Invaded: A Study of Wild Pollinator Responses to Introduced Flower Species

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Abstract

Pollinators are threatened primarily by habitat loss and fragmentation. Agriculture and ranching form large monocultures and areas of primarily wind pollinated grasses. In places where flowers are found, including state parks and national wildlife refuges, invasive species thrive and, in some areas, dominate. This study aims to determine whether native pollinators show feeding preferences between invasive and native flowers. If pollinators show little to no preference, then areas with any flowers, even invasive ones, should support healthy pollinator communities. I anticipate that Lepidoptera (butterflies and moths) and Anthophila (bees) will show greater preference for native species while Diptera (flies) will not show any preference My results show no significant preference for either native or introduced species on the whole. One genus showed significant preference for introduced flowers. Time of day was the most significant factor.

Introduction

Invasive species pose one of the greatest threats to biodiversity today. Invasive flowers outcompete native species for water, nutrients, and sun, which often leads to shifts in plant species composition and diversity, which can impact associated insect communities (Ridenour and Callaway, 2003; Callaway and Ridenour, 2004). Invasive plant/native plant interactions are well documented, but less so plant-insect interactions. This study set out to find whether invasive and introduced plant communities can host healthy pollinator assemblages.

Plant-insect interactions date back to the origin of flowers. Flowering plant diversity drastically increased as insect diversity did. Flowers co-evolved with insects due to pollination. Flowers that attract other organisms including but not limited to insects can spread their pollen further, increasing genetic diversity and seed production. Flowering plants also evolved to attract specific pollinators, and some pollinators evolved to only feed on specific plants. Generally, purple, blue, and white flowers attract bees while yellow and pink flowers attract butterflies (Dyer et al. 2006; Yurtsever, Okyar, and Gula, 2010). The shape of flowers also influences who will pollinate them. Long narrow flowers are most frequently fed upon by very small solitary bees and tiny flies, while large open-faced flowers are fed upon by butterflies and larger bees.

Bees (clade Anthophila) are the most efficient pollinators in the world. Their branched thoracic hairs, pollen collecting corbicula on their hind femora, and habit of actively collecting pollen to consume later all make them the most efficient spreaders of pollen between flowers. Specialism in their feeding strategies ranges from *Bombus spp.* who will feed on any flower whose nectar they can access, to *Xenoglossa spp.* who will only feed on plants in the Cucurbitaceae family. The feeding preferences of the bee genera, and all other groups found in this project, are described in Table 1. Wasps (suborder Apocrita, excluding Formicidae and Anthophila) and ants (Formicidae) are occasionally lesser pollinators of flowering plants. While many wasps and ants are carnivorous, some are nectar feeders that visit flowers, and some bolster their carnivorous diet with high-energy nectar. Despite lacking the pollen collecting hairs that make bees such effective pollinators, the tendency of wasps and ants to visit many flowers consecutively fosters pollen transfer. Of these two, it is important to note that wasps are generally much better pollinators than ants (Harriss and Beattie 1991). All wasps and ants are generalists in terms of nectar feeding. Flies (order Diptera) are often overlooked but incredibly important insect pollinators. The adults of many families feed exclusively on liquids, and nectar is a very high energy food source. Flower flies (Syrphidae) are well documented pollinators (Ssymank et al. 2008), though other families are known to pollinate as well. They, like wasps, lack any specific pollen carrying adaptations but visit flowers often enough to somewhat effectively move pollen between them. Flies are considered generalist feeders. Butterflies and moths (order Lepidoptera) are some of the most effective pollinating insects, excluding bees. Their bodies are covered in hairs that trap pollen, transporting it between flowers. Further, most butterflies and moths are obligate nectar feeders. While some lepidoptera larvae are specialist feeders, most adults are generalists and will feed on whatever floral resources they can access. Thrips (order Thysanoptera) are miniscule insects that feed on the liquid in plant cells. They pierce plant cells in the leaves, stems, and flowers to extract the juice inside. While pests in high concentrations, thrips also pollinate their host species. Being weak flyers and lacking any specific pollen carrying adaptations, thrips are not very effective pollinators, but are present in high enough numbers to be counted in this project.

Insects and flowers coevolved over many thousands of years. Invasive species are species with which native pollinators have not coevolved. Some invasive species have native relatives in a given area, and thus the insect pollinators are somewhat familiar with the plants. Some invasive species are totally alien, and insect pollinators will not have any sort of familiarity with them. Specialist feeders may be less likely to feed on introduced plants, while generalist feeders may be more likely to accept the new species as acceptable food sources. Williams, Cariveau, Winfree, and Kramer, 2011, found that insect pollinators are generally willing to feed on non-native species, but do not prefer these invaders over native species.

While prairies are, first and foremost, grasslands, the wildflower component of prairies cannot be overlooked. Grasses are wind pollinated, and so insect pollinators are a lesser but still vital component of the ecosystem. As more and more lands are dedicated to human development and agriculture, the prairies that support insect pollinators grow increasingly small and divided. Nearly 40% of insect species are faced with extinction, with Lepidoptera and Hymenoptera constituting the most threatened terrestrial orders (Sánchez-Bayo, Wyckhuys 2019). This same paper cites habitat loss from agriculture and urbanization as one of the top drivers of this loss of insect life. Therefore, the remaining land dedicated to natural ecosystems is vital to the continued existence of these insects. The role of public lands is clear; they represent some of the largest stretches of undisturbed or reconstructed prairie habitat in the country. In addition, corridors of habitat, such as along roadsides and in fallow fields can provide much needed food resources to insects if planted or allowed to fill with flowers. These habitat corridors are shown to increase pollen transfer, increase pollinator diversity, and encourage pollinator presence (Townsend, Levey 2005; Wratten et al. 2012).

The purpose of this particular project was to determine whether the composition of the flowers present influences the kinds and densities of pollinators living therein. Restoration requires money and effort, both of which are in short supply for public land managers and farmer's whose lands could host such habitat corridors. Disturbed land left to repopulate itself will fill in with invasive and non-native species, which are opportunistic and can out-compete native species for space. However, if these introduced species can host healthy and diverse pollinator communities, then restoration efforts to plant native species could be implemented over a long period of time, or at a lesser intensity without sacrificing effectiveness.

Methods

Sites were chosen along the southern and northern perimeter service roads through the National Bison Range (NBR) and along public access trails in the Ninepipes National Wildlife Refuge (NNWR) (Figure 1). The NBR hosted 11 sites; eight on the southern perimeter road and three along the northern road parallel to Mission Creek. NNWR hosted the remaining 11. The sites at NNWR were placed along highways 212 and 93, as well as along Ninepipe and Olsen Roads. All sites were chosen specifically for their densities of wildflowers and were thus not randomly chosen. The sites as a whole hosted a wide variety of wildflowers both native and introduced.

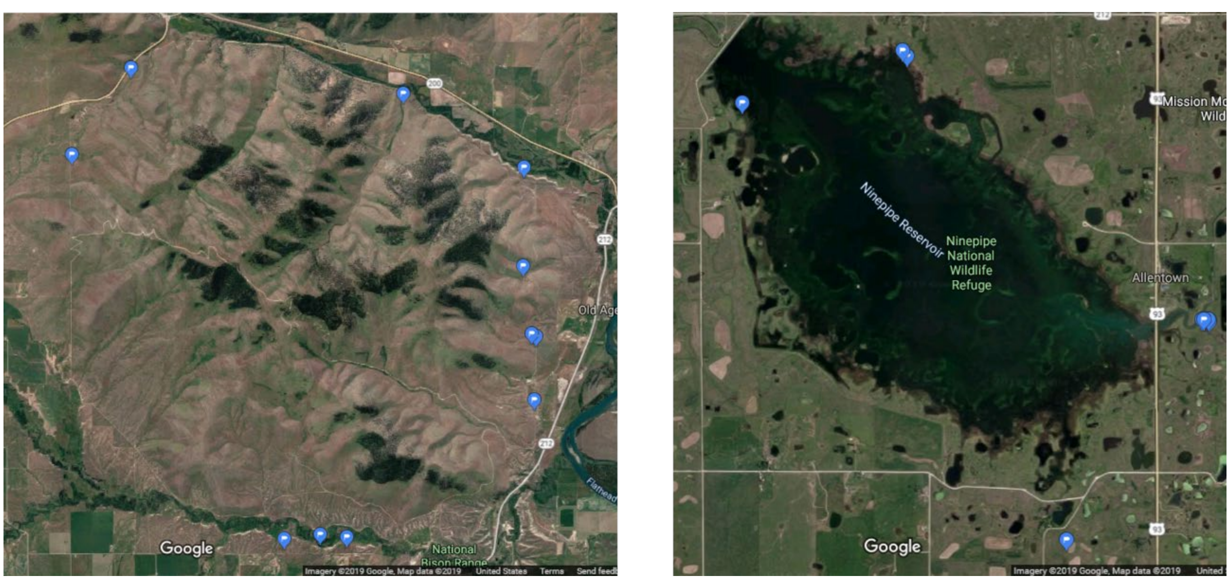

Figure 1. Maps of the National Bison Range (left) and Ninepipes National Wildlife Refuge (right). Sites marked with blue flags.

At each site, five plots were established at randomly assigned distances perpendicular to a 40 m transect. At each interval along the transect, distances from the main transect were randomly chosen by rolling a 20-sided die. Numbers 1-10 were to the left of the transect while facing the 40m mark; numbers 11-20 were to the right. Each of the 22 sites contained five plots for a total of 100 plots. Figure 2 shows a sample site.

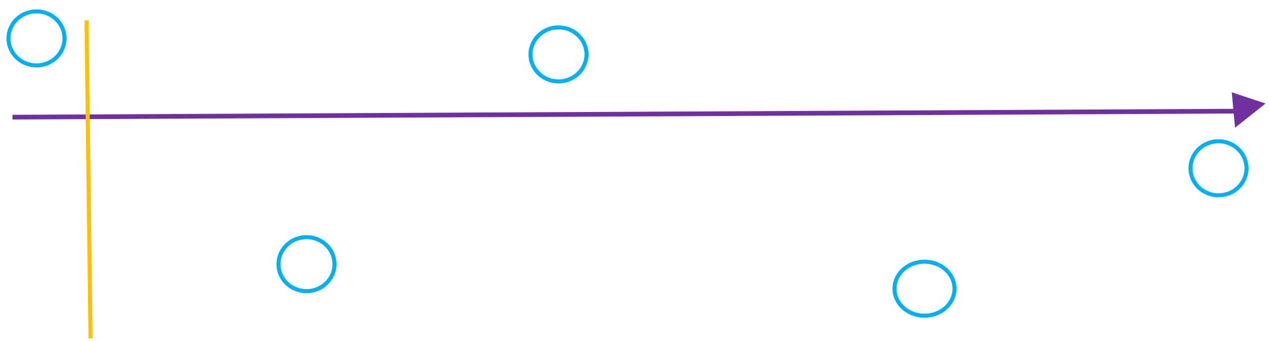

Figure 2. Purple line is the main 40m transect, with the arrow pointing to the 40m end. Each hoop is a plot placed equally spaced along the transect, a random distance from the transect. The orange line is the horizontal transect, with the 0m mark at the top of the figure (to the left of the transect) and the 20m mark at the bottom (to the right of the transect.)

This process allowed for randomization of plots within the specifically chosen sites. At every site, I tried to survey five plots. Plot boundaries were marked by 0.363 m^2 hula hoops, allowing for small and consistent plot size. At every plot, I counted and identified all the plants present so as to know the density of the plants as well as the relative densities of native and introduced species. Once counted, I watched each plot for 15 minutes. Within the 15 min, I counted all the insect pollinator visits to each flower. A visit was defined as any time an insect landed on the flower. Ants were counted as individuals, as they cannot fly. Insects were identified to genus when possible, and to family when generic identification was impossible due to lack of time, capture, or key. All plots within each site were surveyed within the same day to prevent pseudo-replication or unintended temporal differences.

The data collected was non-normally distributed as determined by a series of Shapiro-Wilkes tests. Therefore, said data was analyzed with a series of Kruskal-Wallis tests. I compared the total number of insect visits made to each of two categories of flowers: native and introduced. After doing so, I analyzed the genera found at more than five plots to determine if there was any preference for flowers within specific genera. Due to the scattered nature of the insect visits (ie. some insects were only seen once or twice over the course of the experiment), this analysis could only be done on select groups. Finally, I analyzed the number of insect visits by time of day, flower density with the plot, the range on which the data was collected, and by flower species to examine other potential factors influencing insect feeding strategies. In addition to analyzing potential other factors on the overall data, I looked at the most observed genera to see if flower density, time of day, site, range, or flower species influenced their feeding strategies. All analysis and graphs were made using R Studio (R Core Team, 2018).

Results

Insect Preferences by Flower Status - Overall

Overall, there was no sign of preference for either native or introduced flower species. Figure 3 shows the graph of all flower species watched and the number of insect visits to each one. The complete list of flowers observed can be found in Table 2. Figure 4 shows the status of these flowers, either native or introduced, and the number of visits to each category of flower. While all the insects together made more visits to introduced flowers than to native flowers, the difference was not significant.

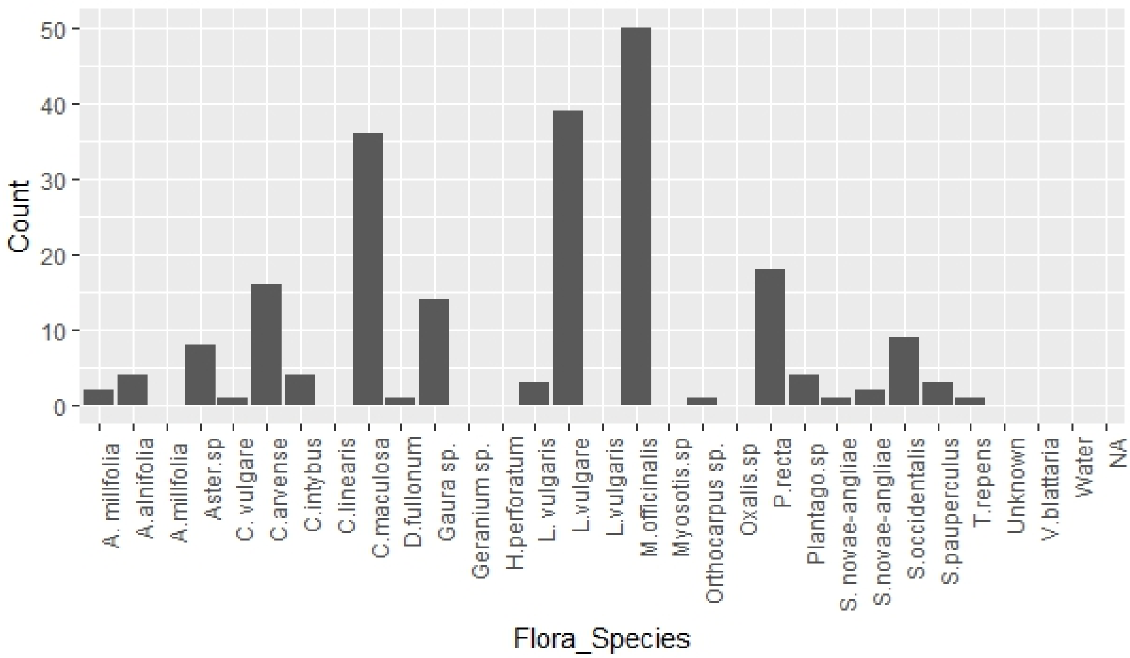

Figure 3. Every flower species observed over all 110 plots, plotted against the number of visits made to each species by all the insects observed. Some flowers were not visited at all, while some were immensely popular.

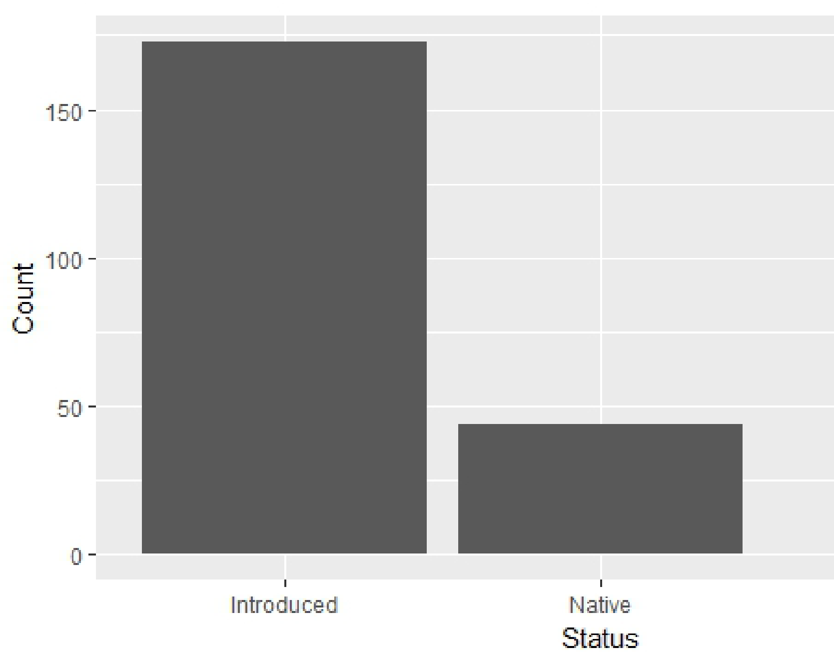

Figure 4. Every visit made by all insects plotted against the status of the flowers visited; either native or introduced. The difference between the two is not significant (p-value = 0.6844).

Insect Preferences by Flower Status – Five Most Abundant Groups

Breaking the data down by genus or family, I found that four of the five most consistent insect visitors showed no significant preference for introduced or native flowers. *Ceratina sp.*, Formicidae, Syrphidae, and Thysanoptera were as likely to visit introduced flowers as they were to visit native flowers. One genus of sweat bees, *Lasioglossum sp.* showed a significant preference for introduced flowers (Figure 6). This is consistent with what I found in my experiment last summer in Michigan.

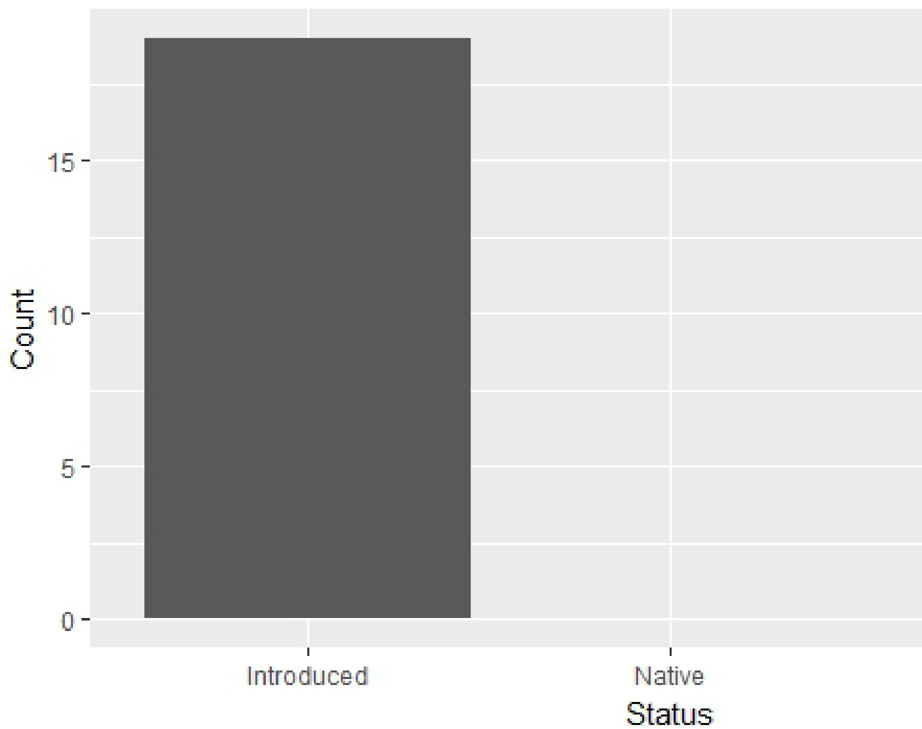

Figure 6. The total counts of *Lasioglossum sp.* across the status of the flower species. These bees were found at six sites. At every site, they were only found on *P. recta, C. arvense,* and *C. maculosa*; all invasive species in Montana.

Insect Preferences by Other Factors - Overall

Analyzing the data by other potential factors including time of day, range (NBR or NNWR), site, flower species, and flower density yielded one significant result. Most of these factors did not significantly influenced how the insects as a whole fed. Time of day was extremely significant (p-value = 5.047e-05). Most insect visits were logged between 10:30am and noon (Figure 7.)

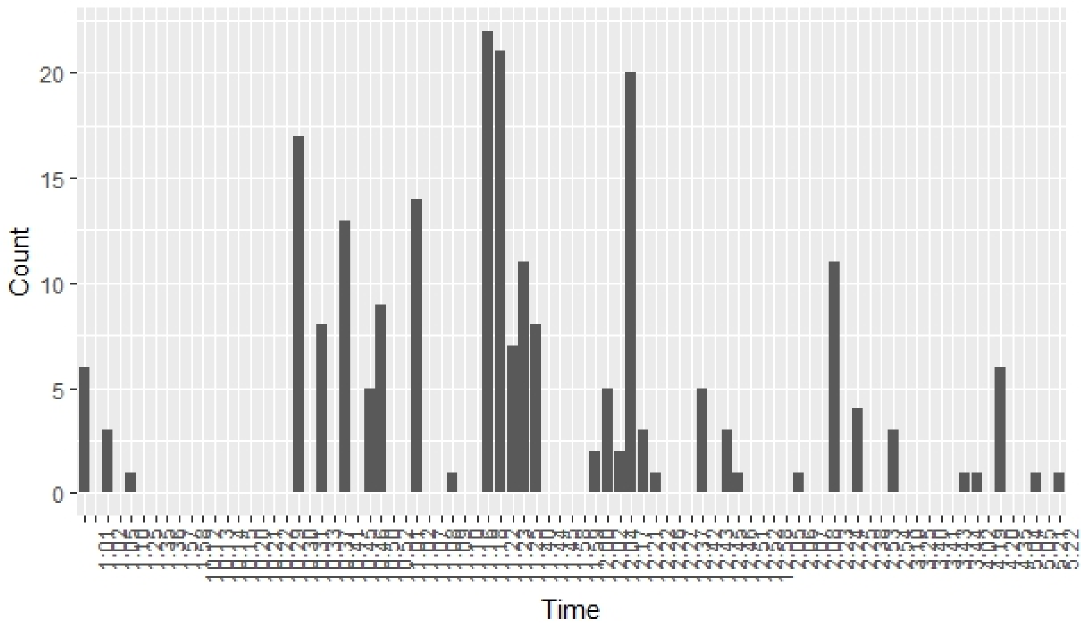

Figure 7. A graph of the time of day at which I began watching each plot, graphed against how many insects visited in that time. Most visits occurred between 10:30am and noon (p-value = 5.047e-05). Note: 1pm – 2pm is on the far left of the graph. The rest of the labels are in chronological order.

Insect Preferences by Other Factors – Five Most Abundant Groups

On a familial and generic level, some significant results appeared. *Lasioglossum sp., Ceratina sp.,* Formicidae, and Thysanoptera all showed preference for specific flower species. However, since each group did not show significant preference for introduced or native species, their preferred food resources include species from both groups. *Ceratina sp.* showed a significant preference for time of day (Figure 8.)

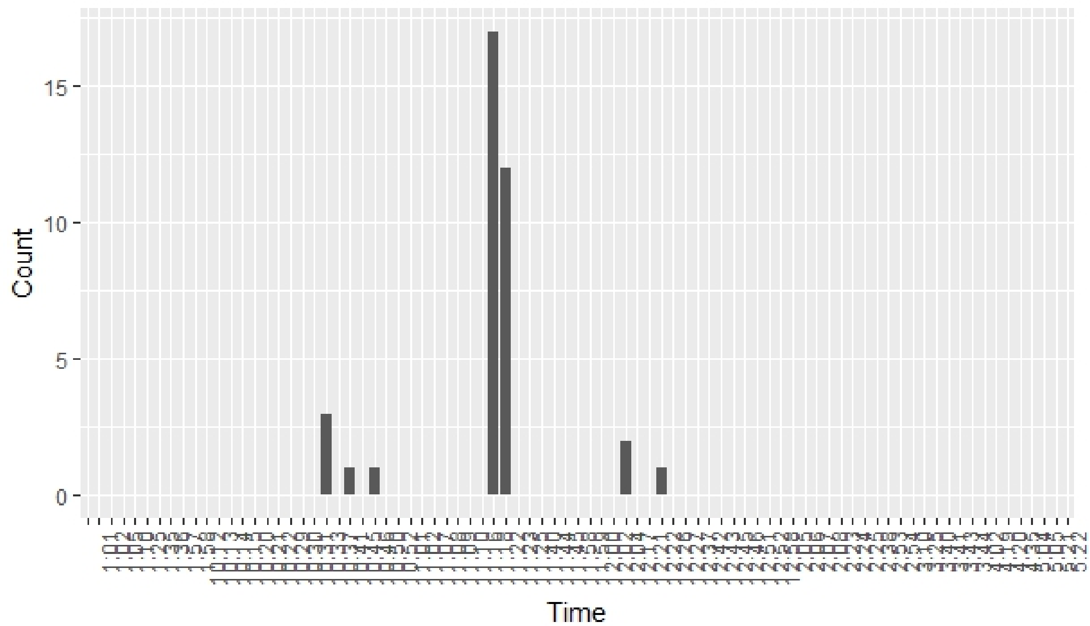

Figure 8. *Ceratina sp.* visits compared to the time of day during which each visit was made. These small carpenter bees prefer to feed in the mid-morning.

My results show that status of flower species (introduced vs. native) does not significantly influence the feeding preferences of insect pollinators. Across the suite of insects observed, no other factor significantly influenced their feeding preferences either. In examining the most commonly observed groups of insects, most showed preference for specific flowers, but whether those were introduced or native did not matter. Time of day influenced all the groups as a whole, as well as one genus of bees.

Discussion

The data analysis did not support my hypothesis that native pollinators would generally prefer native wildflowers over introduced species. There was no significant difference in pollinator preferences except in one genus of bees, which showed a preference for introduced flowers; the opposite of what I expected. 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 the pollinators or could fulfill some other criteria pollinators use to choose their food.

The results of this experiment have many potential applications. For land managers, farmers, homeowners, and others concerned for the welfare of pollinators, the findings detailed above can inform how best to serve these vital insects.

From a pollinator conservation standpoint, this study suggests that any habitat corridor, roadside, fallow field, or other natural area containing any assortment of flowers is capable of supporting a diverse pollinator community. For land managers and owners, this means that pollinator conservation can mean simply leaving some land without pesticides or other treatment and allowing flowers to fill in the space. In the long term, the ecosystem effects of invasive plants are negative and said species should be cleared. In the short term and especially for those with limited resources and time, these introduced plants can provide food resources for precarious insect populations.

Further, since time of day seems to be the most important factor in determining pollinator visits, land managers can use this knowledge to prevent insect killings by pesticides. Farmers can be careful about when to use aerosol pesticides and avoid the times of day when insects are most likely to be flying. Finally, since most of the insect groups showed marked preference for particular species, landowners who want to plant pollinator gardens or encourage pollinator preference can plant species most commonly visited.

Future studies of pollinator responses to introduced and invasive species in ecosystems could examine how pollinators respond to changes in ecosystems as introduced species first become established. Whether new species are immediately accepted or need some adjustment period before pollinators will feed on them could matter to farmers and landowners looking to establish new habitat corridors. The long-term effects of feeding on introduced species, especially where said species form a monoculture would also be helpful for pollinator conservation. Generally, greater flower diversity leads to healthier bees (Nicholls, Altieri, 2013). This trend is likely explained by the greater diversity of pollen in their diets and could be extrapolated to other pollen and nectar feeding insects. Since introduced and invasive species tend to form monocultures over time, examining how changes to plant assemblages impacts the native pollinator communities.

Tables

Insect	**Description and Feeding Preferences**
Eucera sp.	Long-horn bees. Generalist feeders.
Megachile sp.	Leaf-cutting bees. Genus split; some are specialists, and some are generalists
Lasioglossum sp.	Small black sweat bees. Generalist feeders
Hylaus sp.	Yellow-face bees. Generalists, but their feeding strategy makes studying their food preferences difficult
Bombus sp.	Bumble bees. Generalists
Ceratina sp.	Small carpenter bees. Generalists
Heriades sp.	Leaf-cutting bees. Probably generalists, but little is known of the feeding in this genus
Halictus sp.	Sweat bees. Generalists
Agepostemon sp.	Jewel bees. Generalists
Symphyta	Sawflies. Generalists
Ichneumonidae	Parasitoid wasps. Adults are generalist nectar feeders.
Vespula	Yellowjackets. Adults are generalist nectar feeders.
Atanycolus sp.	Tiny little wasp. Parasitoid; adults are occasionally generalist nectar feeders
Formicidae	Ants. Adults are generalists.
Hesperiidae	Skipper butterflies. Generalists.
Melittia sp.	Small moths. Species observed was a wasp mimic. Generalists.
Thysanoptera	Thrips. Generalists. Feed on the liquid in plants; pollen moving is coincidental.
Culicidae	Mosquitoes. Adults, especially males, are generalist nectar feeders.
Calliphoridae	Blowflies or carrion flies. Adults are generalist nectar feeders.
Syrphidae	Flower flies or hoverflies. Adults are generalists.
Curculionoidea	Weevils. Generalists.
Coccinellidae	Ladybugs. Generalists.

Table 1. List of all the insects observed over the course of this project.

Flower Species	**Description and Status**
Achillea millfolia	Yarrow. Plant grows 2’ – 4’ tall, small white flowers growing in an umbral. Native.
Oxalis sp.	Wood sorrel. Short yellow flowers, superficially resemble clover. Native.
Gaura sp.	Beeblossum. Plant grows 12” tall, with small pink flowers in a raceme. Native.
Geranium sp.	Geranium. Low-growing purple or pink flowers, lacy leaves. Native.
Amelanchier alnifolia	Saskatoon serviceberry. Shrub grows up to 18’ tall with large white 5-petaled flowers. Native.
Symphoricarpos occidentalis	Ghostberry or snowberry. Shrub grows 3’ to 6’ tall with small irregular pink flowers. Native.
Symphyotrichum novae-angliae	New England aster. Plant grows 6’ tall with bright purple ray and disk flowers. Native.
Senecio pauperculus	Balsam ragwort. 6” to 14” tall with medium sized yellow ray and disk flowers. Native.
Orthocarpus sp.	Owl clover. Tiny plant with pink and yellow irregular plume flowers. Native.
Collomia linearis	Tiny trumpet. Plant grows up to 20” tall with very small pink 5 petaled flowers. Native.
Linaria vulgaris	Common toadflax. 3’ tall plant, yellow flowers resemble snapdragons. Invasive.
Potentilla recta	Sulphur cinquefoil. Leaves highly divided into 5. Flowers 5 petaled, pale yellow. Introduced.
Cirsium vulgare	Bull thistle. 3’ tall plant, thorny all over leaves and all down the stem. Large purple flowers. Introduced.
Cirsium arvense	Canada thistle. Low thistle with spiky leaves but not stem. Pale purple ray flowers. Introduced.
Myosotis sp.	Forget-me-not. Tiny plant with very small bright blue, 5 petaled flowers. Introduced.
Melilotus officinalis	Yellow sweet clover. Plant grows 2’ to 6’ tall with very small irregular yellow flowers in racemes. Introduced.
Leucanthemum vulgare	Ox-eye daisy. Large white flowers with yellow centers on stems 1’ to 3’ tall. Introduced.
Plantago sp.	Plantain. Common weed, rubbery low leaves in a rosette with flowers rising 8” above. Highly irregular white flowers. Introduced.
Trifolium repens.	White clover. Three lobed leaves, white blooms appear almost fluffy. Introduced.
Hypericum perforatum	St. John’s wort. 2’ tall plant with dark yellow flowers. Leaves have very small holes visible if held to the sunlight. Introduced.

Dipsacus fullonum	Fuller’s teasel. 3’ plant with hooked spikes underneath the leaves and tiny purple flowers arranged around a spiky head. Introduced.
Centaurea maculosa	Spotted knapweed. Thistle-like plant with divided leaves and small purple ray flowers. Introduced.
Verbascum blattaria	Moth mullein. Tall spikes of flat yellow flowers with purple accents near center. Introduced.
Cichorium intybus	Chicory. 5’ semi-woody plant with regular purple flowers up the stem. Introduced.

Table 2. List and description of the flower species observed over the course of the experiment.

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