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A Starling in a Pear Tree: Assessing the Influence of Bird Dispersal on Callery Pear (Pyrus calleryana)

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Abstract

Invasive species can disrupt ecosystems and negatively affect other species. Callery pear (*Pyrus calleryana*) is an invasive ornamental tree that is spreading quickly throughout the United States. It is possible that birds are responsible for spreading Callery pear by eating the fruit and depositing seeds in new areas. European starlings (*Sturnus vulgaris*) and American robins (*Turdus migratorius*) are mentioned in most studies as responsible for the dispersal of Callery pear. However, there is also evidence that Cedar waxwings (*Bombycilla cedrorum*) also feed on the tree. Invasive plants can impact avian health, reproduction, and migration. Additionally, there are many aspects of bird dispersal to understand in order to see the full picture of the mutualism between birds and Callery pear. There is little research done on the interactions between birds and Callery pear despite them having such an important relationship. This review aims to identify gaps in the scientific literature on this topic and future research needed. A pilot study survey was completed to better understand bird and Callery pear interactions. The ideas discussed in this study will be useful to future ecological research focusing on invasive plant and bird interactions. Furthermore, this research will aid management decisions regarding Callery pear.

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University *of* Dayton

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Introduction

Invasive Species Overview

Invasive species can be defined as "a non-native organism whose introduction causes or is likely to cause economic or environmental harm, or harm to human, animal, or plant health" (Exec. Order No. 13751, 2016). Invasive species are a well-documented problem that costs billions of dollars in damages and control costs each year. They can negatively affect biodiversity, native species, and ecosystem structures and processes (Pimentel et al. 2005, Vitousek 1990). Because of the serious threats that invasive species pose, it is important to understand how they spread into new areas and reproduce. Invasive plants use strategies to compete for resources with other plants such as differing phenology (McEwan et al. 2009), allelopathy (McEwan et al. 2010), and animal mutualisms (Wenny 2000) which will be the focus of this paper.

History and Biology of Callery Pear

Callery pear (*Pyrus calleryana*) is an invasive tree spreading across the United States, and its impacts on invaded ecosystems is an area of active research (Vogt et al. 2020, Coyle et al. 2021, Sapkota et al. 2021, Woods et al. 2021, Hartshorn et al. 2022, Maloney et al. *in review*). Callery pear was first brought to the United States between 1909 and 1919 from China to help the U.S. native common pear (*Pyrus communis*) to fight fire blight, which had been killing pear populations. Callery pear samples were then tested against fire blight and other stressors. These experiments revealed that this tree was very resistant. Because of this, Callery pear made a good rootstock for other pear species. By the 1960s, Callery pear was planted as an ornamental tree in many urban areas in the United States. The Bradford cultivar was the first cultivar created by rootstock grafts, and it was then cloned. The creation of other cultivars (Capital, Whitehouse, Autumn Blaze, Aristocrat, Chanticleer, Cleveland Select, and more) followed. Each tree in a cultivar is a clone of the

original tree. Additionally, Callery pear is self-incompatible, which means it cannot self-pollinate. Therefore, trees from the same cultivar are incompatible with each other. These early Callery pear trees did not produce much viable fruit and should have been unable to spread like other invasive plants because of this. However, when trees from different cultivars have even a single difference in self-incompatibility alleles, they can produce viable fruit due to genetically different scions (or plant parts being combined with the rootstock) and subsequent sprouting. The hybridization of cultivars has led to Callery pear's viable fruiting (Culley and Hardiman 2007, Swearingen et al. 2010). In the 1990s, Callery pear began escaping from its intended areas and became an invasive concern (Vincent 2005). The trees that have escaped and spread into natural areas (grown from viable seed) are no longer part of cultivars as they have different genotypes and reproduce sexually with other nearby Callery pear trees (Swearingen et al. 2010).

Callery pear has differential anatomy, and potentially different ecological function, than its native counterparts where it invades. Fruits have a dry, slightly tough covering which is sometimes described as woody. They are overall inconspicuous in appearance (Gilman and Watson 1994, Swearingen et al. 2010). They are greenish-brown in color and turn into a reddish-brown when ripening. They also can exhibit tiny lighter spots on the outer covering. The typical pomes of Callery pear are between 10 and 15 mm long. One fruit can have between 1 and 4 seeds (Vincent 2005), that are ~5 mm (USDA, NRCS 2022). Cultivar parents have had larger fruits and seeds than invasive parents, but invasive parents produce more seeds that are also viable (Hardiman 2008). Trees have abundant fruit crops, with many fruits growing in bunches on many limbs (*personal observation*). Fruits are produced in the summer and ripen in later fall, but they persistent can stay on the tree throughout the winter (Bednorz et al. 2015, Swearingen et al. 2010). Callery pears have also exhibited earlier and later leafing phenology than native plants, which aids its competitiveness (Maloney et al. *in review*), and a longer winter season has been shown to delay Callery pear leafing and possibly

increase fruit numbers (Bednorz et al. 2015).

Invasive Plant and Bird Interactions

How Invasive Plants Affect Birds

Invasive plants can replace native species when an invasion occurs, disrupting avian behavior and foraging patterns. Invasive plants can affect the nest-site selection and success, food choice, and body condition of birds, threatening bird species richness and diversity. Some bird species may benefit from invasive plants as they become dependent on the plants for food or nest substrates. This can create difficult management decisions as some birds may become dependent on invasive plants (Whelan and Dilger 1992).

Nest-Site Selection and Nest Success

Invasive plants can play a role in avian nesting due to their differing structures from native vegetation. Some birds prefer invasive plants for nest sites and have consequently had higher nest success in invasive plants. Schlossberg and King (2010) found that shrubland birds selected invasive plants (multiflora rose, Japanese barberry, Japanese honeysuckle, oriental bittersweet, common buckthorn, and autumn olive) over native plants for building nests. Specifically, grey catbirds had greater nest success in invasive plants, possibly because they provided more cover for the nests than the native plants (Schlossberg and King 2010). At the scale of a patch (5-20ha), nest success in invasive plants increased with invasive plant abundance. Heckscher (2004) found that Veereies (*Catharus fuscescens*) preferred invasive shrubs (multiflora rose, Japanese honeysuckle, Asiatic bittersweet, Chinese privet, wineberry, Japanese barberry) in a forested area for nesting, which led to a higher nest success rate. Heckscher (2004) suggested that the increased nest success is due to the density of surrounding vegetation that deters nest predators. Creating dense thickets and monocultures is a strength of some invasive species, like Callery pear, and this may better protect some bird nests. Other studies have shown negative

effects of selecting non-native plants on nest success. Schmidt and Whelan (1999) found that American robins (*Turdus migratorius*) and wood thrushes (*Hylocichla mustelina*) nesting in invasive honeysuckle were subject to higher predation than those that nested in native plants. Wood thrushes experienced competition with American robins in honeysuckle and thus had lower nest success. These birds may have favored honeysuckle because of its early leafing phenology, and earlier nests can experience unique threats. Other studies have found that early leafing and flowering can attract migrant birds for settlement (Remeš 2003, McGrath et al. 2008). Since Callery pear has an early spring phenology, it may pose similar threats to native bird species which may preferentially nest in these trees (Maloney et al. *in review*). Borgmann and Rodewald (2004) found that nest success was reduced in invasive honeysuckle and multiflora rose for Northern cardinals (*Cardinalis cardinalis*) and American robins in rural and urban landscapes due to increased predation in smaller shrubs or higher predator abundances in urban environments. Considering that proximity to the ground and density of vegetation are factors in nest protection, Callery pear may provide a safer nest substrate than invasive shrubs due to its height and its tendency to form dense thickets (Culley and Hardiman 2007, Vincent 2005, Swearingen et al. 2010). Meta-analyses have determined that the impacts of invasive plants on avian communities and nest survival are highly context dependent and not generalizable (Stinson and Pejchar 2018; Nelson et al. 2017), indicating that research on the interactions between native bird species and Callery pear is warranted.

Food Choice

Many bird species choose the fruits they consume based on fruit properties. The size of the fruits and seeds can affect whether a bird will prefer to eat them. Fruits smaller than the bird's gape width are removed more often than fruits larger than the gape width (Herrera 1984). Sallabanks (1993a) found that American robins preferred invasive hawthorn (*Crataegus monogyna)* fruits

to native hawthorn (*Crataegus douglasii suksdorfii*) likely because the invasive fruits were larger. The invasive hawthorn fruit had an average diameter of 9.05 ± 0.06 mm, while the native hawthorn fruit had an average diameter of 7.89 ± 0.09 mm. This selection strategy could allow birds to consume more biomass within a shorter time (White and Stiles 1991). Callery pear fruit sizes are similar to the invasive hawthorn, suggesting that they may provide a similar attraction to birds when compared to smaller native fruits.

Color can also affect fruit selection (Siitari et al.1999). Birds are affected more by the conspicuousness of the fruit than the actual color of the fruit, often selected bicolored fruit displays over unicolored displays (Schmidt et al. 2004; Whelan and Wilson 1994). This suggests that Callery pear's fruit may not be as attractive in color as bicolored displays since it is very similar to the leaves from the summer to the fall, which adds to the fruits' inconspicuousness.

Birds also prefer shrubs with greater fruit abundance (Sallabanks 1993b, Whelan and Wilson 1994), and sites with greater fruit abundance in surrounding vegetation (Sargent 1990). Suthers et al. (2000) found that migratory songbirds preferred habitats with greater fruit abundance as stopover sites, and abundant fruit was provided by invasive multiflora rose. Mudrzynski and Norment (2013) also found that migrant songbirds preferred habitats with greater fruiting shrub species richness. These birds preferred eating invasive Bella honeysuckle and common buckthorn to native dogwood. Invasive plants that create monocultures and dense fruit sources could impact stopover site selection for birds. The availability of fruit can depend on the season; thus, bird diets may differ temporally. Overall, invasive plants more often impact bird species abundance in the winter and species richness in breeding seasons (Nelson et al. 2017). McCusker et al. (2010) found that Amur honeysuckle had a positive relationship with frugivorous bird densities in the winter. Many non-native plants have fruit into late autumn and winter after most native fruits are no longer available (Greenberg and Walter 2010). Invasive fruit can be an important food source for birds in the winter. Birds consume exotic fruit the

most in the late fall and winter. Therefore, invasive plants could alter the migratory range of birds (White and Stiles 1992). Callery pear provides fruit well into the fall and winter and is likely to cause changes in migratory patterns for birds that consume its fruit. Invasive plants can become dependable food sources for birds; therefore, it is important to investigate whether these fruits are still supporting the birds' health and if quick, complete removal of these plants would negatively affect birds.

Avian Body Condition

Birds may choose fruits based on their nutritional content. Stiles (1993) found that lipid content was the most important factor when birds were selecting fruits. Lafleur et al. (2007) found that starlings chose fruits with the highest percent of soluble carbohydrates. Martínez del Rio and Stevens (1989) found that starlings chose D-glucose and D-fructose solutions over higher sucrose solutions, likely because they cannot digest sucrose. Lafluer et al. (2007) found that American robins chose fruits based on a higher percentage of protein. Callery pear's lipid content may be important in affecting food choice and supporting birds in the winter as reliance on fruit at this time likely is due to the need for fat during migration (Suthers et al. 2000, Mudrzynski and Norment 2013); however little is known about the nutritional value of Callery pear fruit. Invasive fruit can have lower nutritional quality than native fruit (Ingold and Craycraft 1983), and may affect avian body condition, which can be measured by differences in body mass and tarsus and wing lengths (Labbé and King 2020, Gleditsch and Carlo 2014). Labbé and King (2020) found bird body condition decreased with prevalent invasive *Rosa* and *Rhamnus* fruits, but Gleditsch and Carlo (2014) found that bird nestlings had better body condition with increased invasive *Lonicera* fruits. Callery pear fruit may lead to decreased bird body condition while still being an important food source in the winter.

Both invasive and native fruits can ferment and may cause bird deaths due to alcohol intoxication when consumed (Fitzgerald et al. 1990, Kinde et al. 2012, Stephen and Walley 2000, Tryjanowski et al. 2020). Birds mainly eat Callery pear fruits in late autumn after they could be softened by a frost (Culley and Hardiman 2007, *pilot study*).

By this time, Callery pear fruits may ferment and intoxicate birds necessitating research on the interaction between Callery pear fruit quality and avian foraging.

How Bird Dispersal Affects Plant Invasions

Birds are one of the most common and crucial dispersers of fleshy-fruited invasive plants (Bartuszevige and Gorchov 2006, Gosper et al. 2005, Reichard et al. 2001, Panetta and McKee 1997). Some invasive plants have developed fruiting strategies to attract birds because they are so valuable in dispersal (Renne et al. 2002), due to their abundance across various habitats and ability to travel long distances. Certain characteristics of each bird species can influence the effectiveness and distance of dispersal. Those relevant to this paper include fruit handling techniques, gut passage, and post-foraging behavior (Gosper et al. 2005).

Fruit Handling

Birds consume fruit in a variety of ways. Some are seed gulpers, which consume the seeds along with the fruit and disperse seeds through defecation or regurgitation. Other birds are seed discarders, which eat parts of the fruit, separate the seeds, and do not consume the seeds. The seeds are then dispersed by falling to the ground or by attaching to the bird's body. Others are seed predators, which damage the seeds, so they are no longer viable either through mechanical means (mandibulation) or digestion (Gosper et al. 2005). Thus, not all birds that eat invasive fruits are equally effective dispersers. The way birds consume Callery pear is important in determining whether they are the most effective dispersal vehicles of the tree.

Gut Passage

The passage through a bird's digestive tract can influence germination and dispersal distance (Traveset 2001, Murphy et al. 1993, Levey and Martínez del Rio 2001). Bartuszevige and Gorchov (2006) found that a small portion of observed bird species that consumed invasive Amur honeysuckle

actually defected viable seeds, which could indicate poor dispersal of Amur honeysuckle. When passing through the gut, seeds can experience scarification. Many plant species depend on scarification for germination and successful recruitment, so in this case, gut passage is positive. Mandon-Dalger et al. (2004) found that seed passage through the gut of the red-whiskered bulbul (*Pycnonotus jocosus*) increased germination for the invasive Brazilian peppertree (*Schinus terebinthifolius*). This result could be due to the birds removing the pulp that contained germination inhibitors. Yagihashi et al. (1999) found that bird ingestion led to faster germination for Japanese bird cherry (*Prunus ssiori*), likely because the fruit of this autumn fruiting plant does not typically decompose until spring, so gut passage accelerated this process. The implications of seed gut passage on the dispersal of Callery pear seeds is unknown since the germination strategies of this species is not fully elucidated.

Avian Dispersers of Callery Pear

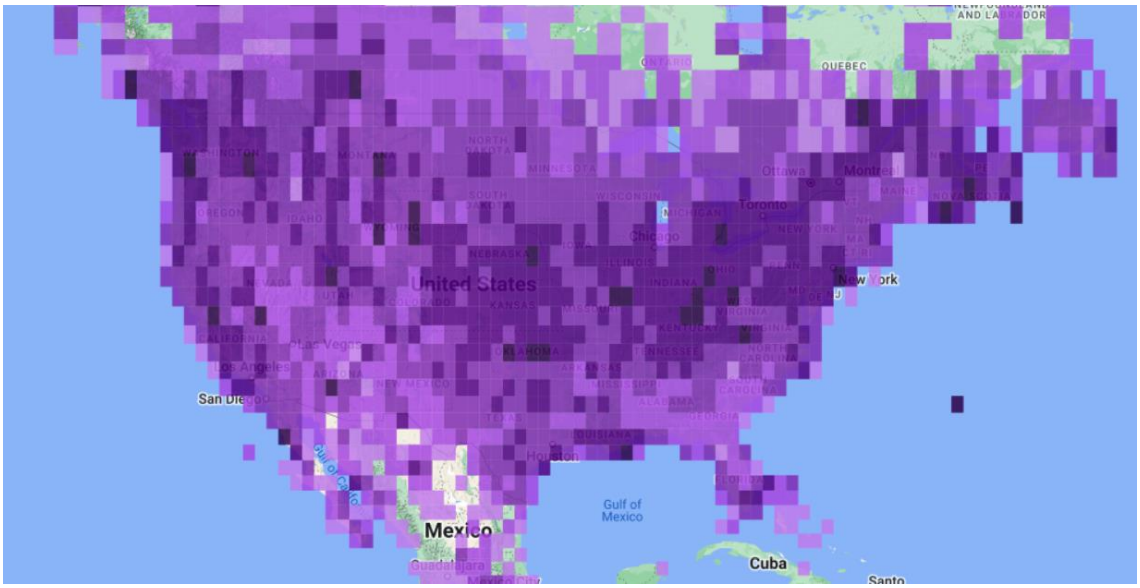
Studies that discuss Callery pear dispersal observed that European starlings (*Sturnus vulgaris*) and American robins (*Turdus migratorius*) are the avian dispersers (Culley and Hardiman 2007, Culley and Hardiman 2009, Hardiman 2008, Gilman and Watson 1994, Swearingen et al. 2010). Understanding the mutualistic interactions Callery pear has with birds can aid management of the invasive tree and help predict its effects on birds. Focusing on the functionally similar species of birds that interact with Callery pear is useful to better understanding dispersal patterns and rates (Levey and Martínez del Rio 2001, Gosper et al. 2005).

European Starlings

European starlings (*Sturnus vulgaris*) are an invasive bird species that were brought to the United States in the 1890's. New Yorkers wanted their local fauna to reflect those in Shakespeare's plays. They have since multiplied

and spread throughout North America and other countries (Linz et al. 2007, Fig.1), becoming a problematic and detrimental invasive species.

Fig. 1 Map of European starling observations in the continental United States from eBird, year-round, from 1900 to present day. Image provided by eBird (www.ebird.org) and created 2022.



European starlings prefer building nests in both natural and artificial cavities but can nest in dense vegetation or on the ground (Cabe 2020). They have generalist diets and eat both plants and invertebrates. Starlings adapt quickly to new food sources when familiar ones are unavailable (Lafleur et al. 2007), so they are likely to utilize Callery pear after other food sources are depleted. Starlings often forage in old-agricultural fields, edges, and areas where invasive plants and Callery pear are common (Lafleur et al. 2007) and have strong flocking tendencies for which they are well-known. They have unique behavioral displays known as murmurations where flocks move in collective patterns (King and Sumpter 2012), with an average size of per 30,082 ± 6,699 SEM birds per murmuration (Goodenough et al. 2017). Larger starling flocks that forage together occur in the later summer to winter, making them strong seed-dispersing groups due to larger number of seeds dispersed at a time

(Chavez-Ramirez and Slack 1994, Fischl and Caccamise 1987). Migration is variable among starlings, as some are year-round residents and others migrate southwards (Kessel 1953). These starling foraging behaviors may significantly improve Callery pear dispersal since its fruits are readily eaten between late autumn and winter (Culley and Hardiman 2007), it is often found in disturbed areas, old fields and edge habitats (Culley and Hardiman 2007, Vincent 2005, Swearingen et al. 2010), and migratory birds can spread seeds over greater distances. Starlings consume and disperse numerous invasive plants including Russian olive (*Elegaganus angustifolia*)(LaRue 1994), Amur honeysuckle (Bartuszevige and Gorchov 2006), Chinese tallow tree (Renne et al. 2002), and English holly (*Ilex aquifolium*)(Zika 2010). As dispersers of Callery pear and other invasive plants, starlings may be contributing to invasional meltdowns. An invasional meltdown occurs when two or more invasive species aid each other's invasion. Invasive plants feed starlings and starlings disperse their seeds. Invasional meltdowns result in biological invasions that are more severe than if each species were acting alone (Simberloff and von Holle 1999).

American Robins

American robins (*Turdus migratorius*) are native to the United States and are commonly found in urban, suburban, and rural areas. Many migrate from Canada and the northern U.S. to the southern U.S. and Mexico (Vanderhoff et al. 2020). Robins overall have variable nesting site selection and will likely nest in a tree like Callery pear (Howell 1942). Robins have experienced lower nest success in invasive shrubs like honeysuckle and multiflora rose. (Schmidt and Whelan 1999, Borgmann and Rodewald 2004), but the height of Callery pear trees may provide more protection for robin nests. Fruit is much more important and frequent in their diets in the fall and winter (Wheelwright 1986). They are willing to try novel fruits even when familiar fruits were present, suggesting they will eat Callery pear even when other food sources are available (Lafleur et al. 2007). Robins typically eat fruit whole, which disperses seeds away from the parent plant (Witmer 1996). They

can regurgitate large seeds (6 mm), shortening the seed voiding time, and pass smaller seeds (3 mm) through their gut (Murray et al. 1993). Callery pear seeds are typically 5mm, so more research is needed to understand whether robins regurgitate Callery pear seeds. They have short gut retention rates overall, which can result in shorter dispersal distances (Karasov and Levey 1990). White and Stiles (1991) found that robins in old fields and mixed age and mature woods consumed fruits with an average size of 3.7-9.0 mm in diameter, but all fruits in the study were 3-8 mm narrower than the average gape width of robins. Therefore, many Callery pear fruits (10-15 mm) are within their average gape width. Wheelwright (1986) found that robins consumed *Rosaceae*, the family containing Callery pear, more than other taxa across their North American range. Robin flocks can consist of up to several hundred individuals (Vanderhoff et al. 2020). Chavez-Ramirez and Slack (1994) found that robins dispersed Ashe juniper in a scattered distribution due to their loose flock structure, differing post-foraging perch sites, longer distances traveled from parent trees, and post-foraging invertebrate consumption on the ground. The loose flock structure will impact Callery pear dispersal patterns, and the other post-foraging behaviors suggest robins effectively disperse Callery pear away from the parent plant into new areas. They are known dispersers of invasive plants such as European hawthorn (*Crataegus monogyna*) (Sallabanks 1993a), Amur honeysuckle (Bartuszevige and Gorchov 2006), Chinese tallow tree (Renne et al. 2002), and English holly (*Ilex aquifolium*)(Zika 2010). Robins move between abundant fruit sources and disperse seeds at edge habitats. Bartuszevige and Gorchov (2006) suggested that robins were contributing to a positive feedback loop of Amur honeysuckle at the edges of woodlots. The birds disperse the invasive plants at the edges, the plants grow at the edges, and the birds are drawn to the fruit at the edges. American robins, European starlings, and Cedar waxwings are all found foraging at edge habitats, and likely are creating a positive feedback loop for Callery pear at edge habitats.

Cedar Waxwings

Cedar waxwings (*Bombycilla cedrorum*) have yet to be cited by any study as dispersers of Callery pear, however, there is evidence that they consume the fruits. One study assessed the danger of windows near Callery pear trees for Cedar waxwings. They were attracted to the fruit on the trees and subsequently collided with windows more often (Brown et al. 2020). Additionally, the pilot study survey had reports of Cedar waxwings feeding on the trees (*pilot study*). The images below show Cedar waxwings in Callery pear trees, and in some, they are clearly eating the fruit (Fig. 2). Waxwings are also known to disperse invasive plants, specifically, honeysuckle (Witmer 1996b) and multiflora rose (Drummond 2005), Brazilian Pepper Tree (Kinde et al. 2012), *Rhamnus* and *Elaeagnus* (Labbé and King 2020).

Fig. 2 Cedar waxwings (*Bombycilla cedrorum*) eating Callery pear (*Pyrus calleryana*) fruit.

A. (Annis, n.d.)

B. (Fisher, n.d.)

C. (Beers, n.d.)

D. (Williamson, 2012a)

E. (Williamson, 2012b)

Cedar waxwings are a native bird in the United States. Many Cedar waxwings migrate south for the winter (Brugger et al. 1994, Witmer et al. 2020). Waxwing populations have seen range expansions and population increases in the last 20 years, likely because of urban and agricultural fruiting shrubs and trees, including those in old fields and edge habitats (Brugger et al. 1994, Witmer 1996a). Callery pear is likely contributing to their expansion due to it being a fruiting tree found in many of those locations. Waxwings move in large, tight flocks, and thus, remove and disperse substantial amounts of fruit together. Their typical post-foraging behavior (i.e. staying on one perch between foraging) causes their dispersal distribution of seeds to be clumped, which will affect Callery pear dispersal patterns (Chavez-Ramirez and Slack 1994). Waxwings usually nest in wooded edges and old fields (Witmer et al. 2020). Putnam (1949) found they often picked limbs of maple, cedar, apple, and pear trees for nests in northern Ohio. Therefore, they likely nest in Callery pear. Cedar waxwings are especially important dispersers for many plants. They are one of the most common avian frugivores in North America and one of the few avian fruit specialists (Witmer et al. 2020). They eat fruits whole most have a high sugar content like Virginia juniper, apples (*Malus* and *Pyrus*), and cherries (*Prunus*)(Witmer 1996a). They prefer fruits 6–8 mm in diameter and have made food choices based on abundance and caloric content (McPherson 1987, Avery et al. 1993). Because of their fruit-heavy diet, waxwing feces is more acidic, which has been suggested to inhibit germination for honeysuckle (Witmer 1996a, Bartuszevige and Gorchov 2006). It is possible that their acidic feces may promote germination for Callery pear since it has shown to lower the pH of the surrounding soil, likely from its leaf litter (Woods et al. 2021), and it grows well in a range of pH levels (Culley and Hardiman 2007, Gilman and Watson 1994). Cedar waxwings have extendable portions of their esophagi where they can store extra food and eat at faster rates (Levey and Duke 1992). This feature adds to their effectiveness as a disperser. Eating fermented fruits has led to life-ending

injuries for waxwings that were caused by alcohol intoxication (Fitzgerald et al. 1990, Kinde et al. 2012), so they are more likely to be harmed from fermented Callery pear fruits than other bird species.

Conclusions and Hypotheses

The relationship between avian communities and invasive plants is inextricably complex and has important ecosystem implications. Callery pear is an invasive tree in the United States that has sparked an upwelling of research (Vogt et al. 2020, Coyle et al. 2021, Sapkota et al. 2021, Woods et al. 2021, Hartshorn et al. 2022, Maloney et al. *in review*). While being cited as a bird-dispersed plant, there is little literature available on Callery pear and bird interactions, and its role as a shelter and food source for avian communities is not understood. A better understanding of Callery pear and bird interactions can aid the management of invasive trees and ornithological and ecological studies. These are potential hypotheses raised by this review that future research could focus on include: (1) Early leafing of Callery pear could attract nesting birds earlier than other native plants. (2) Callery pear may provide a safer nest substrate than lower invasive shrubs but should also be compared to native nesting substrates. (3) Callery pear is likely an important winter food source for birds. (4) Callery pear's nutritional value may affect fruit selection by birds and bird health. (5) Birds consume more Callery pear fruit after it is softened by a frost. (6) Softened Callery pear fruit has the ability to ferment and cause alcoholic intoxication for birds that eat the fruit, which may lead to injuries and deaths. (7) Callery pear may affect the overwintering and migration ranges of birds. (8) The abundance and availability of Callery pear fruit are likely to affect bird food choices. (9) Fruit color display is unlikely to impact bird food choice. (10) European starlings, American robins, and Cedar waxwings are likely the most prominent consumers and dispersers of Callery pear. (11) Cedar waxwings (and possibly other bird species) are underrepresented in Callery pear literature despite being important dispersers with unique relationships with

Callery pear. (12) Identifying functional groups of the birds that eat Callery pear will help predict its dispersal patterns and help manage its spread. (13) Different species of birds are likely to produce different spatial patterns of Callery pear seed dispersal at different locations. (14) European starlings, American robins, and Cedar waxwings are likely in a positive feedback loop with Callery pear being dispersed at and growing at edge habitats. (15) Callery pear seeds may experience increased germination after bird gut passage. (16) Cedar waxwings may further increase the germination of Callery pear by consuming and defecating the seeds if acidic feces is present on the seeds. (17) European starlings, American robins, and Cedar waxwings likely gulp Callery pear fruit and carry seeds farther from the parent plant than if the fruits were larger. (18) American robins may regurgitate larger Callery pear seeds, affecting both the dispersal distance and gut scarification. (19) An invasional meltdown is occurring between Callery pear and European starlings.

Pilot Study

Through the University of Dayton, Olivia Clark conducted a survey to use citizen science in assessing Callery pear and bird interactions in Ohio. A Google form was sent in August and November 2021 to the Ohio-birds email listserv organized by Miami University. A total of 16 responses were given to the Google Form and 6 email responses including relevant observations or information were given. All of the Google Form responses indicated these interactions were located in either urban or suburban areas (Fig. 3).

Fig. 3 Responses from Ohio birders about bird and Callery pear (*Pyrus calleryana*) interactions recorded from August to December 2021 through a Google Form survey. One response indicated a confidence level of 4 out of 5 in identification, and all others indicated a 5 out of 5. All responses were reported the between August and December 2021.

Bird species:	Please briefly describe the interaction (the bird was in the tree, it was eating fruit, etc.).
Cedar Waxwing	A group of 5-7 waxwings were ravaging the Callery Pears in our negihborhood
Blue-gray gnatcatcher	Observed the gnatcatcher at the top of the tree, flying out into the yard and returning to the tree. It went to nearby trees but always returned to the pear tree.
Carolina Chickadee	Observed chickadee work the tree for bugs. Joined by another one. Both flew off, one returned and worked the tree again.
Ruby-throated hummingbird	There are three hummingbirds (male and female) that come to my yard and frequent this resting spot multiple times a day. I have seen them go from leaf to leaf as well.
Blackburnian warbler	Eating bugs off leaves during rain
Magnolia Warbler	Feeding off bugs in tree early morning
Eastern wood pewee	Sitting in tree, flying out from branch to catch bugs and returning to perch
Red-eyed vireo	Picking bugs off tree
Yellow-bellied Flycatcher	Catching flies, returning to branch. Eliminated least flycatcher due to length of tertials (extending past tail).
Least Flycatcher	Feeding off flies, leaving branch to catch and returned to tree
Ruby-crowed kinglet	Quickly jumping from branch to branch picking at bugs
Magnolia Warbler	Picking bugs off leaves
cardinal	2 cardinals feeding on lawn under tree, then flew up into branches, all leaves still green
european starling, cardinal, robin	The Bradford Pear trees are along the edge of the property between the park and Arlington Memorial Gardens Cemetery. I observed them from the cemetery. All 3 species were in the same tree eating the fruit.
American Robin	They were eating the fruit. I am not 100% sure on my tree id. I need the leaves! I hope this is Callery Pear.
American Robin and European Starling primarily, a couple of House Finch and House Sparrows were in the trees or on the ground, but didn't notice them feeding. Were they after the seeds in the fruit?	Both Am. Robins and Euro. Starlings were in the Callery Pear trees as well as on the ground where the fruits were mostly mashed. Both robins and starlings were feeding on the fruits either from the tree directly or from the ground. Some of the robins swallowed fruits whole from the tree, starlings and robins both were picking at the fruit pulp if fruits were on the ground. As mentioned earlier, House Finch and House Sparrows were in the trees but did not notice them feeding on the fruits.

From the survey responses, it appears European starlings, American robins, Cedar waxwings, and Northern cardinals ate Callery pear fruit, but many other species used the trees for other food sources like insects. A few of the locations were described as suburban, where the Callery pears are expected to be ornamental and not part of an escaped population. The Cedar waxwing interaction was reported in August, which is earlier than expected based on

Callery pear and invasive plant literature that observed birds mainly consuming these fruits in late autumn and winter (Culley and Hardiman 2007, White and Stiles 1992). Observations submitted through email responses also indicated birds do not eat Callery pear until late autumn after the fruits were softened. This highlights the importance of studying the seasonality of Callery pear fruit consumption. Many of the photos submitted were of the insectivorous bird species, but there were two images of an American robin eating Callery pear (Fig. 4). There were also responses suggesting that birds were eating the fruit pulp off of the ground (Fig 5). If birds are eating fruits off of the ground, this can affect whether the birds still contribute to dispersal at this time or at the same magnitude. If the birds are eating the mushed pulp, they may not necessarily be eating, and thus dispersing, the seeds. Additionally, dispersal can be affected if the seeds are exposed to seed predators due to the fruit being open on the ground. Seed predators eating these exposed seeds will likely damage the seeds so that they cannot be dispersed. Thus, the timing of fruit softening and falling and subsequent feeding behaviors should be explored further.

Fig. 4 American robins (*Turdus migratorius*) consuming Callery pear (*Pyrus calleryana*) fruits on 25 December 2021.

Fig. 5 Callery pear (*Pyrus calleryana*) fruit litter on the ground with American robins (*Turdus migratorius*) nearby. Some fruits are crushed. Pictures were taken on 29 December 2021.

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