RESEARCH NOTE

White-tailed Deer (*Odocoileus virginianus*) Disperse Seeds of the Invasive Shrub, Amur Honeysuckle (*Lonicera maackii*)

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Natural Areas Journal 33:78–80

ABSTRACT: White-tailed deer (*Odocoileus virginianus* Zimmerman) are known to disperse seeds of a hybrid complex of invasive honeysuckle shrubs in northeastern United States. We investigated whether they also disperse seeds of Amur honeysuckle, *Lonicera maackii*, a problematic invasive shrub in the Midwestern and eastern U.S. We found that deer ingest ripe fruit and void intact seeds of *L. maackii*. Based on tetrazolium tests, most (68%) of these voided seeds are viable, but the proportion viable was significantly lower than that for seeds taken directly from ripe fruits. White-tailed deer are potentially important in the long-distance dispersal of this invasive shrub.

Index terms: invasive plant, *Lonicera maackii*, seed dispersal, seed viability

INTRODUCTION

Elucidating dispersal processes is important for understanding the invasion of exotic species (Sakai et al. 2001). Many invasive plant species have animal-dispersed seeds, and both native and exotic animals have been found to be important vectors (Richardson et al. 2000). Most frequently birds are the seed dispersal agents, but mammals are the major dispersers of some invasive plants (e.g., mule deer (*Odocoileus hemionus*), jackrabbits (*Lepus californicus*), and brush rabbits (*Sylvilagus bachmanii*)) disperse *Carpobrotus edulis* (D'Antonio 1990)). In eastern North America, white-tailed deer (*Odocoileus virginianus* Zimmerman; hereafter 'deer') disperse seeds of several invasive species (Myers et al. 2004). Included are those of a hybrid swarm of invasive *Lonicera* species, consisting of *L. tatarica* and *L. morrowii* and their hybrid *L.* x *bella* (Velland 2002; Myers et al. 2004). In many areas, deer are much more abundant than estimated pre-settlement densities, with significant negative impacts on native vegetation, including suppression of seedling recruitment of oaks (*Quercus* spp.) and other trees (Côté et al. 2004). This abundance increases the potential for deer to be quantitatively important dispersers of invasive plants.

We investigated whether deer disperse viable seeds of *Lonicera maackii* (Rupr.) Herder (Caprifoliaceae), one of the most problematic invasive shrubs in forests and successional areas in eastern North America (Luken and Thieret 1995). *Lonicera maackii* negatively affects growth and fecundity of forest annuals and perennials (Gould and Gorchov 2000; Miller and Gorchov 2004), tree seedling recruitment (Gorchov and Trisel 2003; Hartman and McCarthy 2004), with impacts on forest floor diversity and composition (Hutchinson and Vankat 1997; Collier et al., 2002; Hartman and McCarthy 2008), and reduction of nesting success of native birds (Schmidt and Whelan 1999; Rodewald et al. 2010). In southwest Ohio, deer commonly browse *L. maackii* (S.M. Castellano unpubl., data) and have been observed ingesting ripe fruit while doing so (D.L. Gorchov, pers. observation), though we don't know whether branches with fruits are preferred. The fruits are bright red, globose, 3.5–8.5 mm in diameter (Luken and Thieret 1995) and contain an average of 4.6 seeds (D.L. Gorchov, unpubl. data). Fruits remain on shrubs until late fall (Bartuszevige et al. 2006), presumably due to their low lipid content (about 4.5–5%; Ingold and Craycraft 1983). Seeds are dispersed by frugivorous/insectivorous birds, but digested by granivorous birds (Bartuzevige and Gorchov 2006).

METHODS

We fed ripe fruits of *L. maackii* to captive deer at Hueston Woods State Park in Butler County, Ohio, in late fall 2009. The Park maintained two neutered males and four does within an enclosure of several hectares (Chad Smith, Park Naturalist, pers. comm.). These deer were fed a daily diet of cracked corn supplemented with "sweet feed" grain mixture during the colder months. Deer are allowed to browse plants within their enclosure but find these plants less desirable or out of reach (Chad Smith, Park Naturalist, pers. comm.).

We conducted a total of three feeding trials approximately one week apart. At each trial, approximately 500 ripe *Lonicera* fruits were incorporated into the corn-sweet feed blend in the feeding trough at regular feeding times, and deer were allowed to eat the food at their own pace. Approxi-

mately 48 hours later, we collected all the fresh deer scats from the enclosure. This time length was chosen because a study using a radioisotope marker to measure gut retention showed that 95% percent of the marker, and presumably gut contents, had been passed in under 48 hours, varying slightly with different size deer (Mautz and Petrides 1971). All scats were stored in plastic bags under refrigeration until processing.

Deer scats were soaked in warm water and rinsed until the fecal material was removed, leaving only the undigested portion. This material was dried on a screen and intact *Lonicera* seeds, being relatively large and easily distinguished, were hand removed under a dissecting microscope and dried.

Intact seeds were placed in Petri dishes containing sterile sand, moistened with sterilized water, and warm-stratified in a lighted environmental growth chamber for a period of 12 weeks at 12 hours at 25 ºC and 12 hours at 15 ºC, followed by a two week lighted incubation period of 12 hours at 20 ºC and 12 hours at 10 ºC (Hidayati et al. 2000).

Following stratification, seeds were tested for viability using a 1% solution of tetrazolium chloride (Grabe 1970). Seeds were soaked in distilled water overnight, and a small cut was made on each with a razor to allow better stain penetration. Care was taken to avoid damage to the developing embryo. Seeds were stained for 2 hours at approximately 30 ºC. Following staining, seeds were dissected under a microscope and evaluated for positive staining, indicating viability.

The proportion of passed seeds that were viable was compared to two controls, stratified and non-stratified seeds that had been taken directly from the same batches of ripe fruit, using a G test (Likelihood Ratio Chi-Square) in SAS version 9.2.

RESULTS

Of the seeds recovered from deer scat and stratified, 68% were viable (Table 1). This viable proportion was lower than for stratified control (87%) and non-stratified control seeds (84%), with treatments significantly different (G^2 = 11.128, df = 2, P = 0.0038). Unstained seeds either lacked a developed embryo, suggesting pollination failure, or showed evidence of fungal infection, suggesting mortality post-maturation.

Table 1. Numbers of viable and non-viable *L. maackii* seeds from three treatments based on tetrazolium test.

Treatment	Viable	Non Viable	Total
Non-stratified control	68	13	81
Stratified control	74	11	85
Stratified deer-passed	61	29	90
Total	203	53	256

DISCUSSION

This is the first report that deer disperse viable seeds of *L. maackii*. While deer dispersal of invasive *Lonicera* was demonstrated by Vellend (2002), the *Lonicera* taxa in that study were phenologically distinct from *L. maackii*, as they fruit in summer, whereas *L. maackii* fruits ripen in fall and are usually not removed from shrubs until late fall and early winter (Bartuszevige et al. 2006).

The proportion of deer-passed seeds that were viable was lower than the proportion for seeds taken directly from fruits, a pattern that corresponds with Vellend's (2002) findings on percent germinations. The proportion of seeds that pass the digestive system intact, however, is not known and requires further study.

Viable *L. maackii* seeds are dispersed by at least five bird species: (American robin (*Turdus migratorius*), cedar waxwing (*Bombycilla cedrorum*), European starling (*Sturnus vulgaris*), hermit thrush (*Catharus guttatus*), and northern mockingbird (*Mimus polyglottus*) (Bartuzevige and Gorchov 2006). Which dispersal agent is more important in seed dispersal of a given plant species depends on the number of fruits consumed, the proportion passed intact and viable, the distances seeds are dispersed, and the suitability of sites where seeds are deposited. For example, Jordano et. al. (2007) found that small bird species accounted for most dispersal of *Prunus mahaleb* seeds; large birds and carnivorous mammals moved seeds longer distances, preferentially dispersed seeds to open habitats, and were the major vector of seed movement between populations. Of *L. maackii* seeds passed by robins, 76% were viable, comparable to control seeds, whereas waxwing-passed seeds had significantly lower viability (44%; Bartuzevige and Gorchov 2006). Most *L. maackii* seeds defecated by robins arrive in forest edges and wooded corridors (Bartuzevige and Gorchov 2006), sites that are presumably very suitable for establishment and growth given the abundance of *L. maackii* in these habitats. Deer might be more effective at dispersing seeds to the interior of forests, depending on their movement patterns during the period when they consume *L. maackii* fruit. They may also be more important for long-distance dispersal, given their extensive daily movement and long gut retention times (e.g., Vellend et al. (2003) projected that > 25% of *Trillium grandiflorum* seeds would be dispersed over 1 km by deer).

ACKNOWLEDGMENT

We thank Chad Smith and Shawn Conner, naturalists at Hueston Woods State Park, for permission to work with captive deer, Peter Frank and Holly Andrews for assisting with lab work, and anonymous reviewers for valuable comments on an earlier draft of this manuscript.

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and spread of invasive shrubs, dispersal vectors, including white-tailed deer, and landscape attributes favoring invasion. Other interests include native plants and native habitat restoration.

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