Urban Pollinators

Bee Diversity in Iowa City, Iowa

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Abstract

The main goal behind this project is to provide Iowa City with information about how bee diversity compares across our five study sites and how the diversity of bees compares with the floral diversity. There has been a drastic decrease in the amount of pollinators across the globe. Without them we will lose a lot of the produce that we eat on a daily basis. For this project we only looked at urban bees and how urbanization affects bee diversity. We collected bees at five different sites using two types of methods, pan trapping and sweep netting. We expected to collect a lower amount of bees in areas where there was more impervious surface. We did see a pattern with the amount of impervious surface at each site. The more impervious surface there was the lesser amount of bees caught, but there was a higher diversity of bees. We then compared the bee diversity to flower diversity at each site and had about the same results. We tended to see a higher diversity in bees where there was a low diversity of flowers. This could be due to the amount of flowers in bloom at the time of collecting or be due to the types of flowers planted. We saw that the bees collected preferred the plants that we considered to be weeds. Since pollinator bees are on the decline we need to find ways to save the bees. In order to keep them around, we need to create new habitat and plant flowering plants they seem to prefer.

Introduction

Pollination is one of the most important supporting services that ecosystems provide. Pollination occurs when pollens are transferred from one flower to another, resulting in fertilization of plants' ovaries and production of seeds. Although some plants rely on wind to pollinate, over 75% of flowering plants on earth are dependent on animal pollination (U.S. Fish & Wildlife Service, 2015). Insects and birds are important pollinators, which include butterflies, moths, flies, flower beetles, bats and hummingbirds, with bees become the major pollinators.

There are almost 20,000 identified species of bees in the world, with 4000 native bee species living in the United States (Joel, 2015). European honeybees (*Apis mellifera*) are the most well-known and managed bees in the world, which contribute mostly to the world's food supply (American Beekeeping Federation, 2015). As opposed to specialist bees, which may forage exclusively on a single suite of plant species, honeybees are generalist, which have a broad range of flower preference and can forage from a variety of plants, such as broccoli, apples and melons (Moisset & Buchmann, 2011). In the U.S., farmers have been taken advantages of this characteristic of European honeybees and have a long history of importing honeybees for domestic crop production. According to American Beekeeping Federation (ABF), the value of honeybee on crop production in the United State is $14.6 billion, with crop yield and quality being tremendously reduced without pollinations of honeybees (American Beekeeping Federation, 2015).

Regardless of the critical roles of honeybees in agriculture, they are not efficient bees for all flowering plants and crops. For example, honeybees do not pollinate tomato flowers because they are not able to get the pollen by vibrating the flowers at a specific frequency and tomato flowers don't produce nectars which attract honeybees (the Xerces Society for Invertebrate Conservation, 2015). As introduced bees, honeybees also may not best fit with native flowers, given that many of the native plants coevolve with a specific assemblage of native wild bees, such as bumble bees, mining bees, squash bees and leaf cutting bees (Moisset & Buchmann, 2011). Wild bees are hidden treasures for native flowers in the U.S., which have been delivering pollination services far before the arrival of honeybees. It does better than honeybees when pollinating native plants, such as pumpkins, cherries and berries. For instance, bumble bees are main pollinators for tomato and pepper, while solitary blue orchard bee (*Osmia lignaria*) can be best adapted to cold weather and pollinate willow, apples, and cherries. As a specialist, squash bee (*Peponapis pruinosa*) favors in pollinating pumpkins, squash and other cucurbits. Although wild bees have remarkable ability to pollinate native plants, their significance is not widely understood and many people don't even notice their presence. Nevertheless, wild bees have becoming more and more popularized as key pollinators for sustainable agriculture and gardening, given that the number of managed honeybees is declining because of factors including disease, climate change and colony collapse disorder.

As urbanized areas expand, wild bees also become the most critical pollinators to meet the growing demand of pollination services from urban agriculture and gardens (e.g. small-scale organic farming, community gardens and urban allotments), where managed honeybees haven't been introduced (Research Institute of Organic Agriculture FiBL, 2007).

Bees in Iowa

Historically, Iowa's landscape has been dominated by native tall grass prairies, which are the most productive habitat for bee pollinators, providing suitable habitat and abundant flower resources for native wild bees. The lush native prairies with wild flowers blooming in different seasons attract various types of bees, including honey bees, bumble bees, mining bees, squash bees and leaf cutting bees, etc. Each prairie plant community has specific plant species matching a suite of bee species. For example, prairie blazing stars (*Liatris pycnostachya*) and wild bergamot (*Monarda fistulosa*) commonly attract long-tongued bees such as bumble bees, while lead plant (*Amorpha canescens*) attracts leafcutter and honey bees (The Xerces Society for Invertebrate Conservation, 2015).

Native wild bees are ecological heritage of Iowa's landscape. Even in urbanized environments, wild bees still exist and take advantage of the valuable floral resources for food and habitat in urban gardens and yards. There are a variety of ways to classify wild bees in Iowa. The most common approach is to categorize bees based upon their nesting behavior. One major category is ground nesting bees, which live underground in burrows and tunnels. This includes bumblebees, which use pre-existing cavities made by rodents or small mammals. There are also digger bees that dig cylindrical tunnels in shady areas. Digger bees include many of the members in family *Andrenidae*, *Halictidae* and *Colletidae* (e.g. yellow-faced bees) and the genera *Lassioglossum* and *Agapostemon*. Digger bees are usually solitary bees, are docile and less likely to sting than social bees (e.g. honey bees). The common habitats for ground-nesting bees in urban areas are loose soils with thin and sparse vegetation. (Moisset & Buchmann, 2011).

Another category is hole-nesting bees, which take advantage of already existing holes and modify them. Members of the family *Megachilidae*, (e.g. mason and leafcutter bees) are common hole-nesters. Mason bees (genus *Osmia*) use mud to build walls between cells in their chambers and leafcutter bees cut rounded leaf pieces for a similar purpose. Instead of using existing holes, carpenter bees (e.g. genus *Ceratina*) are different from hole-nesting bees as they create burrows, tunnels, or holes on their own. This is because they have sharp jaws which can help them excavate tunnels in wood. The last type of bees, in terms of nesting, are cuckoo bees. Their behavior mimics cuckoo birds, as they don't gather pollen; instead they parasitize the nests of other bees, especially in the family *Andrenidae*. Some members of cuckoo bees are in the families *Apidae, Halictidae,* and *Megachilidae*. The genus *Nomada* is a typical cuckoo bee with hairless and wasp-like appearance. (Moisset & Buchmann, 2011).

Every category and species of bee has its own niche that may overlap with others to create a complex community. Little is known about wild bees, thus more research is needed. This will provide a better understanding of their habitat and floral preferences, to promote richness and abundance in an ever changing landscape.

Effects of urbanization on bees

Bees play a significant role in pollination of crops and flowers. Concern for the future of agriculture has grown as reports of colony collapse disorder increased, leading to more research on pollinators. During a study in a California field, it was discovered that wild bees played a larger role than expected in increasing crop yields if a natural habitat was nearby (Klein, et al., 2012). This encouraged several studies in Iowa.

Prairies are known to have high diversity and richness. Iowa has less than 1% of its natural prairie, leading to the belief that there would be few species and low abundance. This turned out to be incorrect. So far there are 300 wild bee species in the state with more being discovered. The next step is to look at their habit preferences. A study of Iowa prairies showed that the size of the prairie made no significant difference to the bee diversity, but the flower diversity had a proportional effect (Hendrix, Kwaiser, & Heard, 2010). Since Iowa is divided up between agriculture and urban regions, floral diversity is increasingly determined by people.

As the human population increases, more will move into cities. As these cities expand, they take up what once was natural space. Cities generally have a negative impact on organisms. However, some groups of organisms are able to survive and thrive under certain conditions. Few studies have been done on the effects of bees in urban regions. A study in North Carolina determined that suburban areas have a higher richness and abundance of bees compared to natural forests (Carper, Alder, Warren, & Irwin, 2014). The results also suggest that open areas and floral resources are positive indicators. Another factor that can effect species is interspecies interactions. In California, the presence of *Bombus vosnesenskii*, a better competitor, decreased the species richness when present (McFrederick & LeBuhn, 2006). This study also agreed with the others that resource availability and distance to resources positively influence diversity and richness. In Chicago, results found that bee abundance and richness increased with areas of higher human density (Lowenstein, Matteson, Xiao, Silva, & Minor, 2014). In addition, the denser areas had a higher diversity of flowers providing a positive effect by humans. Grass cover and solar radiation were the most important variables to determine species composition (Lowenstein, Matteson, Xiao, Silva, & Minor, 2014).

Methods

Study Sites and Collection Methods

All study sites were located in Iowa City, Iowa, USA. We sampled five sites that represented a range of different types of land cover and geographic areas around the city. The area of all five sites are one hectare, or 100 meters x 100 meters. Three of the sites: Willow, Goosetown, and Longfellow are located in Iowa City neighborhoods, and were chosen haphazardly. The Wetherby and ESRC sites were located on public land and were chosen because both sites had a unique attribute that may mean higher bee diversities. Wetherby Park is the location of a community garden that would contain many different types of introduced plant species in addition to the normal plants in the park. At the ESRC, there are many species of native prairie plants and other plants that have intentionally planted to increase native plant diversity.

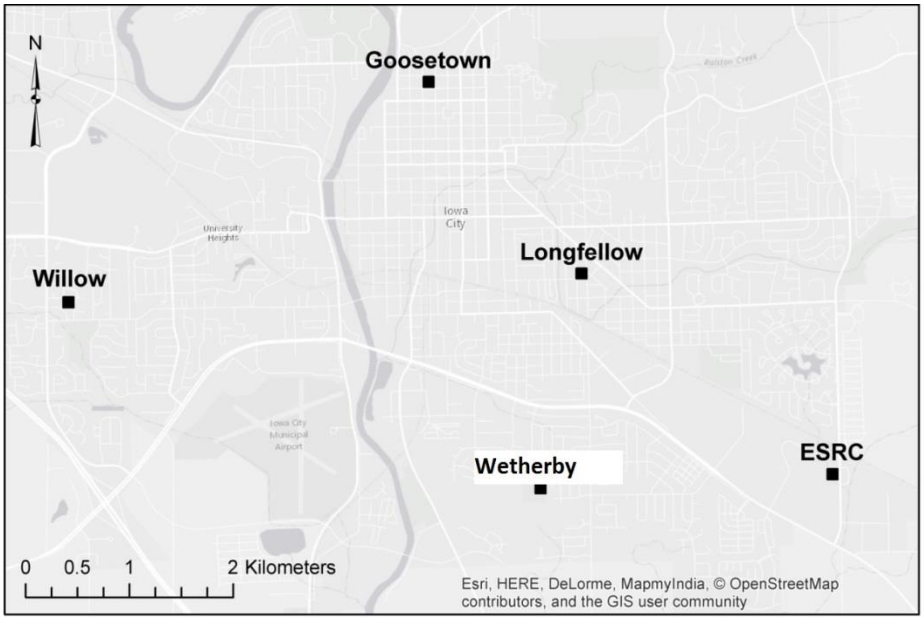


Figure 1 Study sites

All five sites were sampled using two different sampling techniques during the month of April, 2015. Samples were taken using both pan traps and sweep nets in order to facilitate the capture of different types and sizes of bees, with pan traps generally capturing smaller bees and sweep nets capturing larger bees. Floral diversity counts were taken at the time of sampling at each site in order to ensure that an accurate estimate of floral diversity.

For the five sites examined, we wanted to get data of both collection practices if possible, weather being the main factor in our decisions on if we could go and collect. We needed temperatures to reach at least 60° F which is the threshold for bees to become active. The days of collecting also had to have little to no wind. Pan trapping included 12 bowls of 3 different florescent colors, blue, yellow and white. These three colors are the most noticeable to pollinators. The order of the bowls was chosen at random and the bowls were placed at each site roughly 9-10 meters apart from one another. Once the bowls were set out we applied a small amount of soap and water to each bowl, this allows for the surface tension to break when a bee lands in the bowl. *When the surface tension breaks the bee will sink to the bottom and die*. Bowls were placed in the morning and were left out for 6 hours. Come afternoon time we checked to see if we had bees or other insects captured in the bowls. If there were bees we had to strain them and wash them with water then they were placed in whirl-pak bags with diluted alcohol and taken back to the lab for storage and identification.

We were able to sweep net all sites once, mostly during the afternoon hours. For sweep netting each individual site you had one hour for a group of two or three, two of the three were doing the sweep netting while the third identified plant species and assisted when bees were caught. To sweep net you had to divided the chosen area into .5 hectare halves that each person would then begin sweep netting for 30 minutes, stopping your stop watch each time you have caught a bee, once the 30 minutes are up you switch sides with your partner and begin sweep netting the other area. After capture in the nets we had to kill our bees for later identification. To kill the bees we used cyanide "serenity chambers" to stun and kill our samples.

Bee Identification and Data Analysis

Bees were identified down to genus level using a morphological key. The gender was identified with by counting antennal segments under dissection scope (11 segments for males, 10 for females). Once they were identified and sexed, all data pertaining to bees and site floral resources were compiled and tables were constructed to represent relationships between different criteria.

The percentage of impervious surface was determined by analysis of images of our sites from the National Land Cover Dataset using the program ArcMap 10.2. The data was in raster form with 30m resolution and cells were averaged for total percentage of impervious surface at each son.

Pearson's correlations were calculated comparing the number of bees caught at each site, the number of bee genera at each site, the number of plant genera at each site, the total floral resources of each site and the percentage of impervious surface at each site.

Results

We collected 104 bees specimens of which 78 are currently identified to genus level. The number of individuals of each genera are as follows:

10 Lassioglossum -all females

3 Nomada-all males

6 Colletes- 2 females, 4 males

4 Halictus- all females

12 Ceratina- 5 females, 1 male

9 Apis- all females

33 Andrena- 18 females, 15 males

1 Agapostemon- female

4 Osmia- 1 female, 3 males

2 Bombus- 2 females

Total: 52 Females, 26 males

While we caught bees with both sweep netting and pan trapping, the number of individuals and genera varied greatly between sites. The site data is summarized in the following table:

Table 1-Bee Diversity by Site

Site ID	Number of individuals	Number of genera	Number of males	Number of females	Number of genera with only one gender collected
Brown	26	5	10	16	4
Dearborn	16	6	8	8	4
ESRC	19	7	3	16	7
Wetherby	7	3	1	6	2
Willow	10	6	4	6	4

The Brown Street site (Goosetown) had the greatest number of individuals with 26, almost four times that of Wetherby. With the exception of the Dearborn, all sites had more females collected than males. There were many genera with only one gender represented.

While the data set is still small, the amount of bees caught exclusively by one method is very high compared to previous studies, with no more than one genus per site caught by both methods (Hendrix et al 2010). The results for differences in capture method results are summarized in the following table:

Table 2-Capture Method Results

Site ID	Number of individuals	Number of genera	Number genera caught by both methods	Number of genera only by pan	Number of genera only by sweep
Brown	26	5	1	2	2
Dearborn	16	6	1	1	4
ESRC	19	7	1	6	0
Wetherby	7	3	0	1	2
Willow	10	6	1	0	5

With the exception of the almost exclusively female honeybee, we do not know the expected gender ratios of most of the other bee species we caught. We did, however, observe that the proportion of females we caught was almost three times that of males. We also observed that males and females differed quite a bit in terms of the proportion of those captured by each of our two methods. Females being close to 60-40 in favor of pan trapping, while the split for males was approximately 73-27 in favor of pan trapping. The gender difference results are summarized in the following table:

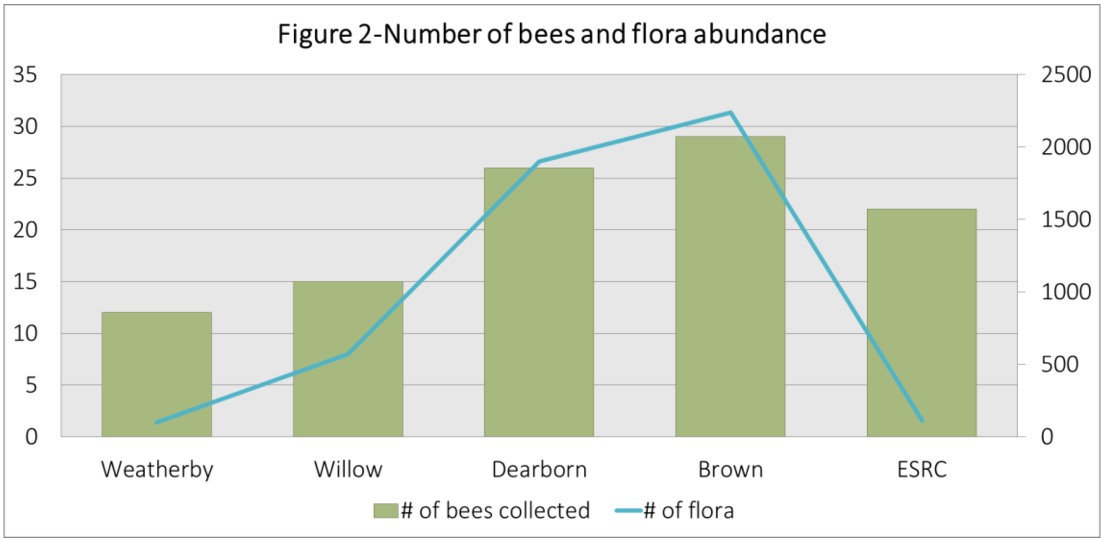
Tale 3-Gender Disparity Results

Site ID	Number of individuals	Number of males	Number of females	Proportion of males by pan	Proportion of females by pan	Proportion of males by sweep	Proportion of females by sweep
Brown	26	10	16	0.8	0.563	0.2	0.438
Dearborn	16	8	8	1	0.25	0	0.75
ESRC	19	3	16	1	0.9375	0	0.0625
Wetherby	7	1	6	0	0.667	1	0.333
Willow	10	4	6	0	0.167	1	0.833
total	78	26	52	0.731	0.596	0.269	0.404

We also recorded the floral resources of each area. Inventorying the amount of floral resources as well as what genera are visited by bees will give us an understanding of the effect on habitat quality on urban bee diversity, as well as provide future suggestions of species for urban planting to encourage pollinators. We graphed the number of bees collected (including unidentified individuals) compared to the total floral abundance in figure 2 and we summarized floral diversity and abundance in the following table:

Table 4-Floral Diversity and Abundance by Site

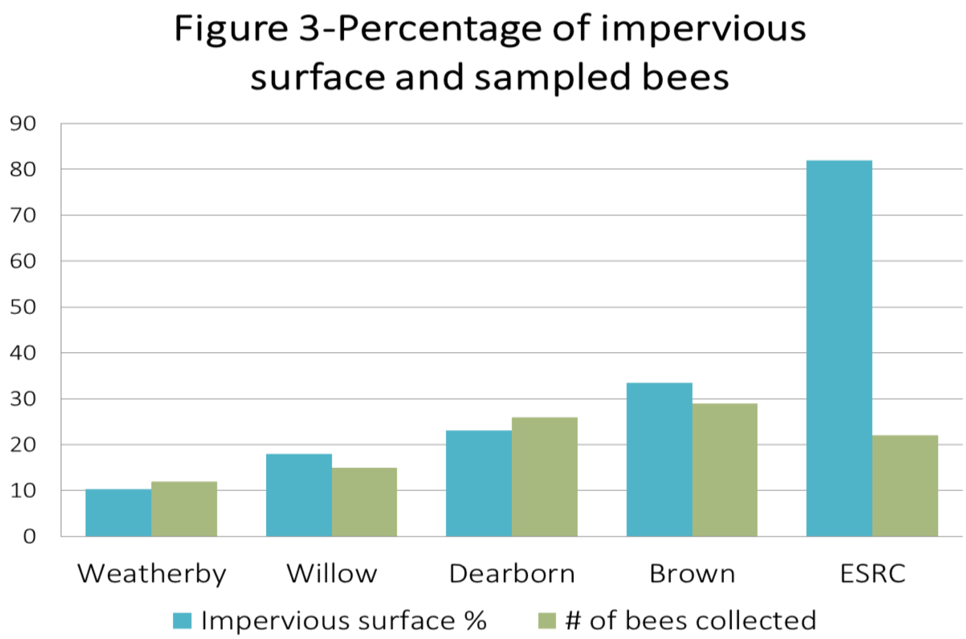
Site ID	Number of Genera	Number of Genera Visited by Bees	Total Floral Resources
Brown	19	5	2457
Dearborn	28	3	1149
ESRC	3	1	101
Wetherby	3	3	537
Willow	9	3	130



We also calculated the amount of impervious surface at each site, as a rough approximation for the degree of urbanization, to see if there was a relationship between the degree of urbanization and the diversity and abundance of bees. The results are summarized in the following table and figure:

Table 5-The Degree of Impervious Surface at Each Site

Site ID	% Impervious Surface	Number of Bees Collected
Brown	33.5	29
Willow	17.9	15
Dearborn	23.1	26
Wetherby	10.3	12
ESRC	82.0	22



Finally we looked at Pearson's correlations between several of our measured data to find relationships between them. We observed a moderately strong correlation between between both the number of bees collected and the number of bee genera with the number of flower genera at a site. We also saw a moderately strong correlation between the number of bees caught and the total floral resources. We saw a weakly positive correlation between the amounts of impervious surface, which is unexpected.

Table 6-The Relationships Between Multiple Measured Variables

	Impervious surface %	# of bees collected	# of bee genera	# of total flowers	# of floral genera
Impervious surface %	1.00	0.36	0.46	-0.22	-0.22
# of bees collected	0.36	1.00	0.71	0.83	0.77
# of bee genera	0.46	0.71	1.00	0.47	0.65
# of total flowers	-0.22	0.83	0.47	1.00	0.93
# of floral genera	-0.22	0.77	0.65	0.93	1.00

Discussion and conclusion

Habitat loss and degradation due to urbanization may adversely affect bee population (Banaszak-Cibicka & Zmihorski, 2012). In our study, we used percentage of impervious surface as an indicator to represent urbanization intensity and assessed the relationship between it and bee population across five sampled sites. Our results indicate that bee abundance and diversity are weakly associated with urbanization intensity but are strongly positively correlated with floral diversity and abundance. It thus suggests that maintaining flowering plants abundance and diversity in urban gardens and yards is a key step for promoting bee population in urban areas. Considering that flowers in urban areas provide necessary food for bees to sustain, including nectars and pollens, it is important to plant more flowers so as to support bee populations in greater size. Flowering plants also need to be diversified in colors, fragrances, and shapes, in order to attract different kinds of bees, including both specialists and generalists. Planting a variety of flowers which bloom at different times can also attract a great diversity of bees and serve healthy bee diets. For example, bumble bees need abundant early-flowering plants in spring, such as willows and manzanita to supply their queens with pollen and nectar. Therefore, early-blooming flowers can help establish a viable bumble bee population whose pollination is in return beneficial for the plant communities throughout their growing season.

One important finding is that weedy flowers such as creeping charlie, violets and dandelions are actually key food resources for a variety of bees (27 of 55 bees collected via sweep netting were collected from one of these three flowers). The fact that bees greatly rely on weeds suggests that gardeners may consider leaving flowering weeds to serve as alternate nectar sources for pollinators when they manage their yards. As a result, herbicides for weeds should be limited to allow weeds to grow if protecting and promoting bee habitat is the priority for gardening.

Besides offering good food resources, creating or maintaining high-quality shelters for bees to live is another key aspect of protecting bees from declining in urban areas. Since 60%-70% of bees are ground-nesting bees (e.g. Genus *Andrena*, Bumble bees) (Joel, 2015), which prefer sandy and loose soils for nesting, it is recommended to create habitats made up with exposed and undisturbed soil with shady vegetation on slops in urban gardens and yards (Figure 4). It is also estimated that 30-40% of bees are hole-nesting bees (Joel, 2015). Therefore, building artificial tunnels (e.g. bee house, Figure 5) in gardens and yards can be an effective way to provide hole-nesting bees with easily accessible shelters. Besides, improving habitat quality by reducing pesticides and herbicides usages, applying chemicals that are the least harmful to bees or suing them when bees are least active (e.g. early in the morning and late in the evening) and avoiding using insecticides when flowers are blooming or when it is windy are all best management approaches for keeping healthy bee populations (The Xerces Society for Invertebrate Conservation, 2014).

Figure 4 habitat for ground-nesting bees

Figure 5 bee house

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