*D	Viburnum wrightii 'C.A. Hildebrant's'	0	—
1969-291*B	Viburnum × bodnantense	0	—
1969-291*A	Viburnum × bodnantense	0	—
2006-113*A	Viburnum × burkwoodii 'Duvone'	0	—
2006-113*B	Viburnum × burkwoodii 'Duvone'	0	—
2006-113*C	Viburnum × burkwoodii 'Duvone'	0	—
2000-409*A	Viburnum × burkwoodii 'Mohawk'	0	—
2000-409*B	Viburnum × burkwoodii 'Mohawk'	0	—
2000-409*C	Viburnum × burkwoodii 'Mohawk'	0	—
1978-022*A	Viburnum × burkwoodii 'Park Farm Hybrid'	1	4
1978-022*B	Viburnum × burkwoodii 'Park Farm Hybrid'	2	6 wr, 3 wr
2002-134*B	Viburnum × carlcephalum 'Cayuga'	0	—
2002-134*C	Viburnum × carlcephalum 'Cayuga'	0	—
2004-085*A	Viburnum × carlcephalum 'Cayuga'	0	—
2002-137*A	Viburnum 'Chippewa'	0	—
2014-063*A	Viburnum 'sPg-3-024'	0	—
1983-039*A	Viburnum × pragense	0	—
2001-058*A	Viburnum × pragense	0	—

2005-127*A	Viburnum × pragense (3 plants)	0	–
1983-040*A	Viburnum × rhytidophylloides	0	–
1983-040*C	Viburnum × rhytidophylloides	0	–
2002-135*A	Viburnum × rhytidophylloides 'Alleghany’	0	–
2002-135*B	Viburnum × rhytidophylloides 'Alleghany'	0	–
2002-135*C	Viburnum × rhytidophylloides 'Alleghany'	0	–

Table 2- Detailed summary of VLB infestation of viburnum species at the Morris Arboretum.

Species	**Plants Checked**	**Plants with VLB**	**Avg. Infested Twigs per Plant**	**Avg. Cavities per Infested Twig**	**Wound Response in Cavities**
Viburnum betulifolium	3	33%	3.0	2.7	100%
Viburnum bitchiuense	6	0%	–	–	–
Viburnum buddleifolium	2	0%	–	–	–
Viburnum cassinoides	4	100%	4.0	3.4	65%
Viburnum dentatum	20	65%	6.5	7.5	2%
Viburnum dilatatum	9	0%	–	–	–
Viburnum erosum	4	25%	2.0	2.5	40%
Viburnum henryi	3	0%	–	–	–
Viburnum lentago	2	100%	4.0	4.0	9%
Viburnum mongolicum	1	0%	–	–	–
Viburnum nervosum	2	100%	8.0	7.9	93%
Viburnum nudum	7	14%	2.0	7.0	0%
Viburnum opulus	1	100%	4.0	6.8	0%
Viburnum plicatum	17	0%	–	–	–

Viburnum prunifolium	8	0%	–	–	–
Viburnum recognitum	3	100%	8.7	7.3	0%
Viburnum rhytidophyllum	3	0%	–	–	–
Viburnum rufidulum	7	14%	2.0	1.0	100%
Viburnum sargentii	6	100%	4.2	4.2	24%
Viburnum schensianum	3	33%	1.0	1.0	100%
Viburnum setigerum	4	0%	–	–	–
Viburnum trilobum	1	100%	5.0	5.2	19%
Viburnum utile	5	0%	–	–	–
Viburnum veitchii	1	0%	–	–	–
Viburnum wrightii	5	0%	–	–	–
Viburnum × bodnantense	2	0%	–	–	–
Viburnum × burkwoodii	8	25%	1.5	4.3	69%
Viburnum × carlcephalum	3	0%	–	–	–
Viburnum 'Chippewa' (japonicum × dilatatum)	1	0%	–	–	–
Viburnum 'sPg-3-024' (davidii × tinus)	1	0%	–	–	–
Viburnum × pragense	3	0%	–	–	–
Viburnum × rhytidophylloides	5	0%	–	–	–

Table 3- Summary of the observed VLB infestation of the 14 species at the Morris Arboretum, grouped based on the previous study of susceptibility based on defoliation. The new data mostly matched the old evaluation, except for *V. lentago*, which had exhibited high infestation and low wound response.

	Species	**Plants with VLB**	**Wound Response in Cavities**
Susceptible	Viburnum dentatum	65%	2%
	Viburnum opulus	100%	0%
	Viburnum sargentii	100%	24%
	Viburnum trilobum	100%	19%
Moderately Susceptible	Viburnum dilatatum	0%	–
	Viburnum lentago	100%	9%
	Viburnum prunifolium	0%	–
	Viburnum × pragense	0%	–
Resistant	Viburnum plicatum	0%	–
	Viburnum rhytidophyllum	0%	–
	Viburnum setigerum	0%	–
	Viburnum × burkwoodii	25%	69%
	Viburnum × carlcephalum	0%	–
	Viburnum × rhytidophylloides	0%	–

Table 4- Summary of the observed VLB infestation of 18 species at the Morris Arboretum whose susceptibility was not previously described based on defoliation. Species are grouped in suggested categories of susceptibility, based on the new data.

	Species	Plants with VLB	Wound Response in Cavities
Susceptible	Viburnum nudum	14%	0%
	Viburnum recognitum	100%	0%
Mod. Susceptible	Viburnum cassinoides	100%	65%
	Viburnum erosum	25%	40%
Resistant	Viburnum betulifolium	33%	100%
	Viburnum bitchiuense	0%	–
	Viburnum buddleifolium	0%	–
	Viburnum henryi	0%	–
	Viburnum mongolicum	0%	–
	Viburnum nervosum	100%	93%
	Viburnum prunifolium	0%	–
	Viburnum rufidulum	14%	100%
	Viburnum schensianum	33%	100%
	Viburnum utile	0%	–
	Viburnum veitchii	0%	–
	Viburnum wrightii	0%	–
	Viburnum × bodnantense	0%	–
	Viburnum 'Chippewa' (japonicum × dilatatum)	0%	–
	Viburnum 'sPg-3-024' (*davidii* × *tinus*)	0%	–