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Survey of Hymenoptera Pollinator Populations on Washington Island, Wisconsin

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Abstract

Pollinating insects are highly beneficial in both natural ecosystems and agriculture, but many species are in decline. This project's goal was to survey Hymenoptera pollinators on Washington Island, WI, and to explore factors influencing their abundance and diversity. The two sites included the Washington Island Butterfly House, which has undergone extensive prairie restoration, and Sweet Mountain Farm, an apiary breeding Western honey bees. Surveys took place 1-3 times per week, during which records on flowering species, weather conditions, and pollinators were obtained. Each day, three patches of flowering plants were chosen to include the most prevalent species within a m^2 quadrat and observed for ten minutes after a one minute "resting period". All insects that contacted a flower were tallied as pollinators. At both sites, varying numbers of honey bees, bumblebees, sweat bees, and wasps were found visiting flowers. Results showed that along with a higher plant diversity, the Butterfly House had greater variety and abundance of Hymenoptera, with 55% sweat bees, 20% honey bees, 18% wasps, and 3% bumble bees. Sweet Mountain Farm, showing less plant diversity, had less variety of Hymenoptera. The site was dominated by honey bees raised on the property, which comprised 73% of all pollinators recorded, followed by sweat bees at 15%, and bumble bees and wasps each at 4%. In the future, the Butterfly House's prairie restoration efforts can serve as an example for other sites, like Sweet Mountain Farm, to increase both native and introduced pollinators.

Keywords: Hymenoptera, Pollinator Preference, Wisconsin

1. Introduction

With nearly 75% of all flowering plants, and 75% of agricultural crops requiring pollinators assistance for fertilization[18], the long-term decline in pollinators has caused great concern for the future of our agricultural system, as well as native ecosystems[13]. In the United States and Canada alone, over 100 of the crops produced rely on pollinators[8]. Without adequate fertilization through pollination, the fruit of such crops develop poorly or not at all, which can be devastating to local economies[8]. Many foods necessary for wildlife populations come from pollinated plants as well[8]. Increased habitat fragmentation, pesticide use, and disease spread has greatly contributed to the decrease in pollinator populations over the last few decades[8]. Since this has been recognized, many efforts have been put forth to protect and restore pollinator populations.

The purpose of this study was to find factors influencing the abundance of Hymenoptera pollinators on Washington Island, Wisconsin. The two sites observed had various differences in wind block, vegetation, and agricultural bee colony presence. With one site being closer to the island's shoreline and also being surrounded by open fields, it was naturally windier than the other site with more wind block from the surrounding forest and elevation. These variables were hypothesized to affect pollinator populations, flower preferences, as well as foraging abilities at each site.

Abundance and diversity of flowers at each site should be considered. Both sites have focused their restoration with native plant species, with few exotic plants as ornamental additions near the buildings on each property. Pollinator visitations overall increase with a larger flower resource, and have been found in higher numbers at native and near-

native treatment sites compared to those with exclusively exotic plants[12]. Therefore, combining exotic plant species with native ones at each site may not be harmful to pollinator activity, but beneficial. Pollinator visitations also increase during peak flowering periods[12], so the composition of plant species and whether or not they provide enough overlapping blooms for pollinators throughout the season can affect pollinator activity. Invasive plant species can outcompete native ones, resulting in a monoculture crop. Pollination mutualisms that exist between hymenoptera and flowering plant species may disappear, and native plants may lose their pollinators to non-native species[20].

Honey bee colonies are often raised and managed for agricultural use to help ensure the pollination necessary for sustainable fruit production. Sweet Mountain Farm, owned by Sue Dompke, serves as an apiary raising colonies of European Honeybees, *Apis mellifera*. A portion of the colonies are sold while the remaining colonies are managed on the property for honey production. While it is feasible for the honey bees at Sweet Mountain Farm to travel to the Butterfly House, or even neighboring islands, honey bees prefer sources closest to their hives, specifically within 300 feet[21]. Honey bees have also been known to exhaust the resources from an entire crop before continuing on to a different area[4]. This could become problematic to native pollinator species who rely on the same flowering plant species, and has been shown with European honey bee competition in some habitats[6]. This could lead to a reduction in native pollinator species at Sweet Mountain Farm, and more variety of pollinators at the Butterfly House, which does not manage European bee colonies.

Weather conditions are expected to affect species of hymenoptera in different ways. Pollinators can tolerate varying amounts of wind, radiation, and precipitation during activity[23], with some species of bees found to forage in rain or even strong wind. The European honey bee activity is known to peak when temperatures are above 60°F, with minimal wind and no precipitation[4]. While certain weather conditions may not be optimal for one species of hymenoptera, another species may take full advantage of the time without competition.

The motion of a flower has been found to be a cue for honey bee attraction, whereas they prefer moving objects over stationary ones[7]. However, the intensity of flower movement can also affect a pollinator's ability to land on it[1]. If conditions reduce handling ability of flowers, pollinators prefer flowers with better grip regardless of how easily they are visually detected[1]; if wind conditions do not reduce a bee's ability to land on a flower, they will choose the most visually detectable ones. This brings into consideration the sturdiness of flowers at each site. A study of flower waving based on stalk size found that, though thinner, longer stalks attracted the most pollinators, they were too difficult for the pollinators to land on[24]. The most frequently visited flower type were those with thin, medium length stalks, for they wave enough to attract a pollinator without removing its ability to land[24]. Therefore, the physical traits of flowering species found in an area and their pollinator visitations can be greatly influenced by wind conditions, with a flower providing enough movement as a visual cue without disabling a pollinator from landing on it.

Though many studies have focused strictly on honey bee activity, it is important to observe all hymenoptera pollinators at the study sites. Alternative pollinators have been increasingly considered due to the susceptibility of honey bee colonies to parasites and disease, which have been found to be species specific[6]. Those severe threats could easily wipe out entire colonies of honey bees, so having a variety of hymenoptera would help ensure continued pollination. The purpose of this study is to better understand hymenoptera pollinator activity and environmental preferences on Washington Island, so that further efforts in restoration can be more efficiently carried out with maximized benefits. This knowledge could be applied to areas throughout Wisconsin and the Midwest, in both rural and urban areas, to help combat the decline in pollinators necessary for human agriculture and natural ecosystems.

2. Materials and Methods

This study took place on Washington Island, which is north of the Door County Peninsula in Wisconsin. The island has an area of 125.5 square miles and is located about 7 miles north of the mainland of Wisconsin. The island is bustling in the summer, but only has 660 permanent residents as of the 2000 census[17]. It remains a rural area, with much of the island as farmland or forested, predominately with maple and cedar. Due to the surrounding Lake Michigan, the climate is often cooler and breezier than the mainland, with a shorter growing period. Washington Island falls within growing zone 5b[19] at 45º22' N 86º54'W[5].

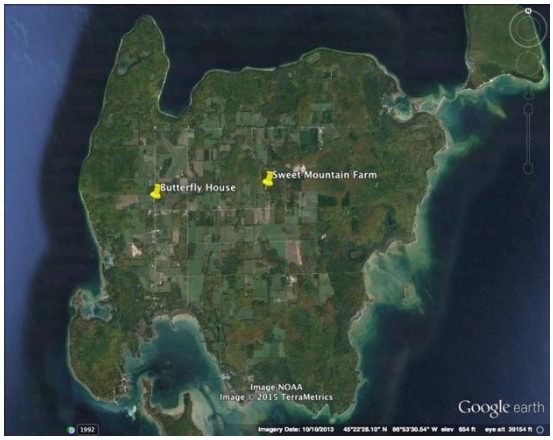

Figure 1. (Above) An overview of Washington Island, WI[5], showing the locations of the Butterfly House and Sweet Mountain Farm.

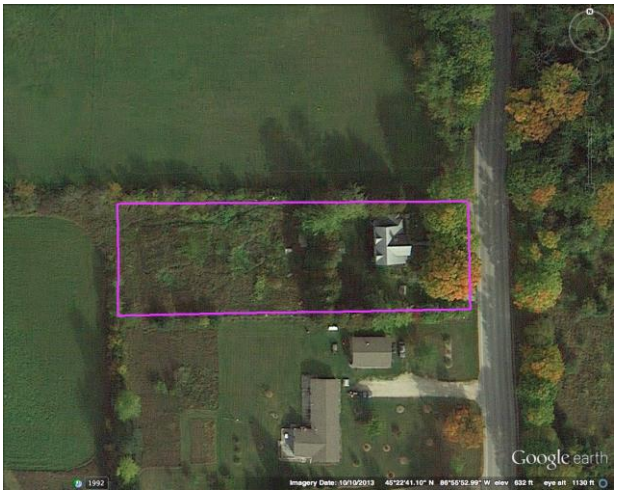

Figure 2: An aerial view of the Butterfly House property[5], with the surveying area within the rectangular outline.

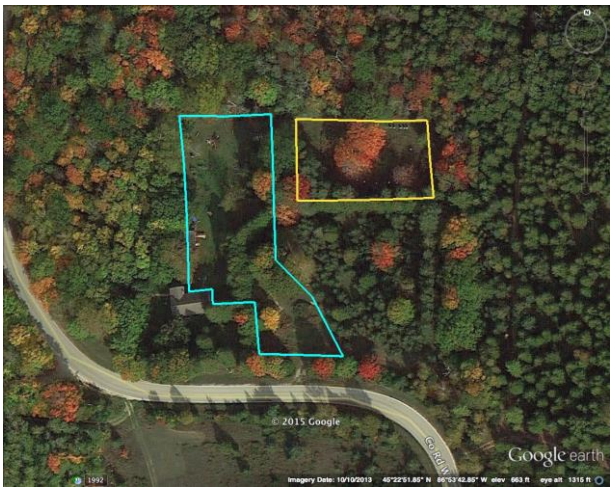

Figure 3: An aerial view of Sweet Mountain Farm[5], with the surveying area outlined in cyan and the bee yard outlined in yellow.

The Washington Island Butterfly House is located on the main road, just beyond the "downtown" area and 1 mile away from the western shore (Fig. 2). The entire property is lined with trees and shrubs, creating a subtle wind block, with large maples in the front that provide shade along with ornamental flower gardens. The back portion of the property is kept as a prairie, with minimal mowing done for a footpath. The surrounding land is pasture for horses and other small livestock, and deciduous forest across the street. The house on site serves as an environmental education center, as well as living quarters for interns. Throughout the week there is frequent foot-traffic through the entire yard, as visitors are encouraged to explore and net insects.

Sweet Mountain Farm is located off of Mountain Road, near the center of the island (Fig. 3). The nearest shorelines are 2.7 miles to the west and 2 miles to the north. It is more secluded with less traffic throughout the day, and is surrounded by dense mixed forest which acts as a wind buffer. There is a ½ acre bee yard on the property, with 140 colonies of European honeybees, *Apis mellifera*. A dozen free range chickens also roam the property. In the center of the yard is a small organic garden plot, which was often watered with sprinklers during the day. The surrounding area is a wild lawn which was mowed semi-regularly. The owners were in the beginning stages of converting a large area of the land into native prairie, and therefore were periodically in the yard cutting juniper bushes and burning brush piles. There is a single golf course located off of the main road that utilizes chemical herbicides, which consequently has been the only factor keeping Sweet Mountain Farm from being certified organic.

Each site was monitored midday, 1-3 times per week throughout the summer months of July and August. First, a walk through was conducted, during which the flowering species on the entire site and their abundances were recorded. Abundance was based on a 1-3 scale, with "1" being an abundance of 1-10 flowers, "2" being 11-50 flowers, and "3" being 50+ flowers. Weather conditions were also recorded, with specific temperatures referenced from weather.com. Next, a m^2 quadrat made from 1.5" PVC piping was placed over an area of flowering plants to be monitored. The area was chosen based on its inclusiveness of the most abundant species, and was always in full sun. Standing or sitting locations during monitoring were also carefully chosen so that a shadow would not be cast over the interior of the quadrat. After the quadrat was placed, a stopwatch was used to time a one minute "resting period," during which the species type and abundance of flowers within the quadrat were recorded. The stopwatch was then set for 10 minutes, and the area inside the quadrat was observed for pollinators. Any insect that came in contact with a flower was recorded; others that flew by or only came in contact with the stems and leaves of plants were ignored. This process was repeated for a total of 3 times per day at each site. If weather was inclement, either being too cold, windy, or rainy, monitoring was halted. All data collected was entered into Google Spreadsheet in order to create tables and graphs to be analyzed. Google Earth software was also utilized in creating images outlining the survey sites and measuring their distances from shorelines.

3. Results

At both sites, varying numbers of honey bees, bumblebees, sweat bees, and wasps were found visiting flowers. The Butterfly House had greater variety and abundance of Hymenoptera, totaling 94 with 20.7% honey bees, 56.5% sweat bees, 3.2% bumble bees, 8.7% wasps, and 3.3% unknown Hymenoptera (Fig. 4). Sweet Mountain Farm was dominated by honey bees raised on the property, which comprised nearly 73.4% of all pollinators recorded. Sweat bees accounted for 15.2% while bumble bees, wasps, and unknown Hymenoptera each represented 3.8% of all 79 recorded pollinators at Sweet Mountain Farm.

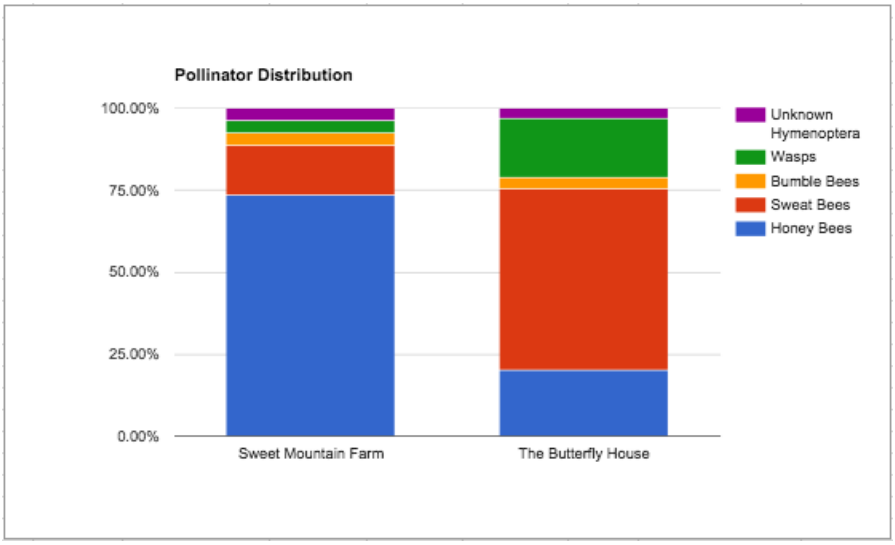

Figure 4. A comparison of pollinator compositions from all surveys at Sweet Mountain Farm and the Butterfly House.

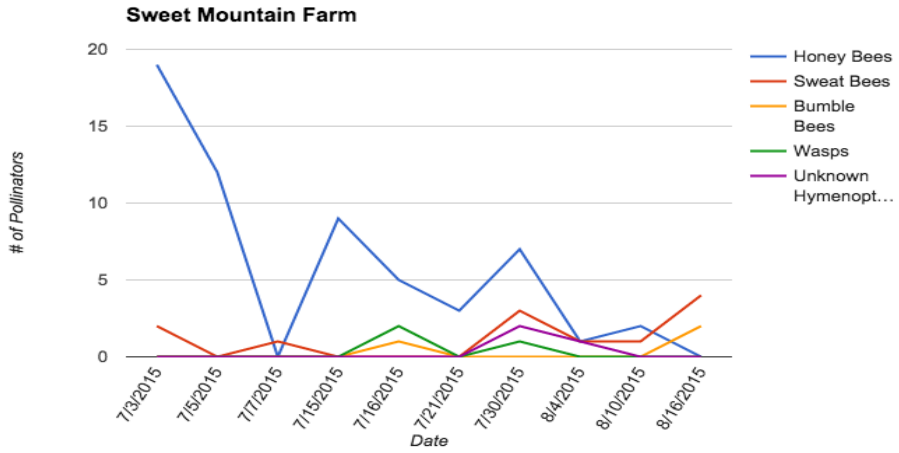

Figure 5. Hymenoptera pollinator abundances over time at Sweet Mountain Farm

At Sweet Mountain Farm, the number of honeybees observed peaked during the beginning of July, and decreased over time with sporadic dips (Fig. 5). Other pollinators at Sweet Mountain Farm did not show a regular pattern either, but did begin to increase towards the end of July.

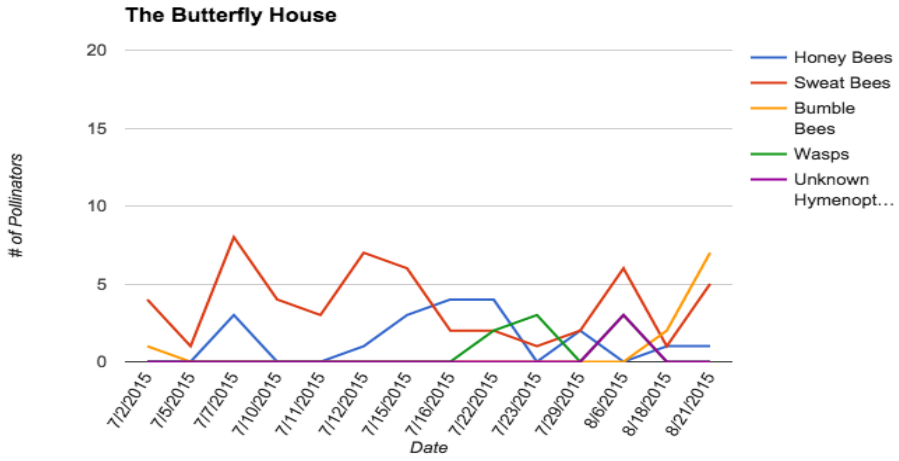

Figure 6. Hymenoptera pollinator abundances over time at the Butterfly House

The Butterfly House was dominated by honey bee and sweat bee pollinators during the surveys until mid-July, when wasps began to be observed more often. Bumble bees were observed randomly in low numbers throughout the study, with no more than 2 ever being seen in a day at each site.

Sweet Mountain Farm had a total of 36 different plant species recorded from July 2nd to August 21st. Three of the plant species found, *Campanula rapunculoides, Epipactis helleborine,* and *Centaurea maculosa* are listed on the Wisconsin Department of Natural Resources terrestrial invasives list as "restricted"[25]. Four other species were also listed by the DNR, but as "non-restricted," including *Pilosella aurantiaca, Daucus carota, Hypericum perforatum,* and *Melilotus officinalis.* The most abundant species were *Medicago lupulina, Rudbeckia hirta, Prunella vulgaris, Plantago lanceolata, Erigeron philadelphicus, Trifolium pretense, Centaurea maculosa, and Trifolium repens.*

The Butterfly House surveys showed a total of 44 flowering plant species from July 2nd to August 21st. Restricted invasive species were *Campanula rapunculoides, Centaurea maculosa,* and *Pastinaca sativa,* and non-restricted species found were *Linaria vulgaris, Daucus carota, Hypericum perforatum, Melilotus officinalis,* and potentially *Convolvulus spp.,* though the identification was uncertain to be native or non-native[25]. The most abundant species

were *Medicago lupulina, Silene vulgaris, Chrysanthemum leucanthemum, Echium vulgare, Hemerocallis fulva, Trifolium pretense,* and *Daucus carota.*

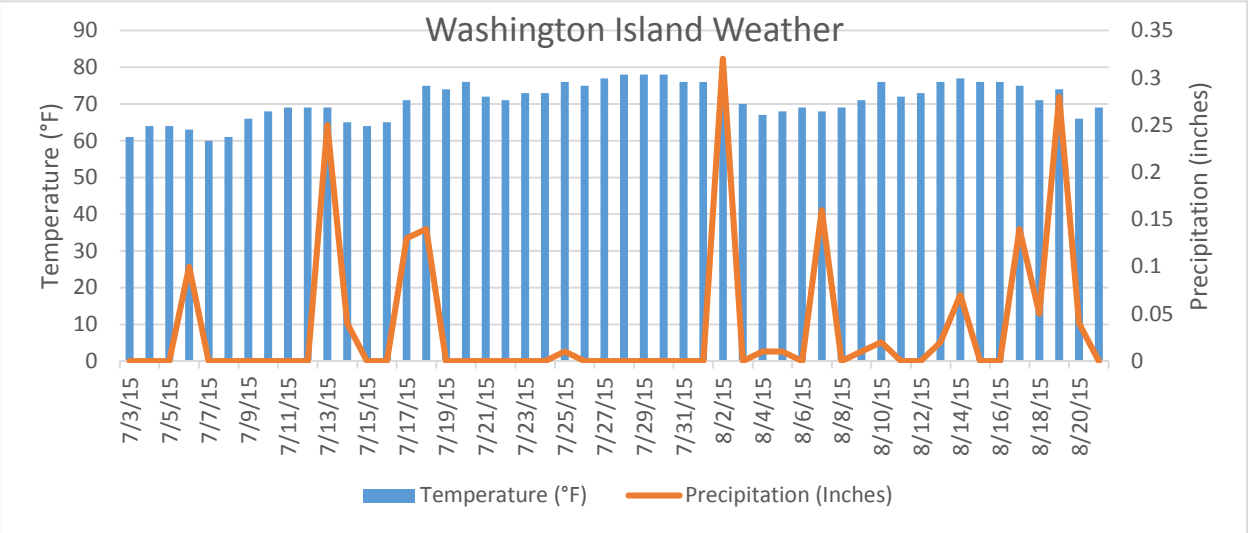

Figure 7. Precipitation and temperature values on Washington Island throughout July and August, 2015. Climate data was retrieved from The Weather Channel[14.]

Maximum daily temperatures over the course of the study ranged from 60°F to 78°F, steadily increasing over time, with 11 significant events of precipitation (Fig. 7). The highest amount of precipitation was on August 2, with 0.32". The average temperature of the survey dates was 68°F.

4. Discussion

The results of this study show that the Butterfly House had a much more diverse population of pollinators than Sweet Mountain Farm (Fig. 4), and slightly more hymenoptera activity overall. These findings seem mainly attributed to the presence of European honeybees, as well as the the composition of plant communities on each property. The large population of European honeybees at Sweet Mountain Farm was noticed during observations, and data suggests their competition may have reduced the presence of other pollinators on the property. However, it is difficult to determine to what extent the honeybees are outcompeting other pollinators due to the differences in floral resources at each property.

A few of the plants that were recorded with high abundance values were ground-level plants with small flowers that weren't often visited by hymenoptera, such as *Medicago lupulina, Prunella vulgaris*, and *Plantago lanceolata*. Other low growing plants did see a lot of pollinator activity, like *Trifolium repens* and *Trifolium pretense*. These clovers appeared to be a favorite for honey bees and sweat bees. *Trifolium repens*, a very low white clover, saw the most activity at Sweet Mountain Farm, where honey bees and sweat bees were able to easily access the blossoms in the middle of the mowed yard. *Trifolium pretense*, red clover, grew to be around a foot tall, and was active with pollinators in a taller grassy area at Sweet Mountain Farm, and along the edges of the Butterfly House's mowed pathways. Oxeye Daisies, *Chrysanthemum leucanthemum*, were found at both sites in high abundance all of July and until mid-August but did not have any hymenoptera observed visiting them. The daisies were always at a visible and accessible height above any dense areas of grass, and offered seemingly perfect landing platforms for pollinators. Different pollinators have varying preferences in flower morphology, including color, size, complexity, and scent, though studies suggest color is the primary factor[3]. Many insects, including bees and wasps, only see ranges of yellow, blue-green, blue, violet, and ultraviolet, and cannot see red at all[21]. With the oxeye daisy having white petals, it should have been easily seen by pollinators, so it is assumed in this study that the pollen and nectar loads or the scent of the daisies were not strongly preferred by pollinators. Of the different species of flowering plants found at the sites, only 20 of them had pollinator visitations observed. This absence of hymenoptera on a large variety of flowers may be due to specific

preference for a few plant species during the months of July and August. Since most of the other flowers in lesser abundance were not thoroughly observed, conclusions on their pollinator activity cannot be made.

While an increase in green space should result in an increase in pollinators, it is not the case when the green space is predominantly turf grass[15]. Low-growing white clover was highly active with pollinators, especially honey bees. The peak in honeybees at Sweet Mountain Farm could be linked to changes in floral abundance or nectar resources, due to their tendency to exhaust a preferred source before moving on to a new one[4], such as with the white clover. Frequent activity at one large patch of white clover seemed to continue until the blossoms died off towards the end of July. Flowering trees, like basswood, were not considered in the study and could easily have been the source honeybees were traveling to for a period of time, resulting in a decline observed at trial sites. Sweat bees, bumble bees, and wasps were not observed at Sweet Mountain Farm much until mid-July, which even then was in small numbers. They began to increase as the honey bees decreased, so it appears that the competition for floral resources is what was restricting other pollinator activity. At the Butterfly House, sweat bees were seen more often than honey bees, but did not seem to outcompete them. Wasps weren't observed steadily throughout the study, but were found in spurts often on small clusters of flowers, such as *Achillea millefolium*, and eventually spiked towards the end of the study when *Solidago canadensis* bloomed in large numbers at the Butterfly House. Bumble bees were not seen in high numbers at either site, which was surprising due to the floral variety and suitable habitat surrounding each area. The bumble bees that were seen visited *Centaurea maculosa, Vicia villosa, Trifolium pretense, Solidago canadensis, Daucus carota*, and *Convolvulus* spp.

Most pollinators at the Butterfly House were found on medium to tall plants, and the few that were found on low-growing plants were at the edges of mowed paths. This could be due to the accessibility and visual appeal of the flowers based on height. Low plants tended to be overlooked and lost within the taller, dense vegetation in the prairie, or could simply have flowers too small for the hymenoptera. The dense growth helped keep plants upright regardless of the stronger winds, but still able to sway which may have helped attract pollinators against the busy, grassy landscape[7]. Areas of less dense vegetation and lower growing flowers were shielded by the wind closer to the property building by a tight border of cedars. This allowed a calmer area for pollinators to forage in case winds were too strong elsewhere. Sweet Mountain Farm's location always left it calmer than the Butterfly House, which allowed easy visitation among the less dense flower patches. The prairie vegetation at the Butterfly House could not only have led to a higher abundance and diversity in pollinators because of floral availability, but also because of better habitat variety for nesting needs.

When surveys were first conducted, Sweet Mountain Farm appeared to have a larger problem with invasive plant species than the Butterfly House. After referring to the Wisconsin DNR listings, it was found that both sites had about the same abundances of invasive plants, both restricted and non-restricted. Despite the equal abundances, it would be expected that species at Sweet Mountain Farm could more easily spread and outcompete native species due to the open space available and frequent disturbance from mowing. Aggressive invasive species, such as *Echium vulgare* and *Centaurea maculosa* which had been seen densely populating entire agricultural fields on the island, could result in reduced pollinator visitations and seed set of native plants if they share the same pollinator species[2]. The opposite may also occur where native pollinators are unable to access the floral structures of an invasive plant, so the pollinator population will suffer[9]. Though not all invasive plants were monitored in the survey, pollinators were found on *Echium vulgare, Campanula rapunculoides, Daucus carota,* and *Centaurea maculosa.*

The unknown hymenoptera were mostly the result of high-activity areas that were difficult to fully monitor, or when the hymenoptera was unable to be viewed for a long enough period of time or at a distinguishable distance. Multiple times Erik Ostrum, an entomologist, joined in surveying and helped distinguish sweat bees from honey bees. Having a second observer to regularly join surveys would greatly improve the confidence in species recognition and reduce possibilities of error, as well as promote a more regular and consistent observation period in the case of any scheduling or weather conflicts with a single observer. Pan traps to collect specimens could also be implemented to improve accuracy and detail of observations.

Though it was seen that pollinator activity declined during days with precipitation, so much that surveys were not taken during rain events, there appear to be no consistent patterns in pollinator activity before and after rain events (Fig. 4, 5, & 6). While conducting the flower abundance surveys at Sweet Mountain, honey bees were often seen in large numbers gathering at water puddles that had formed on tarps in the yard after a rain event. This however, did not seem to affect flower visitation. It is possible that periods of drought could then result in pollinator decline and then spikes after precipitation occurs, since they rely on not only direct moisture collected on surfaces but also the nectar from flowers, which could both be reduced during droughts. The only time span without large amounts of precipitation was from July 19-31, which still wasn't long enough to cause a notable effect in pollinator activity. As far as temperatures, honey bees have been shown to be most active when the temperature is around 68-77°F, and humidity is at 65-75%[10]. Temperatures on Washington Island seemed optimal for pollinators, with highs rarely dipping

below 60°F during the survey days and never exceeding 80°F (Fig. 7). Surveys were always performed midday when temperatures were near their maximum so that hymenoptera were observed during the highest activity times. Though July and August are peak months for temperature and precipitation on Washington Island[14], on multiple occasions wind, cold temperatures, and the expected rain caused longer than ideal periods of time without surveying. There were often days when surveys were conducted at one site, and then a shift in weather prevented surveying from being conducted at the other site. With living accommodations being at the Butterfly House for the duration of the study period, it was often the first site monitored, contributing to the uneven survey dates at both sites. On days with a high volume of visitors at the Butterfly House, trials often had to be delayed due to increased human activity in the yard and could have potentially been affected by the disturbance.

On July 15th Sweet Mountain Farm had a contained brush fire going in the yard which was giving off smoke, but it was just outside of the outlined survey area (Fig. 3). Pollinators rely on the scent of flowers for location[6], therefore the brush fire on the property had potential to disrupt pollinator activity. Honey bees still were observed on flowers, but other insects were not (Fig. 5). Due to the lack of pollinators other than honey bees on previous days, it is unclear whether some hymenoptera were more sensitive to the smoke or not present for other reasons.

Through this evaluation, future management of both sites can be done more efficiently. Areas of the yards can be chosen to be mowed in order to keep back taller, competing plants. Raising mower blade height and reducing mowed areas could be easily adapted as management practices for some areas to encourage pollinator populations[8]. This would likely affect Sweet Mountain Farm more than the Butterfly House, since only the front yard of the Butterfly House is mowed while Sweet Mountain has a much larger mowed area. Nesting areas can also be maintained, leaving bare soil and tree cavities for hymenoptera to inhabit[16]. Sweet Mountain Farm plans to enlarge and enhance its floral resources for pollinators, but may also expand its European honey bee operation, potentially negating any effects that would promote certain native pollinator species. The Butterfly House faces the challenge of maintaining its property, with the constant encroachment of invasive plants, solely relying on yearly interns as groundskeepers. Continued prairie restoration and maintenance at both sites and the removal of invasive plant species can help ensure the ongoing and increasing presence of a variety native pollinators.

5. Acknowledgements

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