Examining Native and Invasive Flower Preferences in Wild Bee Populations

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By Eileen C Reeves

Advisor: Dr. Rose-Marie Muzika

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Abstract

This experiment set out to determine if introduced and invasive flowers are less appealing to native pollinators, potentially contributing to the effects of habitat loss on these vulnerable insect populations. Invasive plants pose threats to native ecosystems by crowding out native plants and displacing native species. Wild bee populations face threats from habitat loss and fragmentation. To determine non-native flowers' effects on wild bees, I observed plots of either native or introduced wildflowers and counted the number of visits made by different genera of bees. I found no significant preference for native or introduced flowers in five of the six genera observed. One genus, *Lasioglossum sp.* showed a significant preference for introduced flowers.

Introduction

Insect pollinators face a wide variety of threats, from habitat loss and fragmentation to pesticides to disease. The federal Pollinator Research Action Plan describes the threats facing pollinators and calls for increased research to protect these integral species. Native bees, the most effective pollinators of many native plants, are a vital part of their ecosystems. Determining specific land management strategies aimed at protecting both the native plants and the insects that feed on them can facilitate healthier ecosystems.

An important aspect of land management is controlling invasive species. Invasive plants threaten native plant populations by crowding and outcompeting native plants for limited resources. In efforts to help bolster failing populations of native pollinators, providing land for wildflowers to colonize may not be sufficient: successional native plants may be required. As insect pollinators depend on plants for their food supply, any disturbance to the plant community has the potential to disturb the insect pollinator community. Some native bees, particularly Apidae genera *Xenoglossa sp*, *Peponapis sp*, and some Andreninae genera are highly specialized, visiting only one genus or species of plant. (Wilson and Carril, 2016.) While these bees are an extreme example, many bees prefer specific plants, and may be unable or unwilling to feed on introduced species. Wild bees will have co-evolved with the species native to their ranges, and may or may not be willing to feed on new species. In this study, I would like to learn how invasive and introduced plant species affect the native pollinator populations.

Previous literature gives conflicting information on this topic. In a review of relevant literature, Litt et al. (2014) found that pollinator prevalence decreases as invasive plant abundances increase. However, Lopezaraiza-Mikel et al. (2007) found that in plots with invasive plants, more pollinators were found. Yet another study found that in reclaimed farmland, pollinators showed a preference for native plants. (Morandin, Kremen 2013.) This topic is little studied, and more research is needed to determine the general effect of invasive and introduced plant species on native bee communities. In determining the potential effects these plants have on the pollinator community, land managers and others concerned with pollinator conservation can better understand how to save the vital parts of ecosystems.

The Upper Peninsula of Michigan contains unique ecosystems. A majority of this part of the state is covered in hardwood forest and forested swamp, with little urban or agricultural land. (Bourgeau-Chavez et al. 2017.) Wildflowers are contained to roadsides and occasional meadows. Bee diversity in the Upper Peninsula is lower than in many parts of the Lower Peninsula (Gibbs et al. 2017), though this could be due in part to sampling bias.

Methods and Materials

Study Site

All research was conducted at the University of Notre Dame Environmental Science Center on the border of Wisconsin and the Upper Peninsula of Michigan. The Center sits on 7500 acres containing hardwood forests, lakes, streams, bogs, and meadows. The plots used in this experiment were largely found in meadows, with some placed along roadways. (Figure 1.) To determine the food preferences of wild bees, I found 33 plots containing primarily one type of wildflower. Flower species can be found in Table 1. Plot size was not standard due to differing densities of flowers. I attempted to standardize flower density, prioritizing that metric over raw plot size. All plots were roughly one meter square, with none larger than 2 m^2 or smaller than 1 m^2.

Observational Methods

I observed each plot for 30 min at varying points during the day. 10am was the earliest start time, as bees are less active before then, and 5pm was the latest I began observations. All observations were made during days on which it was not raining. During each 30 min period, I recorded the number of visits made by wild bees, noting the genus for each visit. For some plots with a very high number of visits, it is probable that my counts were too low due to the abundance of visiting bees and the impossibility of counting every visit. I made an effort to visit each type of flower twice, to minimize any environmental effects. For example, several plots were along roads, and I found the same plant growing in a meadow to minimize any effect the road may have on pollinator visits. Such replication was not possible in every case due to scarcity of certain plants and time constraints. Of the 33 plots, 19 were comprised primarily of introduced plants and 14 were comprise primarily of native wildflowers. Of the 19 introduced, four are on an invasive species list for Wisconsin (WI DNR); *Melilotus alba, Linaria vulgaris*, *Leucanthemum vulgare*, *Lotus corniculata*. The rest are considered non-native, but not necessarily invasive. Because I wanted to determine the effect of non-native species on wild bees, I decided that both invasive and introduced species might reveal this, as neither would have the co-evolution of native species. There are several non-native bees in Michigan; the European honey bee, as well as a few others. I found no honey bees. It is likely that all the bees written about in this study are native to the area, though there is one non-native *Lasioglossum* (*L. zonulus*) found in Gogebic county that may have been observed.

Plants were identified to species with Newcomb's Wildflower Guide. I assigned each flower a status of "Native" or "Introduced." Since only a few of the introduced species were technically invasive, I merged the two categories for the sake of statistics. Bees were identified to genus on the wing, in the field. Identifying bees to species requires a specimen, and in some cases requires dissection, neither of which I wanted to attempt. I hypothesized that generic identification was enough to find statistical significance. In a few cases, I took photos and compared these photos to pictures taken by the USGS Bee Inventory and Monitoring Lab, which provides high quality macrophotographs of bees. Two genera were not included in my data analyses as they were only spotted at two plots, and therefore did not have enough data associated with them to reveal meaningful statistical results.

To analyze my data, I performed ANOVA tests to determine whether there was a significant difference in bee visits between native and introduced flower species. Both the bee counts as an overall count and each genus independently were tested for significant differences. All statistical tests were done using R. (R Core Team, 2016.)

Results

I found six genera of bees over the duration of my project. (Table 2.) Two in the family Apidae (*Bombus, Svastra*), two in the Halictidae family (*Halictus, Lasioglossum*), and two in the Megachilidae family (*Megachile, Osmia*). *Bombus* species were the most abundant. These large, extremely fuzzy bees are eusocial, living in large hives underground. According to Gibbs et al. 2017, there are nine species of bumble bees in Gogebic County. These bees are generalist feeders, showing no loyalty to any specific type of flower. The one *Svastra sp.* found, *Svastra obliqua,* was found at three plots. This species has a scattered range in MI, and is not confirmed to be present in this county. However, I am reasonably confident in my identification, and believe that based on its scattered presence throughout the state that it is reasonable for it to occur here. *S. obliqua* live in loose aggregations of females, nesting underground. These bees are pollen specialists, feeding only on pollen from flowers in the Asteracea family, though adults may also feed on nectar from other flowers. The genus *Halictus* has one species in this county; *H. rubicundus* (Gibbs et al. 2017). This species displays a range of social behaviors, with some individuals nesting in weakly social aggregations and other showing solitary nesting behavior. *H. rubicundus* is a generalist species, without specificity in feeding. *Lasioglossum* species were the second most commonly observed bees. There are nine species of *Lasioglossum* in Gogebic county, one of which is an exotic species. Without identifying the bees observed to species, I do not know whether this exotic species was observed or not. *Lasioglossum* is a large genus of small sweat bees. These bees are generalists for the most part, although some exceptions exist. They are extremely abundant in the United States and are important pollinators of many wildflowers. (Wilson, Carrill, 2016) The genus includes solitary, primitively eusocial, semisocial, and parasitic species. Most nest in the ground, with some nesting in rotting wood. At least one nest site was observed in my project. The family Megachilidae can be identified by the unique positioning of their pollen collecting hairs. While other bees have these hairs on their metathoracic legs, Megachilids have their pollen collecting hairs on the undersides of their abdomens. Two genera in this family were observed in this project. *Megachile* is large genus with species that display a large range of foraging behaviors. Species are most often generalists, with only a few showing specialist feeding. All species are solitary, nesting in a variety of environments. *Megachile* usually line their nests with leaves or flower petals. Five species of *Megachile* live in Gogebic county. Finally, I observed the one species of *Osmia* found in Gogebic county. *Osmia lignaria*, the blue orchard bee, is a solitary bee that nests in preexisting structures like beetle burrows or dead twigs. These bees are a dark metallic blue. While generalist feeders, *O. lignaria* prefer pollinating fruit trees and vines. County records all from Gibbs et al. 2017.

Overall, there was no significant difference in number of visits by wild bees to native and introduced flowers (Kruskal-Wallis chi-squared = 0.062407, df = 1, p-value = 0.8027). Examining each genus of bee separately, I found that *Bombus, Svastra, Halictus,* and *Megachile* showed no preference for native or introduced flowers (p=0.814, p=0.134, p=0.2336, p=0.803). The p value for the *Svastra* genus is approaching significance, and could potentially be significant with a larger sample size. One genus, *Lasioglossum* showed a significant preference for introduced flowers (p= 0.0281).

Discussion and Conclusion

The data analysis did not support my hypothesis that wild bees would prefer native wildflowers over introduced species. (Figure 2.) There was no significant difference in bee preferences except in one genus, which showed a preference for introduced flowers; the opposite of what I expected. (Figure 3.) These results suggest that generalist feeding strategies extend to non-native flowers. The introduced flowers could be closely related to native flowers so as to be appealing to bees, or could fulfill some other criteria bees use to choose their food. Of the 10 introduced flower species I examined, four genera do not have native species, and five genera do have native representatives in MI and WI. (One genus observed had two invasive species included in this project. Bumble bees have been shown to have color biases towards certain colors of flowers (Raine, Chittka 2007, 2006), and this innate choosing of flower color, shape, size, or some other criteria could matter more than evolutionary familiarity.

A future study could do well to extend this research. Very little is known about bee preference or avoidance of invasive plants, and while this project began that research, more could be done. This project was limited in size and time, as I was taking classes in addition to collecting data. This meant that I was held to bloom times that aligned with research weeks and did not have the chance to collect data on all the wildflowers found here. Further, this project was conducted in an area relatively lacking in bee diversity. Fewer than 50 species of bee are found in this county, and far fewer were found in this experiment. Extending the research throughout the summer would give a more complete picture of the floral and bee diversity. Repeating this experiment in an area with higher bee diversity could reveal if these patterns extend across more genera, especially specialist feeders.

These findings have implications for land management and pollinator conservation. Land set aside for pollinators, be it roadsides, abandoned farmland, or empty lots are all capable of supporting at least some wild bee diversity. Ensuring that plants in these areas be native is ideal, though non-native flowers will not necessarily detract from overall species composition and pollinator recovery. As native bees face threats from habitat loss, this research shows that habitat containing any flowers, not just native flowers, can help recover declining bee populations. More research is needed to determine whether all bee genera show this lack of necessity, but these preliminary results suggest that flowers, regardless of their native or invasive status are capable of supporting wild bee populations. Invasive flowers pose different threats, and should be managed appropriately, but they do not necessarily pose a threat to wild bees.

Tables

Flower Name	**Plant Status**	**Description**
Ranunculus acris	Introduced	Tall buttercup. Small, five-petaled yellow flowers on top of a 1’ – 3’ plant.
Hieracium aurantiacum	Introduced	Devil’s paintbrush. Small orange flowers, many petals, on a short fuzzy plant.
Trifolium repens	Introduced	White clover. Very small plants, clusters of three leaves, single round white flower on top. Common in lawns.
Trifolium pretense	Introduced	Red clover. Clusters of three leaves, plant terminating in a purple globular flower.
Chrysanthemum leucanthemum	Introduced	Common daisy. Yellow center surrounded by white petals. Single flower on a stalk 1’ – 3’ tall.
Potentilla recta	Introduced	Sulphur or rough-fruited cinquefoil. 5 petaled yellow flower, reminiscent of a simple rose. Flowers in clusters on a plant 31” tall. Stems hairy at the top
Lamium purpureum	Introduced	Purple Dead Nettle. Sprawling plant with a square stem. Uppermost leaves tinged with purple. Spike of small purple flowers.
Linaria vulgares	Introduced	Yellow toadflax, butter-and-eggs. Small plant with narrow leaves and yellow flowers in a raceme.
Melilotus albus	Introduced	White sweetclover. Clusters of three leaves, racemes of tiny white flowers. Plants from 3’ – 8’ tall.
Lotus corniculatus	Introduced	Bird’s foot trefoil, butter-and-eggs. Low, sprawling plants. Yellow flowers, leaves in

		clusters of five, though three are more prominent than the last two.
Iris versicolor	Native	Blue flag iris. Large, showy, dark purple flowers with a yellow patch at the base of the petal. Single flower on a stalk 4” – 31” tall. Leaved flat, oval, nearly as tall as the flower stalk. Grows in dense clumps.
Asclepias syriaca	Native	Common milkweed. Plant grows 2’ – 6’ tall. Large clump of white or pale pink flowers with 5 reflexed petals and an elevated central crown. Leaves very broad, opposite or whorled around the stem. Sap very thick, sticky, and white.
Asclepias incarnate	Native	Swamp milkweed. Plant grows 4’ – 5’ tall. Large clump of deep pink flowers with 5 reflexed petals and an elevated central crown. Leaves long and narrow. Very thick white sap emerges upon breaking leaves.
Rubrus allegheniensis	Native	Blackberry. Somewhat sprawling plant, more upright than related plants. Older stems woody, all covered in sharp prickles. 5 petaled white flowers, reminiscent of simple roses.
Stellaria sp.	Native	Chickweed. Very small white flowers. 5 petals, deeply lobed so as to appear as 10 petals. Low growing plants.
Heracleum maximum	Native	Cow parsnip. Plant can grow 5’ – 8’ tall. Small white flowers in a large umbel, 8” across. Leaves very large and deeply lobed.

Rudbeckia hirta	Native	Black-eyed Susan. Plants 2’ – 3’ tall. Single flower on each stem. Yellow petals around a dark black center. Narrow, fuzzy leaves.
Erigeron sp.	Native	Fleabane. Small flower heads, yellow centers with many narrow white petals around. 1’ – 3’ tall.
Hypericum punctatum	Native	Spotted St. John’s Wort. Clusters of 5 petaled yellow flowers at the top of a plant growing 1’ – 3’ tall. Leaves simple with a blunt point.
Achillea millefolium	Native	Yarrow. Clusters of small white ray-and-disk flowers on the top of a branching stem, 0.5’ – 3.5’. Leaves almost feathery, arranged spirally on the stem.

Table 1. All species of flowers observed in my experiment. In two cases, species could not be determined due to the similarity of the species in the genus. (USDA, NCRS. 2018; Newcomb 1977.)

Bee Family	**Bee Genus**	**Description**
Apidae	*Bombus sp.*	Large, densely hairy bees. Bright yellow and black striped bees, occasionally with orange on the abdomen. Eusocial, generalist feeders.
	Svastra obliqua	Large, fuzzy golden bees. Males with extremely long antennae. Solitary, pollen specialists on Asteraceae, though adults will eat nectar from other flowers.
Halictidae	*Halictus rubicundus*	Small, dark bee. Prominent white stripes on the abdomen. Pollen pockets on metathoracic legs. Generalist feeders. Variable sociality.
	Lasioglossum sp.	Large genus, generally small, dark bees. With or without striped abdomens. Wing

		venation weakens near margin. Variable sociality, generalist feeders.
Megachilidae	*Megachile*	Large genus, medium to large bees. Pollen carried on the underside of the abdomen as opposed to on the metathoracic legs. Individuals observed in this experiment superficially resembled *Bombus.*
	Osmia lignaria	Small, dark metallic bees. Solitary. Generalist feeders although they prefer fruit trees.

Table two. The families and genera of the bees observed in this experiment. Three genera were monospecific for Gogebic county, and are identified to species in the table. (Gibbs et al. 2017)

Figures

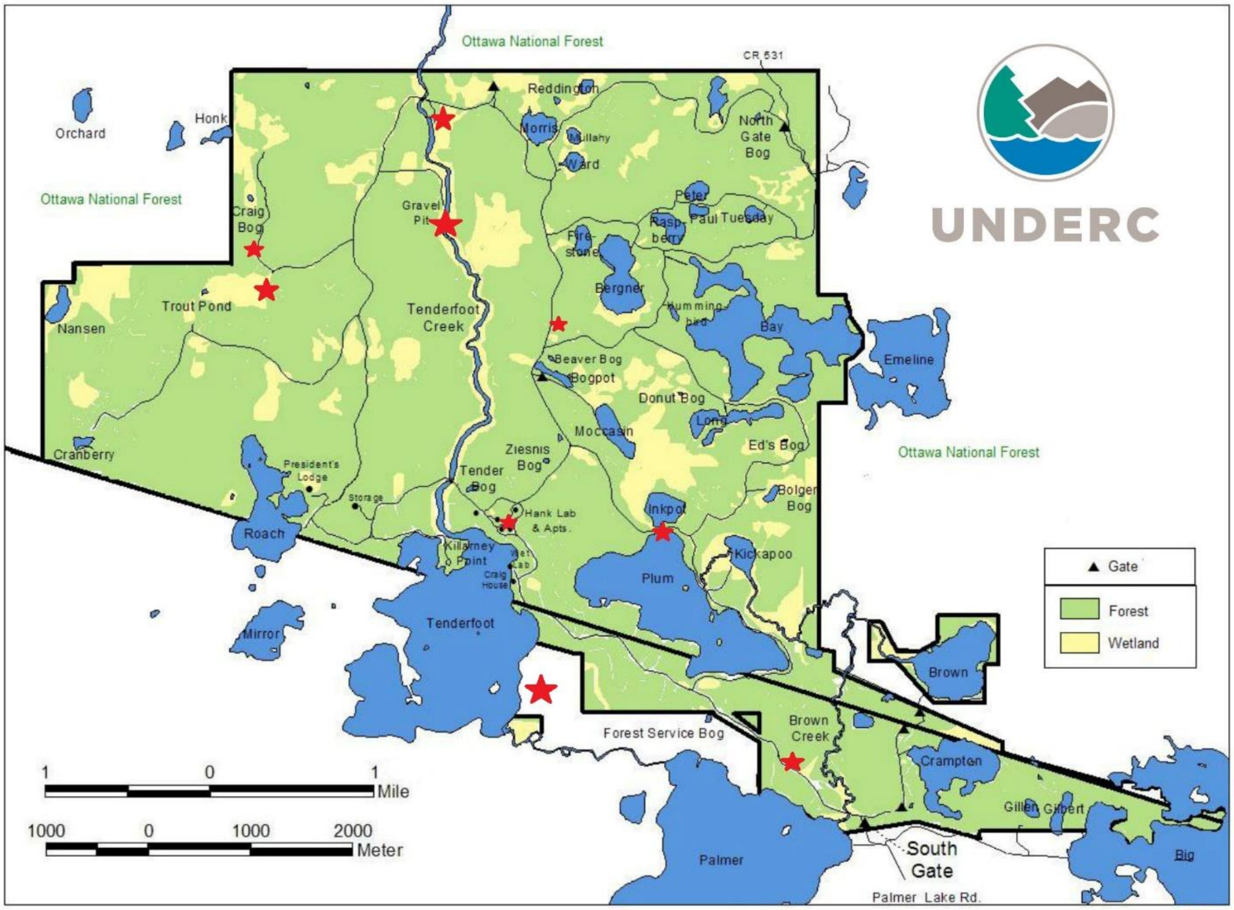

Figure 1. Site map of the UNDERC property. Plot locations marked with red stars. Several meadows contained multiple plots. Map from https://underc.nd.edu/

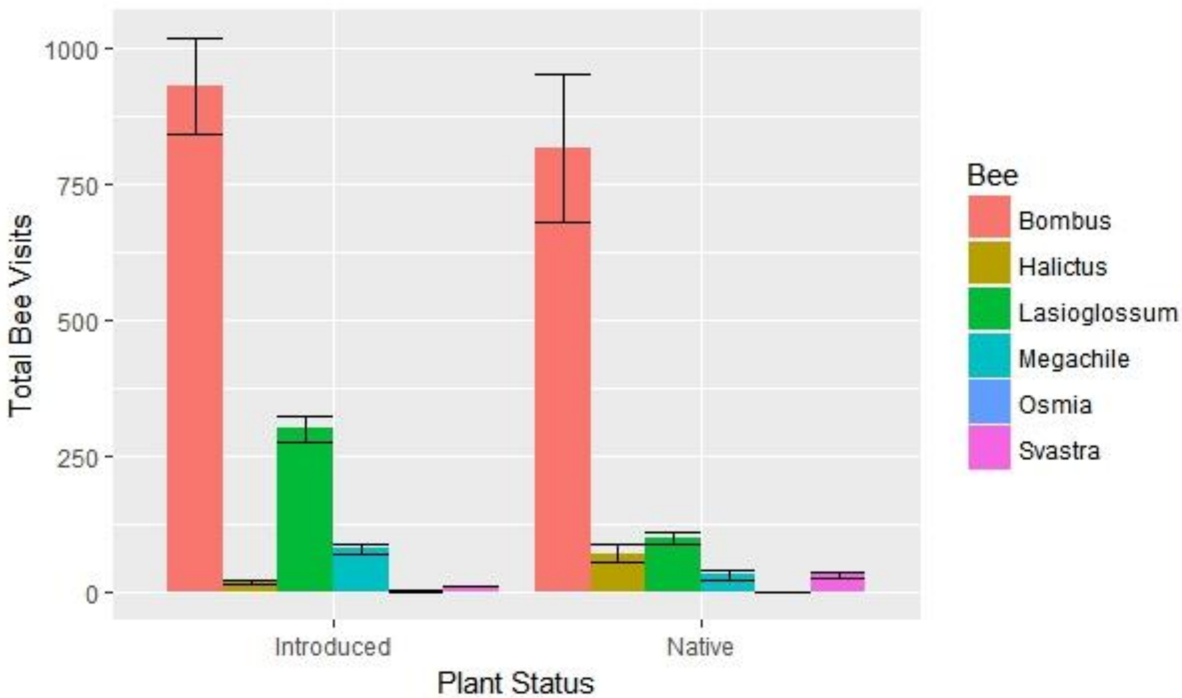

Figure 2. Comparing bee visits by genus to introduced and native flowers. Bars show the total number of visits summed across all flowers, separated into native and introduced flowers. Error bars are standard deviation, calculated with R. (R Core Team, 2016.) Five of the six genera showed no preference for either native or introduced flowers. *Lasioglossum sp.* showed a preference for introduced flowers, with non-overlapping error bars. Plots made with ggplot2. (Wickham, H. 2009)

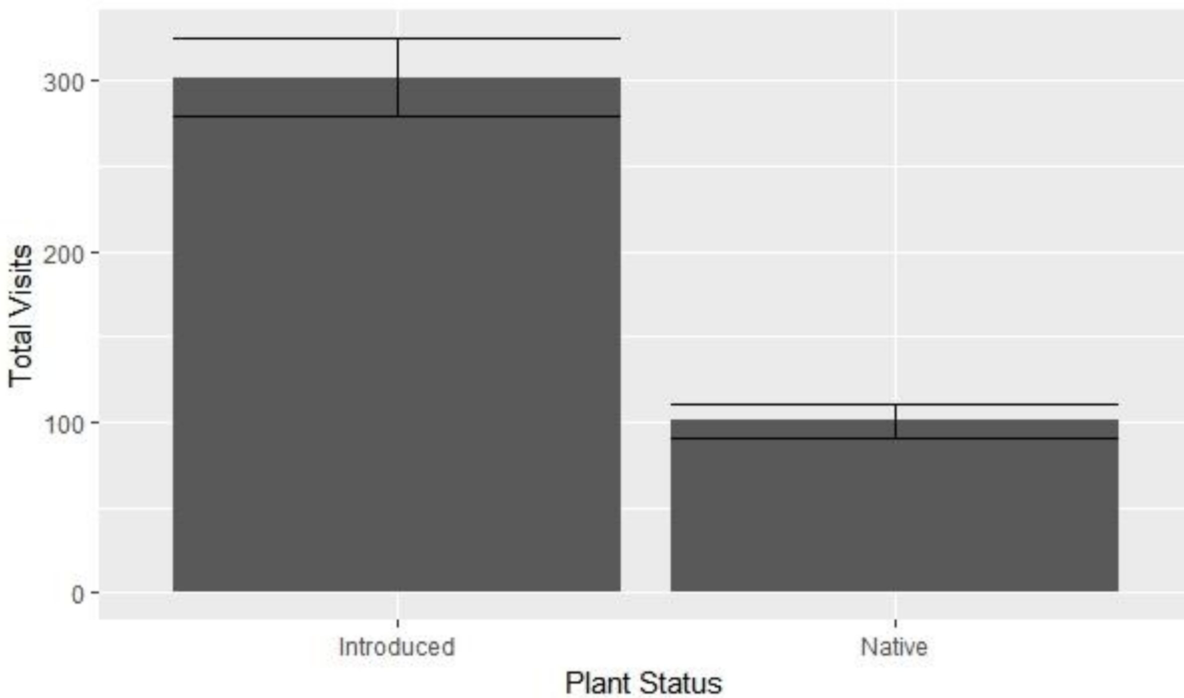

Figure 3. *Lasioglossum sp.* visits to introduced and native flowers. Bars show the total number of visits summed over all flowers observed, split into introduced and native bees. These bees showed a significant preference for introduced species. (p=0.0281.) Plots made with ggplot2. (Wickham, H. 2009)

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