Attractiveness of Species of Vitex (Chastetree) to Pollinators

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Abstract

Native and non-native bees are important pollinators of both food and ornamental crops. However, bee populations across the world have declined, mainly through loss of habitat. Careful selection of landscape plants in urban areas can help mitigate habitat loss and create new habitat for pollinators. Ten mature genotypes of Vitex, comprising V. agnus-castus L., V. negundo L., and a hybrid between V. agnus-castus x V. rotundifolia L. f., were evaluated during June and July 2016 to assess their attractiveness to pollinators. Pollinator counts were taken two times daily, at 9:00 a.m. and 11:00 a.m., twice weekly for three weeks. Pollinators were also captured from the Vitex plants for identification. Insects captured from Vitex plants were identified to genus and bumblebees [Bombus spp. (Latreille, 1802)] were further identified to species. Bumblebees and honeybees [Apis mellifera (Linnaeus, 1758)] were more numerous on Vitex plants than carpenter bees. V. agnus-castus plants attracted more bumblebees than honeybees. V. negundo and the V. agnus-castus x V. rotundifolia hybrid attracted more pollinators over the course of the study than V. agnus-castus. Our study shows that Vitex plants can be a good resource to support pollinators in an urban landscape.

Index words: urban landscape, bumblebees, honeybees; Vitex agnus-castus, Vitex negundo, Vitex rotundifolia.

Species used in study: Vitex agnus-castus L.; Vitex negundo L.; Vitex rotundifolia L.

Significance to the Horticulture Industry

Ornamental plant breeders who produce cultivars of exotic plant species are increasingly required to prove that their cultivars are not detrimental to the environment. Pollinators have been of special concern in recent years. We explore the attractiveness of Vitex cultivars to pollinators in this study. Our findings indicate that cultivars of Vitex species are attractive to both honeybees and bumblebees, as well as other pollinators, and should be included as part of an urban landscape designed to support pollinators.

Introduction

Pollinators contribute both economically and ecologically to the regions in which they live. An estimated 87.5% of flowering plants globally, approximately 308,000 species, are pollinated by bees and other animals (Ollerton et al. 2011). The value of food crop pollination services in the United States was estimated to be approximately 14.6 billion dollars per year in 2009 (Koh et al. 2016). Wild bees were estimated to provide 20% of the food crop pollination services provided (Koh et al. 2016). Pollinators have also been shown to increase the value of ornamental plants such as holly (Ilex spp.) by increasing berry production (Ollerton et al. 2016).

Unfortunately, populations of honeybees and native bees such as bumblebees have declined in recent years. Both native bees and honeybees have been exposed to pesticides such as neonicotinoids, pathogens such as Nosema (Nägeli, 1857), and pests such as varroa mites (Varroa destructor Anderson & Trueman), which may all have contributed to population declines (Cameron 2011, Goulson 2015). Habitat loss is also considered to be a significant reason for the decline of bee populations (Brown and Paxton 2009, Goulson 2015). Conversion of natural habitat to agricultural production and fragmentation of the landscape by cities and suburbs has decimated habitat for nesting and destroyed food sources for bees (Potts et al. 2010).

Fragmented habitat can lead to smaller bee populations with decreased genetic diversity and less resistance to pests and pathogens (Cameron 2011). Although most pollinator studies have been on the major pollinators, such as honeybees and bumblebees, habitat loss, pesticides, pathogens, and pests may also adversely impact lesser-studied pollinator species.

The world is becoming increasingly urban. In 2014, 54% of the world’s population was estimated to live in urban areas; the figure is estimated to be 66% by 2050 (United Nations 2014). With increasing development comes a loss in bee species richness (Hernandez et al. 2009). However, incorporation of plants that support pollinators in urban landscapes may help mitigate habitat loss. Urban areas had a higher number of bee species in studies comparing urban and agricultural areas (Senapathi et al. 2017). Bumblebees in urbanized areas had higher reproductive fitness and colonies contained more stored food than those in agricultural areas in a study comparing cities, villages, and agricultural areas in England (Samuelson et al. 2018). The composition of plant species in urban areas has a large effect on the area’s ability to support pollinators. In a study of the richness of pollinator species in New York City, neighborhood areas planted with cultivars of common horticultural species such as Petunia Juss. and Hydrangea L. were less attractive to pollinators than nearby green-spaces, which had a more varied mix of plant species (Matteson et al. 2013). Clearly, careful consideration must be given to the choice of species and cultivar when planning urban gardens when the goal is to provide habitat for pollinators.
Table 1. Genotypes, parentage, and morphological characteristics of *Vitex* used in the pollinator study.

| Genotype                  | Species or Parentage         | Flower Color | Plant Height (cm) | Plant Width (cm) | Flower Width (mm) | Flower Length (mm) | Flower Area (mm²) |
|---------------------------|------------------------------|--------------|-------------------|------------------|-------------------|-------------------|------------------|
| F. Danica Pink™ †         | *V. agnus-castus*            | Pink         | 250.0             | 400.0            | 4.7 ± 0.33        | 6.6 ± 0.26        | 31.0 ± 2.23      |
| F. Pink Pinnacle™ †        | *V. agnus-castus*            | Pink         | 353.0             | 491.5            | 6.9 ± 0.33        | 3.9 ± 0.26        | 26.6 ± 2.23      |
| F. Dale White™ †           | *V. agnus-castus*            | White        | 502.0             | 458.5            | 6.7 ± 0.33        | 5.9 ± 0.26        | 39.1 ± 2.23      |
| F. Petty Blue™ †           | *V. agnus-castus*            | Blue         | 437.0             | 484.5            | 8.0 ± 0.33        | 3.0 ± 0.26        | 24.0 ± 2.23      |
| F. ‘Salinas Pink’          | *V. agnus-castus*            | Pink         | 297.0             | 450.0            | 7.5 ± 0.33        | 4.4 ± 0.26        | 33.3 ± 2.23      |
| F. ‘Silver Spires’         | *V. agnus-castus*            | White        | 286.0             | 395.0            | 7.7 ± 0.33        | 3.6 ± 0.26        | 27.4 ± 2.23      |
| V. *negundo* heterophylla  | *V. negundo*                 | Blue         | 313.0             | 454.5            | 7.7 ± 0.33        | 2.1 ± 0.26        | 16.1 ± 2.23      |
| VHET *negundo*             | *V. negundo*                 | Blue         | 408.0             | 487.0            | 8.0 ± 0.33        | 2.0 ± 0.26        | 16.0 ± 2.23      |
| Little Madame              | *V. negundo*                 | Blue         | 261.0             | 411.0            | 7.3 ± 0.33        | 2.0 ± 0.26        | 14.6 ± 2.23      |
| V0502-7                    | *V. agnus-castus* x *rotundifolia* | Blue     | 265.0             | 364.5            | 13.3 ± 0.33       | 4.0 ± 0.26        | 53.3 ± 2.23      |

Species of *Vitex* range from small shrubs to large trees and have long been used as ornamental plants in the landscape (Rani and Sharma 2013). The genus *Vitex* is the largest in the Verbenaceae family (Rani and Sharma 2013). Species of *Vitex* are distributed in Asia, India, the Mediterranean, Pakistan, Sri Lanka, and Southern Europe (Rani and Sharma 2013). Both *Vitex agnus-castus* and *V. negundo* have been used as honey plants (Dogan et al. 2011, Harugade et al. 2016). Flowers of *Vitex* species are attractive to a wide range of pollinators, including honeybees, bumblebees, and butterflies (Ashoke and Sudhendu 2012, Jain 2013, Murren 2014, Reddy et al. 1992).

Since *Vitex* is not native to the United States, the question remains as to whether it is a good choice for a landscape plant to support native bees as well as honeybees. Exotic plants have been shown to be detrimental to some native pollinators (Wilde et al. 2015). Species abundance was four times greater on sites planted with native plants than on sites planted with exotic plants in a study of Lepidopterans in suburban landscapes in Pennsylvania (Burghardt et al. 2009). However, Stout and Morales (2009) concluded that exotic plants could support generalist pollinators in a landscape with few other floral resources. The native status of a plant had no significant effect on attractiveness to pollinators in a study of native and cultivated varieties of flower species in Britain (Garbuzov and Ratnieks 2014). Modifications of floral morphology through plant breeding, such as double flowers, had more effect on attractiveness to pollinators than native status in studies of garden flowers in Britain (Corbet et al. 2001, Garbuzov and Ratnieks 2014). Attractiveness of an exotic plant species to pollinators will vary with the species and must be evaluated on a case-by-case basis.

In this study, our primary objective is to evaluate the attractiveness of *Vitex* to pollinators. As part of this objective we sought to answer the question: are both exotic and native pollinators attracted to *Vitex*?

**Materials and Methods**

The study was conducted during the months of June and July 2016 in a field plot at the University of Georgia campus in Griffin, GA. Ten mature genotypes of *Vitex* were selected (Table 1, Fig. 1). Six were genotypes of *V. agnus-castus*, three were cultivars or selections of *V. negundo*, and one was an interspecific hybrid between *V. agnus-castus* and *V. rotundifolia*. All genotypes were in full bloom at the beginning of the study. The composition of plants in and immediately surrounding the field plots was *Abelia spp.* R. Br. (in bloom), other woody ornamental plants (not in bloom), grasses (both cultivated and wild) and weeds, and mixed hardwood forest (behind the field plot). The University of Georgia Research and Education Garden was located northeast of the field plot, across a road and approximately 403 m (1,322 ft) distant in a straight line, and contained mixed annuals, perennials, and woody ornamentals, some of which were in bloom at the time of the study. Also, located in the Research Garden were several hives of honeybees. The *Vitex* field plot consisted of 9 rows spaced 4.6 m (15 ft) apart. Each row contained 24 *Vitex* plants spaced 2.4 m (8 ft) apart. *V. agnus-castus* plants used in the study were toward the north end of the plot and *V. negundo* plants toward the south end. The *V. agnus-castus* x *V. rotundifolia* hybrid was approximately in the middle of the plot. In 2016, 101 *Vitex* plants of various ages were growing in the field plots. Of these plants, 87 were *V. agnus-castus*, 12 were *V. negundo*, 2 were *V. trifolia*, and one was the *V. agnus-castus* x *V. rotundifolia* hybrid. For this study, we chose only mature specimens of *Vitex*: 6 genotypes of *V. agnus-castus*, 3 genotypes of *V. negundo*, and the *V. agnus-castus* x *V. rotundifolia* hybrid. None of the plants used in the study were at the ends of the rows. Since we were constrained by using mature plants, we had one plant per genotype as some of the genotypes had not been replicated, or had replicates that were considerably younger than the mature genotype. Height and width measurements were of the individual trees.

Pollinators were counted twice a day at 9:00 and 11:00 AM. Morning hours were chosen based on prior observation of pollinators in the field and information from prior studies (Jain et al. 2013, Gurel et al. 2008). Counts were repeated twice a week for three weeks. Counts were discontinued when the peak blooming period was substantially over. Pollinators on each plant were counted for a three-minute period on opposite sides of the plant. Following the counts, pollinators were captured from each plant that had been used in the counts by placing a 3.8 L (1 gal) plastic bag over a randomly selected inflorescence containing at least one pollinator, closing the bag with the
Fig. 1. Flowers of the two species and one hybrid of Vitex used in the study. Fig. 1a. Flowers of V. agnus-castus. Fig. 1b. Flowers of V. negundo. Fig. 1c. Flowers of hybrid of V. agnus-castus x V. rotundifolia.
pollinator inside, and sealing it. Five bags per plant per count period were collected when possible, and were labeled by date, time of collection and plant identification code. Captured insects were killed by placing the plastic bags in a freezer at 0°C (32°F). Insects were stored in the freezer and later identified to genus with a Wild MPS545 stereomicroscope (Wild Heerbrugg Ltd., Heerbrugg, Switzerland). Identifications were made by the first author with the aid of a reference collection provided by the Department of Entomology at the University of Georgia. Specimens from the site were sent to, and stored at, the Museum of Natural History, University of Georgia, Athens, GA.

Captured insects were identified to three main categories: honeybees, bumblebees, and carpenter bees [Xylocopa spp. (Latreille, 1802)]. Pollinators in the genus Bombus were further identified to species. Small pollinators and lepidopterans that had been captured were not included in the analysis as they were not considered to be major pollinators of the Vitex plants. After identification, captured insects were stored in a freezer in the laboratory at 0°C.

Flower size was determined for each of the genotypes in the study. Ten flowers from each plant in the study were collected during the peak bloom period. Flowers were not all from the same inflorescence on each plant. Flower length was measured from the bottom of the corolla tube to the tip of the corolla. Flower width was measured across the widest part of the corolla. A flower area was calculated by multiplying width times length.

Data were analyzed with SAS 9.3 (SAS Institute, Inc., Cary, NC) using Proc Glimmix. A log link function was used for count data. Transformed data were backtransformed for presentation. Data were analyzed as a repeated measures experiment and date was treated as a random effect (Millar and Anderson 2004). Means separation was performed using Tukey’s HSD (P < 0.05) for differences within treatment method.

Results and Discussion
The difference among pollinator types captured on Vitex was significant over both species and the hybrid (p = 0.0006) (Fig. 2). More honeybees and bumblebees were captured than carpenter bees. Most of the bumblebees captured were Bombus impatiens (Cresson, 1863) (data not shown). However, specimens of B. griseolis (DeGeer, 1773) and B. bimaculatus (Cresson, 1863) were also caught on the Vitex plants.

The type of pollinator captured varied among the Vitex species and the hybrid (p = 0.0082). An interaction existed between pollinator type and the species of Vitex upon which it was captured (p = 0.0154) (Fig. 3). V. agnus-castus plants attracted fewer honeybees than plants of V. negundo or the V. agnus-castus x V. rotundifolia hybrid. No difference was found among the species and the hybrid of Vitex for bumblebees or carpenter bees. Flower color had no effect on the type of pollinator attracted to Vitex (p = 0.9150). No interaction was found between flower color and the species or hybrid of Vitex (p = 0.1214).

Differences in floral morphology may help explain pollinator preferences among species in the same genus. Flowers of V. negundo were shorter than those of either V. agnus-castus or the V. agnus-castus x V. rotundifolia hybrid (Table 1). A flower with a shorter corolla tube, such as V. negundo, might be more attractive to a short-tongued pollinator like the honeybee than a species with a longer corolla tube such as V. agnus-castus. Smaller pollinators preferred smaller-flowered species of Dalechampia L., while larger pollinators favored larger-flowered Dalechampia (Armbuster and Herzig 1984). Lavender (Lavandula xintermedia Emeric x Loisel. ‘Grosso’) was pollinated far more frequently by bumblebees while honeybees were the common pollinator on borage (Borago officinalis L.), which had shallower flowers (Balfour et al. 2013). In the Cambridge University Botanic Garden, UK, honeybees were attracted to shallower flowers than were bumblebees during an evaluation of twenty-four plant species for usefulness to pollinators as nectar sources (Comba et al. 1999).
Attractiveness of Vitex plants to pollinators may also be driven by other factors than corolla tube length, such as the scent of the flowers or the amount of nectar available. In a study of honeybees, bumblebees, and carpenter bees on Agave schottii Engelm., more honeybees occurred on plants and in sites producing high amounts of nectar, while carpenter bees were present on plants and in sites producing the lowest amount of nectar (Schaffer et al. 1979). Bumblebees occurred on plants and in sites that were intermediate for nectar production (Schaffer et al. 1979).

Attraction of pollinators to a plant may be driven by competition among pollinator species. A follow-up study of pollinators on Agave schottii determined that honeybees dominated patches of plants with high nectar productivity, effectively shutting out bumblebees until the nectar supply had been depleted (Schaffer et al. 1983). Honeybees outcompeted native bees of the genus Andrena (Fabricius 1775) on apple trees (Pyrus malus L.) in an old field in New York state (Ginsberg 1983). Foraging populations of two bumblebee species increased in number when honeybees were absent during the second year of a pollinator study in mountain meadows of the Rocky Mountains (Pleasants 1981). Since bumblebees were present in similar numbers on each species or hybrid of Vitex plants regardless of the number of honeybees present, competition from honeybees did not seem to affect bumblebees in our study.

The number of pollinators we counted during our study varied among species and the hybrid of Vitex. Genotypes of V. agnus-castus had fewer pollinators than those of V. negundo or the V. agnus-castus x V. rotundifolia hybrid (p < 0.0001) (Fig. 4). The difference is likely due to the lesser attraction to honeybees of V. agnus-castus than to V. negundo or the hybrid. Differences in attractiveness to pollinators among species and among genotypes within species are not uncommon. Two milkweed species, Asclepias exaltata L. and A. syriaca L., as well as their hybrid, attracted different numbers and types of pollinators (Stoepler et al. 2012). Attractiveness to pollinators varied among cultivars in a study of a crape myrtle species, Lagerstroemia indica L., and L. indica x L. faurei Koehne hybrids, although all cultivars supported both native and non-native bees (Riddle and Mizell 2016). Time of day of data collection made no difference in pollinator count in our study (p = 0.0645).

Our study shows that Vitex can be a good addition to the landscape to help support pollinators, including native pollinators such as bumblebees. A study of pollinators on both exotic and native species concluded that exotic plant species provided support for native pollinators, especially solitary bees, by providing additional floral resources and extending the time that floral resources are available to bees (Salisbury et al. 2015). When pollination networks in diverse areas of the world were examined, pollinator species richness was greater in locations containing exotic plant species as well as native species (Stouffer et al. 2014). Memmot and Waser (2002) showed that exotic plants could successfully integrate into the native plant-pollinator network, although the effects on native plants might be mixed. The addition of carefully selected non-native plants may enrich floral resources and lengthen bloom time in urban areas. Non-native plants such as Vitex may help mitigate fragmentation of landscape and habitat loss, providing much-needed support to pollinators.

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