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INVASION NOTE

The beginning of the end? Extensive dieback of an open-grown Amur honeysuckle stand in northern Kentucky, USA

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Abstract Amur honeysuckle (*Lonicera maackii*) is recognized as one of the most important invasive species in the Ohio River Valley. In 2012–2013, an outbreak of honeysuckle leaf blight on this species was observed in the region around Cincinnati, OH, USA. Dieback of open-grown honeysuckle stands was then noted in 2013, along with reduced physiological performance. One of these stands with signs of blight and dieback was surveyed in late summer 2013. The honeysuckle dead/total stem density fraction was 61.8 %, compared to 3.2 % reported in the 1980s. The dead/total basal area fraction was 36.9 %. The stem population size structure may also indicate a decline. Future work is needed to determine how widespread the decline is and if the leaf blight is the causative agent or an opportunistic infection.

Keywords *Lonicera maackii* · Honeysuckle leaf blight · *Insolibasidium deformans* · Dieback · Decline · Invasive species

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Introduction

One of the most important invasive plants in the Ohio River Valley is *Lonicera maackii* (Rupr.) Herder (Amur honeysuckle; nomenclature follows USDA NRCS 2014). It was introduced from eastern Asia to the United States as an ornamental shrub in the mid-nineteenth century (Luken and Thieret 1996). It is now naturalized in at least 32 states in the US and in Ontario in Canada (EDDMapS 2014; USDA NRCS 2014). It has been shown to reduce species richness and the survival and growth of both herbaceous and woody species, including the growth of mature trees (Hutchinson and Vankat 1997; Luken et al. 1997; Medley 1997; Gould and Gorchov 2001; Collier et al. 2002; Gorchov and Trisel 2003; Hartman and McCarthy 2004, 2007; Miller and Gorchov 2004; McKinney and Goodell 2010). These effects have been attributed to honeysuckle's extended-deciduous leaf habit and dense canopy, as well as competition for soil resources (Luken and Thieret 1996; Collier et al. 2002; Gorchov and Trisel 2003). It also has allelopathic effects on herbaceous species (Dorning and Cipollini 2006; Cipollini et al. 2008a, b).

In early summer of 2012 and 2013, the senior author observed a widespread outbreak of chlorotic spots on Amur honeysuckle leaves in the southwest Ohio and northern Kentucky area (Fig. 1). These spots later became necrotic, sometimes resulting in leaf death. Inquiries on ECOLOG-L (Ecological Society of America newsgroup) and MIPN (Midwest Invasive

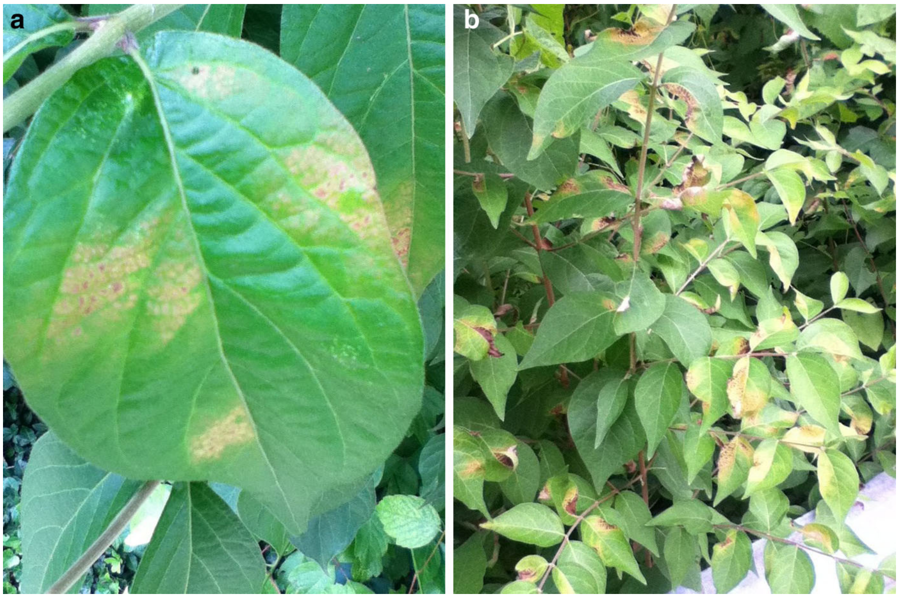

Fig. 1 Photographs of honeysuckle leaf blight taken on 29 May 2012 in Anderson Township, OH, by R.L. Boyce

Plant Network) led to reports of similar symptoms on Amur honeysuckle in Illinois, Indiana, Missouri, and Pennsylvania, as well as other parts of Kentucky and Ohio. Similar symptoms were also reported on Tatarian honeysuckle (*L. tatarica* L.) in Massachusetts and Ohio and on Morrow's honeysuckle (*L. morrowii* A. Gray) in Pennsylvania. The senior author was contacted by Jerry W. Riffle, a retired USDA Forest Service plant pathologist, who suggested that these symptoms were caused by honeysuckle leaf blight (*Insolibasidium deformans* (C.J. Gould) Oberw. & Bandoni), described in Riffle and Watkins (1986). This was confirmed by a diagnosis from the University of Kentucky Plant Disease Diagnostic Laboratory in July 2012.

This fungus infects most native and exotic species of honeysuckle and is present in at least 14 northeastern and north-central US states and five Canadian provinces, as well as Australia, New Zealand, and the UK (Table 1; Riffle and Watkins 1986; Cordell et al. 1989; Riffle 2004). Its growth appears to be supported by moist conditions early in the growing season. Infection is most likely to occur on the underside of young leaves (<20 days old) when temperatures are 15–18 °C and relative humidity is near 100 % (Gould 1945: Riffle and Watkins 1986; Cordell et al. 1989; Riffle 2004). The most recent report of the blight in the US was on *L. morrowii* in Pennsylvania (Love and Anderson 2009). While most *Lonicera* species appear susceptible, *L. japonica* Thunb. appears to be resistant (Gould 1945; Wiapara et al. 2005).

The first signs that this blight could be associated with a honeysuckle decline were noted at a long-term research site on the campus of Northern Kentucky University, where the senior author has been comparing water use and carbon uptake by native eastern red cedar (*Juniperus virginiana* L.) and invasive Amur honeysuckle and Callery pear (*Pyrus calleryana* Decne.). The chlorophyll fluorescence parameters F_v/F_m and Φ_{PSII} both showed declines in 2013 relative to 2012 (Fig. 2) for honeysuckle but not the other two species (data not shown). Honeysuckle photosynthetic assimilation rates A measured late in summer 2013 fell well below those of the other two species (Fig. 3). Leaf, shoot and whole plant dieback was also observed there in 2013.

Even healthy shrubs usually contain some dead stems. Thus, any increase in abundance of dead stems must be relative to this background mortality. Luken (1988) reported, for open-grown stands (i.e., not under a forest canopy) in northern Kentucky, live stem densities per shrub and dead stem densities per shrub of 4.91 and 0.16, respectively. These values can also be expressed as the fraction of dead stems per total stems, or $0.16/(4.91 + 0.16) = 0.032$ or 3.2 %. Thus, larger values can be interpreted as an increase in

Table 1 *Lonicera* species with records of infection by *Insolibasidium deferens*

Species	N/I	Location	References
Unidentified spp.	unknown	US (CT, IN, IA, MA, MI, NE, NY, ND, OH, RI, SD, VA, WI)	Cordell et al. (1989)
×*amoena* (*korolkowii* ×*tartarica*)	–	US (IA)	Gould (1945)
×*bella* (*morrowii* × *tatarica*)	–	US (IA), Canada (ONT)	Gould (1945)
canadensis	Native	US (NY, WI), Canada (MB, ONT, QC)	Gould (1945)
caerulea	Native	Canada (NFLD)	Gould (1945)
dioica	Native	US (IA)	Gould (1945)
discolor	Introduced	Canada (ONT)	Gould (1945)
gracilipes	Introduced	US (IA)	Gould (1945)
japonica	Introduced	New Zealand	Waipara et al. (2005), Landcare Research (2014)
korolkowii	Introduced	US (IA)	Gould (1945)
maackii	Introduced	US (IN, IA, KY, MO, OH, OK)	Gould (1945), R. Boyce (pers. obs.); T. Borgman, M. Carreiro, D. Cipollini, T. Feeley, C. Hamble, R. A. Ingraham, D. Lieurance, D. Miller, J. Rebbeck, D. Schenk, J. Taylor, M. Voges (pers. comm.)
morrowii	Introduced	US (IA, OH, PA)	Gould (1945), Love and Anderson (2009); R. Gardener, G. Olesky (pers. comm.)
×*minutiflora* (*morrowii* × *xylosteoides*)	–	US (IA)	Gould (1945)
nervosa	Introduced	US (IA)	Gould (1945)
nitida	Introduced	Australia, UK	Cunnington and Pascoe (2003) and Beales et al. (2004)
×*notha* (*ruprechtiana* × *tatarica*)	–	US (IA)	Gould (1945)
oblongifolia	Native	US (WI)	Gould (1945)
orientalis	Introduced	Canada (ONT)	Gould (1945)
pileata	Introduced	UK	Beales et al. (2004)
prostrata	Introduced	US (IA)	Gould (1945)
quinquelocularis	Introduced	US (IA)	Gould (1945)
reticulata	Native	US (IA)	Gould (1945)
ruprechtiana	Introduced	US (IA)	Gould (1945)
sempervirens	Native	US (IA)	Gould (1945)
tatsiensis	Introduced	US (IA)	Gould (1945)
tatarica	Introduced	US (IA, MA, MI, NY, OH, PA), Canada (MB, PEI, QC), New Zealand	Gould (1945), Landcare Research (2014); R. Boyce (pers. obs.); D. Cipollini, W. M. Hochachka, D. Lieurance (pers. comm.)
×*vilmorinii* (*trichosantha* × *quinquelocularis*)	–	US (IA)	Gould (1945)

N/I native/introduced (in location given). Locations in the US and Canada also give state or provinces where the blight was recorded

mortality. The size class structure of honeysuckle stands could usually be fit to right-skewed normal distributions, with dead stems usually found in the smaller size classes (Luken 1988).

The object of the current study was to measure diameters of both live and dead stems in an open-grown stand in northern Kentucky that was infected with honeysuckle leaf blight. These data were then

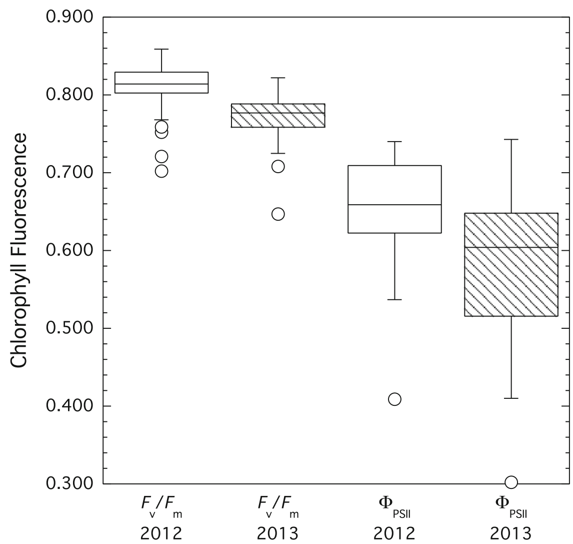

Fig. 2 Box-and-whisker plots of chlorophyll fluorescence parameters for *L. maackii* in 2012 versus 2013. Both dark fluorescence (F_v/F_m) and photosynthetic yield (Φ_{PSII}) were lower in 2013 (Mann–Whitney tests: $U = 664$, $n_1 = 28$, $n_2 = 27$, $P < 0.0001$ (F_v/F_m); $U = 596$, $n_1 = 28$, $n_2 = 27$, $P = 0.0003$ (Φ_{PSII}). Mann–Whitney tests (not shown) for *J. virginiana* indicated that F_v/F_m was significantly ($\alpha = 0.05$) greater in 2012 but Φ_{PSII} was significantly less, while for *P. callyerana*, neither F_v/F_m nor Φ_{PSII} were significantly different

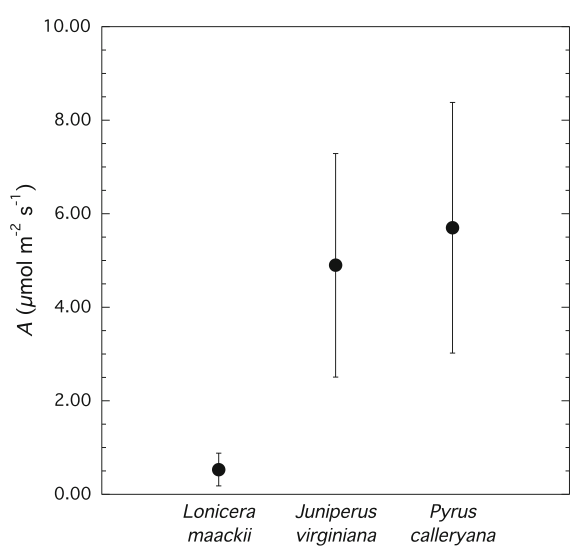

Fig. 3 Mean photosynthetic assimilation rates for *L. maackii*, *J. virginiana*, and *P. calleryana* ± 1 SD (n = 3 individuals), measured on 28 August 2013

used to determine if the number of dead stems was above the background level reported by Luken (1988), as well comparing the population size structure to that of healthy stands from the 1980s.

Methods

Measurements in September 2013 were conducted in an open-grown stand previously described by Castellano and Boyce (2007). It is dominated by Amur honeysuckle and red cedar and is located on a road cut on the edge of Northern Kentucky University's campus that was formed when I-275, a major interstate highway, was constructed in the early 1970s. Three parallel transects were laid from the top of the stand down the slope toward the highway. Every 10 m marked the top of a 2 × 5 m plot, with the plot centered on the transect, and the long axis parallel to the transect. There were 4–5 plots per transect. On each plot, all woody stems taller than 30 cm had diameters at stump height (dsh; 30 cm) measured with vernier calipers. Live stems were measured on 13 plots; because of time constraints, dead stems were measured on only 10 of the plots.

Density and basal area of live and dead stems were calculated separately, and the fraction of dead/total stems and basal area was calculated for each species present. Honeysuckle stems were divided into 0.5 cm diameter classes, and the number in each diameter class was plotted against size class to determine population structure.

Results

Stem densities of live and dead stems are shown in Table 2. The four most common species were Amur honeysuckle, red cedar, rough-leaved dogwood[1] (*Cornus drummondii* C.A. Mey.), and Callery pear. Honeysuckle accounted for more than 60 % of the live stems but more than 85 % of the dead ones. The dead/total fraction of common species other than honeysuckle ranged from 4.2 to 34.2 %; honeysuckle, however, was 61.8 %. Honeysuckle accounted for about 75 % of the live basal area and almost 90 % of the dead basal area (Table 3). The dead/total basal area fraction of common species ranged from 0.3 to 40.2 %; for honeysuckle, it was 36.9 %.

The population structure, where the number of stems is plotted against diameter size classes is shown in Fig. 4. Both live and dead stems had right-skewed

[1] This was misidentified as *Cornus racemosa* Lam. by Castellano and Boyce (2007).

Table 2 Live and dead stem density by species, with dead/total fraction

Species	Live density (ha^{-1})	Dead density (ha^{-1})	Dead/total (%)
Cornus drummondii	2,769 (923, 6,154)	1,400 (100, 3,700)	33.6
Crataegus sp.	–	100 (0, 300)	100.0
Fraxinus americana	231 (0, 615.4)	–	0.0
Juniperus virginiana	4,539 (2,385, 7,615)	200 (0, 600)	4.2
Lonicera maackii	12,615 (9,110, 17,080)	20,400 (13,100, 29,000)	61.8
Prunus serotina	77 (0, 230.8)	–	0.0
Pyrus calleryana	385 (0, 846.2)	200 (0, 600)	34.2
Rosa multiflora	–	200 (0, 600)	100.0
Unidentified	–	300 (0, 800)	100.0
Vitis sp.	77 (0, 846.2)	400 (0, 1,200)	83.9
Total	20,692 (16,540, 25,080)	23,200 (16,200, 31,500)	–

Bootstrapped 95 % confidence intervals are given in parentheses

Table 3 Live and dead basal area by species, with dead/total fraction

Species	Live basal area (m^2 ha^{-1})	Dead basal Area (m^2 ha^{-1})	Dead/total (%)
Cornus drummondii	0.297	0.199	40.2
Crataegus sp.	–	0.010	100.0
Fraxinus americana	0.016	–	0.0
Juniperus virginiana	1.408	0.004	0.3
Lonicera maackii	5.624	3.282	36.9
Prunus serotina	0.001	–	0.0
Pyrus calleryana	0.070	0.009	11.6
Rosa multiflora	–	0.012	100.0
Unidentified	–	0.168	100.0
Vitis sp.	0.015	0.012	44.4
Total	7.430	3.696	–

normal distributions, with peaks in the 1.5–2.0 and 0.5–1.0 cm diameter classes for live and dead stems, respectively. The largest live and dead stems were in the 5.5–6.0 and 4.0–4.5 cm size classes, respectively.

Discussion

The dead/total stem density fraction for honeysuckle is about 20 times greater than that reported by Luken (1988) for open-grown stands. It is also much larger than the rates exhibited by the three other major woody species. The population structure of live and dead stems (Fig. 4) shows some similarity to that of a healthy open-grown stand (Luken 1988); a major difference in the present study, however, is that dead stems were present in almost all size classes, whereas Luken found them only in the smallest size classes. Thus, our results indicate that this stand is currently declining.

Nonetheless, this is only one stand. How widespread is this? The leaf blight was widely noted in other areas in both 2012 and 2013. The senior author has also observed many other open-grown stands, especially in road cuts, that appear to have similar symptoms. Clearly, more data need to be collected over the range of Amur honeysuckle to determine how widespread the decline is.

In addition, honeysuckle leaf blight itself needs more study. Although it was reported as widespread on honeysuckle species over much of the US in the 1980s (Riffle and Watkins 1986), it was not to our knowledge reported on wild populations of Amur honeysuckle until the current study. The blight is more likely to

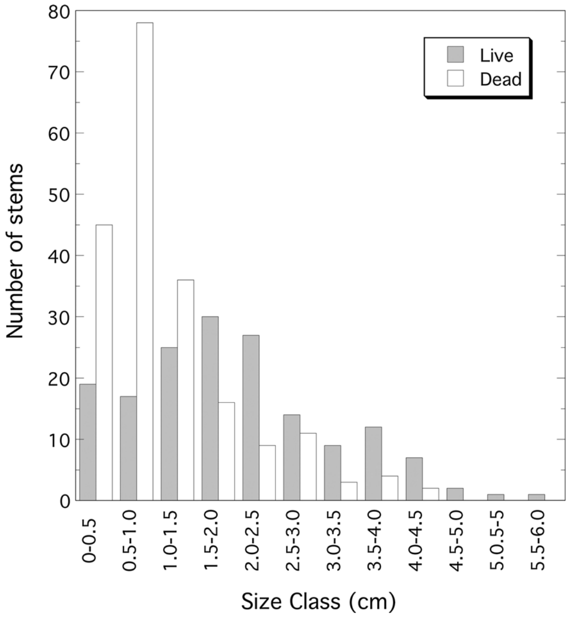

Fig. 4 Size class structure of live and dead stems in the *L. maackii* stand

appear when humidity is high early in the growing season, when leaves are still young (Gould 1945). Surely these conditions have occurred in the invasive range of Amur honeysuckle since Gould (1945) reported that it could occur on that species, and yet there have not been reports of widespread blight and/or decline. Perhaps the fungus that causes the blight has undergone genetic shifts that now allow it to attack invasive honeysuckles with more success. Lag phases have long been noted for naturalized exotic species before they become invasive (e.g., Kowarik 1995). It is possible that pathogens undergo a lag phase before they begin to attack a new host, as suggested by Flory et al. (2011). Native pathogens have accumulated on several other invasive plants over time in North America, including powdery mildew on *Alliaria petiolata* (M. Bieb.) Cavara & Grande and rose rosette disease on *Rosa multiflora* Thunb. (Flory and Clay 2011). Another factor in leaf blight outbreaks may be the increase in spring precipitation seen in much of the Midwest over the twentieth century, including the nearby states of Ohio and Indiana (Andresen et al. 2012), leading to more frequent conditions under which the blight can infect honeysuckle. Precipitation is expected to increase in eastern North America in the twenty-first century (IPCC 2013), and so blight outbreaks may become more frequent. Finally, it is also possible that the blight is an opportunistic disease attacking a species already in decline due to another stressor, such as another disease or drought stress.

In summary, we have found strong evidence that an open-grown stand in northern Kentucky is declining, and, to our knowledge, this has not been previously reported in this species. While our results are for one stand only and thus are preliminary, similar declines have been observed in other open-grown stands in the region. This decline is associated with honeysuckle leaf blight, which might be either the causative agent or an opportunistic infection taking advantage of a species already stressed by another factor. Conditions in the future are expected to favor more frequent outbreaks of leaf blight. We hope that this work will stimulate other assessments of the extent and the causes of this apparent decline in honeysuckle.

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