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Assessment of Pollinator Preference of Native and Nonnative Perennial Flowering Plants in South Dakota's Grasslands

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Abstract:

With global pollinator decline continually worsening as a result of human action, concerned citizens and scientists alike have been looking for answers as to what can be done to help, and the question of whether native or non-native plants provide more benefit to pollinating insects has been long discussed in the scientific community. This research is intended to help answer that question by attempting to determine whether pollinators have a distinct preference between native and non-native plants when presented with both options. The hypothesis at outset of this project was that native plants would provide greater benefit to pollinators, whom they (presumably) evolved alongside, and would thus be selected more frequently than non-native plants. To test this, a collection of various native and non-native plants was deployed in a restored grassland in rural South Dakota and observed for 10 days. Data collected included abundance of different groups of insect visitors and the frequency at which they visited individual plants. Analysis of data gathered during the study showed that there was no clear preference between plants based on native status alone, but rather that differences in visitation frequency possibly occurred as result of individual differences between the species of plants used, meaning that a variety of factors, not necessarily just native status, should be considered when selecting plants with the intent of encouraging pollinator activity. These results can be interpreted by ecologists to provide guidance for further research questions concerning what morphological and physiological traits attract pollinators and why, as well as conservation-minded members of the general public on what species and varieties of plants may provide the most benefit to pollinators when gardening or landscaping. In addition to the findings associated with the main research question, data also showed that pollinating insects that are not native to the study region dominated observations throughout the duration of the study, which may also have contributed to the study's findings as well as spark further research on the relative abundance of native vs. non-native pollinators in the study area. This information could help provide more insight on the state of South Dakota's pollinator populations and allow for more focused interpretation of the results of this study and any others like it.

Introduction:

The world has seen a sharp decline in pollinator (especially bee) populations in the last few decades (Goulson et al., 2015). Pollinators and other insects that utilize flowering plants play a crucial role in both ecosystem health and the ability of global food systems to produce necessary yields to feed an ever-growing population. Insect activity accounts for almost 90% of pollination done in flowering plants worldwide, with bees being responsible for a large portion of all animal-dependent pollination

(Winfree et al., 2010). Without bees and other pollinating insects, the world would see the loss of many flowering plants on which we and other living things depend, alongside a major drop in production of staple food crops that feed much of the world's population. These losses could lead to both economic and humanitarian crises.

Since we depend so heavily on insects to maintain ecological biodiversity and keep food production stable and diverse, there has recently been a rise in public interest about what can be done to help boost forage for pollinators, with the hopes of encouraging pollinator activity restoring population numbers. The question of whether pollinators prefer native plants over nonnative plants has been on the minds of many entomologists and restoration ecologists throughout the years, and this research sought to find an answer to that question. The hypothesis at the outset of this project was that native plants provide greater benefits to beneficial insects, and thus will be selected for more frequently than nonnative plants. The goal of this research was to find out whether native or non-native plants were more popular among pollinating insects, and if they should thus be used more frequently in landscaping and home gardening.

Methods and Materials:

Twelve plants were placed in a random grid, one meter apart on the inside margin of a restored grassland just outside of Volga, South Dakota (coordinates 44°22'38.72"N / -96°56'53.724"W). Plants were chosen based on bloom color (yellow, white, and purple), bloom time, and native status, with 2 plants of each species being deployed in the field. Species included nonnative *Hemerocallis lilioasphodelus* (HELI), *Platycodon grandiflorus* (PLGR), and *Delphinium elatum* (DEEL)*;* and native *Rudbeckia hirta* (RUHI)*, Dalea candida* (DACA)*,* and *Echinacea angustifolia* (ECAN/ECPU). *E. angustifolia* plants were supplemented with morphologically similar, varietal *Echinacea purpurea* due to low bloom viability when data collection began. The white category consisting of *Dalea candida* and *Delphinum elatum* had to be excluded from data collection due to lack of blooms at the time the study was taking place, but were left in the grid for the duration of observations.

Observations consisted of each plant being watched for visitation by flying insects for 3 minutes each. Any insect that encountered the pollen producing part of the plant was counted as a visitor. Counts were kept track on a handheld clicker counter and time was kept with a cell-phone timer. Visitors were categorized as 'honeybee/syrphid', 'bumblebee', or 'other' and the category of each individual visitor was noted by tally during the observation period. Very few butterflies and bumblebees were observed in the surrounding prairie during the study period and did not engage with the study plants at any time while observations were taking place.

After data collection was complete, statistical analysis was done using ANOVA tests to measure the probability that flying insect visitors selected one category of plants more frequently than others beyond the possibility of coincidence. Analysis was done on the following variables: Individual plant species, native status, color, and native status controlled for differences in color. Insect group categories were also measured and ranked based on abundance.

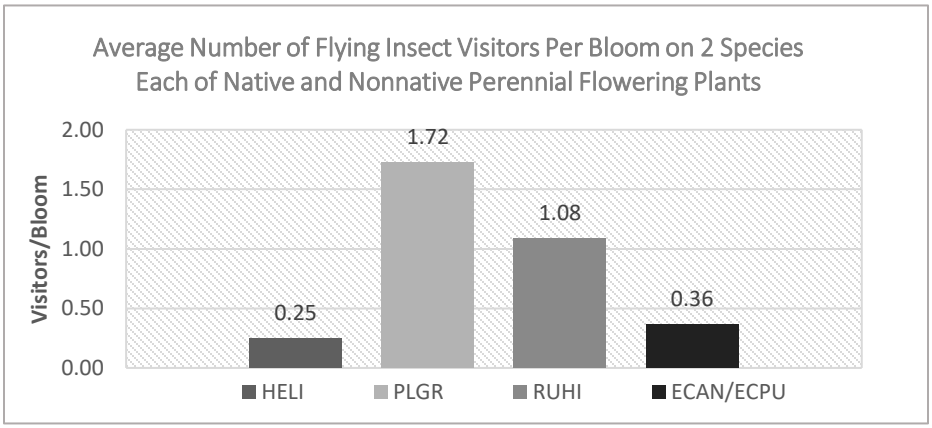
Results:

Data analysis provided mixed results depending on what variables were being considered. When species were considered independently, there was a significant difference in beneficial insect preference, with PLGR being the most selected for, followed by RUHI, then ECAN/ECPU, and lastly HELI (see figure 1). The same holds true even when controlled for color. Purple nonnative PLGR was the most selected for, and by a significant amount more, when compared to the next most popular plant, yellow native RUHI. Each of these categories were significantly more popular than purple native ECAN/ECPU, and yellow nonnative HELI, which were not significantly different from one another. When plant species were grouped based either on native status *or* color, there was no significant difference in insect preference (see figures 2 and 3). These results indicate that beneficial insects in the region do not prefer one color (purple or yellow) more than another, nor do they show a significant preference for either native or nonnative plants.

Total visitor counts were calculated, as was the average number of visitors per plant. Visitors were categorized as either: Bumblebee, honeybee/syrphid, or other. A total of 227 individual visitors were observed during the study. 177 (77.97%) of them were honeybees or bee mimicking flies (syrphids), and 50 (22.03%) that were categorized as 'others,' with small beetles being the most frequently observed insects in this category. No bumblebee visitors were observed visiting any of the plants through the study's duration. On average, each plant received 3 total visitors per observation, with 2 (66.67%) of them being in the honeybee/syrphid category, and 1 (33.33%) being 'others.' Honeybees and syrphids were significantly more abundant than bumblebees and other insects according to the data analysis results.

Figures and Tables:

FIGURE 1



ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	17.52101	3	5.840337	5.029023	0.003306	2.739502
Within Groups	78.97018	68	1.161326			
Total	96.49119	71				

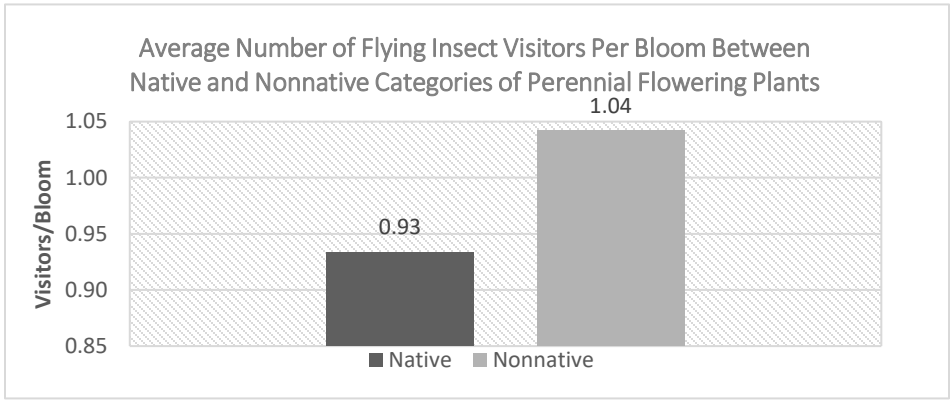
Figure 1:

-Bar graph showing, on average, how many insect visitors were observed per bloom throughout the study. HELI and PLGR are nonnative and yellow and purple respectively. RUHI and ECAN/ECPU are native, and yellow and purple respectively.

-Results of ANOVA test conducted on average number of visitors per bloom on each plant, when considered individually.

p=0.003: statistically significant

FIGURE 2



ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.210477	1	0.210477	0.152284	0.697548	3.977779
Within Groups	96.74965	70	1.382138			
Total	96.96012	71				

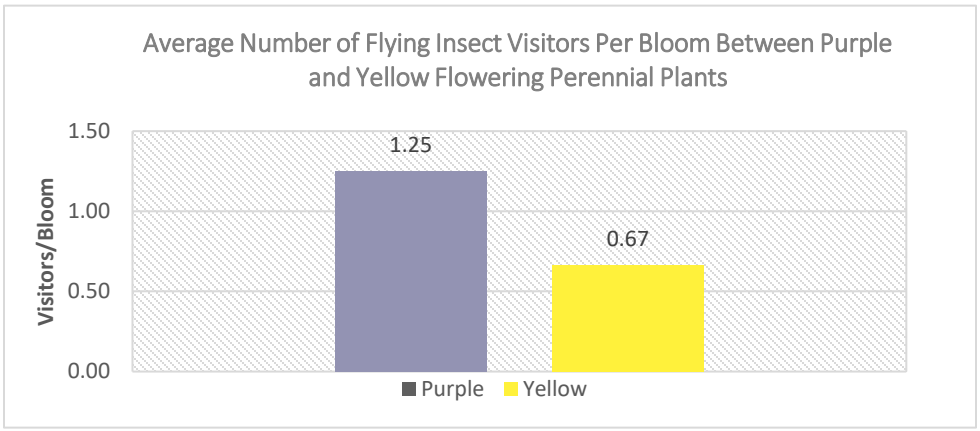
Figure 2:

-Bar graph comparing, on average, how many insect visitors were observed per bloom throughout the study between native and nonnative categories of plants. PLGR and HELI make up the nonnative category, while RUHI and ECAN/ECPU make up the native category.

-Results of ANOVA test conducted on average number of visitors per bloom on each plant, when grouped by native status

p=0.698: no significant difference

FIGURE 3



ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	5.066226	1	5.066226	3.859458	0.053437	3.977779
Within Groups	91.88745	70	1.312678			
Total	96.95368	71				

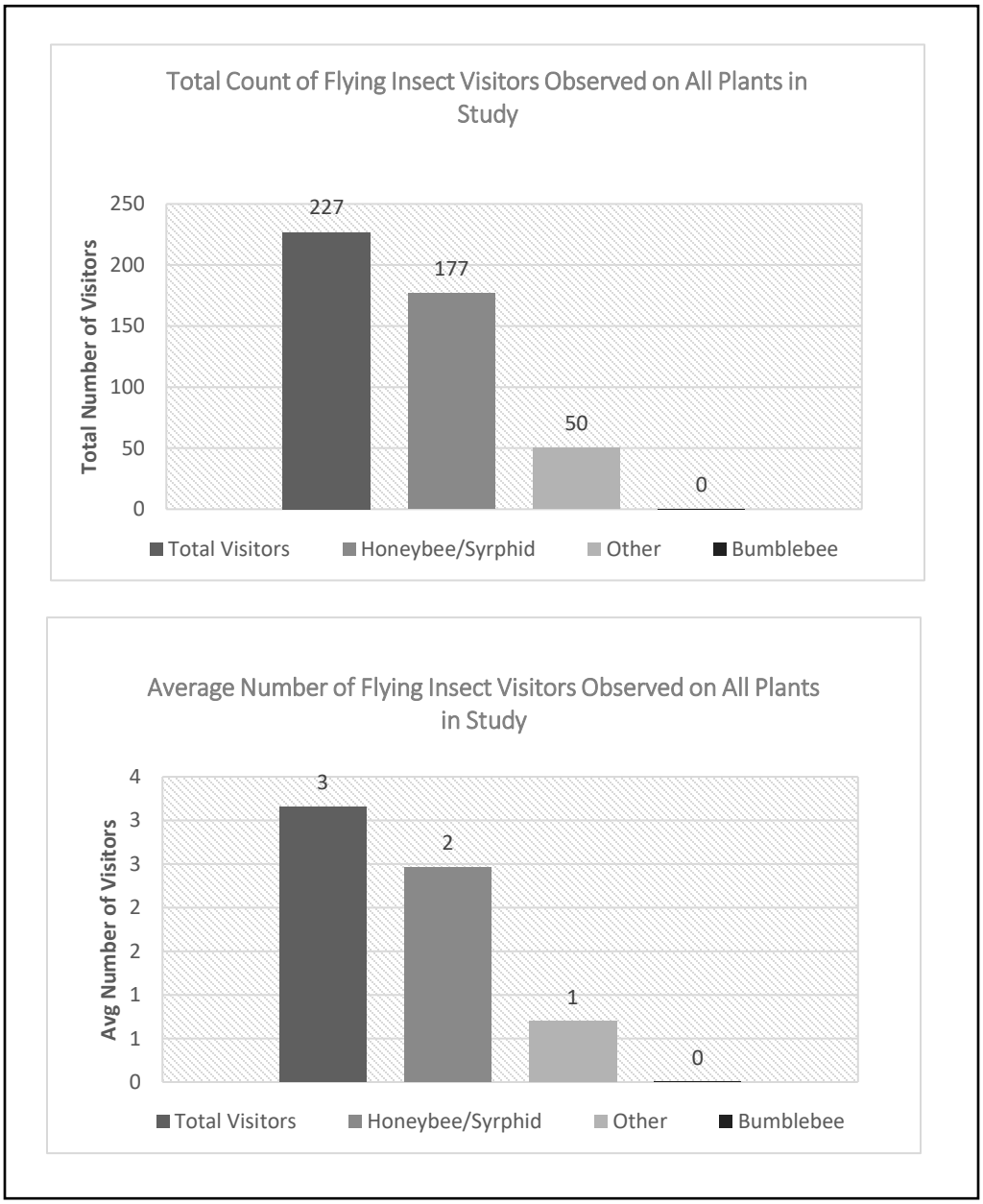
Figure 3:

-Bar graph comparing, on average, how many insect visitors were observed per bloom throughout the study between purple and yellow plants.

-Results of ANOVA test conducted on average number of visitors per bloom on each plant, when grouped by color.

p=0.053: no significant difference

FIGURES 4 & 5



Figures 4 & 5:

-Figure 4 (top) is a bar graph showing the total number of visitors observed during the study.
-Figure 5 (bottom) is a bar graph showing average number of visitors per plant that were observed during the study.

Discussion:

Results of the study found that pollinators in this region show no apparent, significant preference for either native or non-native plants among the species that were selected. Further interpretation of data revealed that, possibly, individual flower morphology and apparent ease of accessibility of nectar sources may be more important for insect selection than either native status or color. Data also showed that a majority of the insects observed in the study were species that are not native to the area in which the research took place, which could possibly explain why native plants were not selected more frequently, but may also be cause for additional concern regarding the health of native insect populations in this region.

The hypothesis made at the beginning of this study did not take into consideration the species and origins of the insects in the region, and the differences in morphology of different flowering plants—both of which appeared to be better indicators of insect preference than native status. Data analysis showed that PLGR: a nonnative species was the most popular. Further research showed that this species is also native to the region in which a majority of the observed insects (syrphid flies) also originated before being introduced to North America at the end of the 19th century (Pfiester & Kaufman 2018).

There are a couple possible reasons the data gathered in this study resulted in the analyses above. Firstly, if we investigate the morphology of the plants themselves, paired with some other non-numerical observations gathered in the study, we can speculate on the differences in preference among insects for the plants used. Plants in the study were chosen purely based on color and native status. No experimentation was done to determine the average nectar content of blooms present on the flowers, nor the accessibility of the nectar. Most flowering plants produce both nectar and pollen, but it varies in amount and ease of accessibility. Pollinating insects visit flowering plants to feed on or collect either pollen, nectar, or both, so we can infer that plants with more easily accessible nectar and/or pollen sources would likely be the most popular amongst insects looking to feed on either of these substances.

PLGR corolla (blooms) were shallow and often wide open, and they had a distinct, shiny substance (presumably nectar) that could be seen at the base of the stigma on each bloom, and little pollen. RUHI had an abundance of pollen on each bloom that was displayed completely openly, but no visible nectar source, as was the same for ECAN/ECPU, only it appeared that ECAN/ECPU had less available pollen overall over the course of the study. HELI had very deep corolla, a moderate amount of pollen on the ends of long, thin anthers, and no obvious nectar source. These differences in individual flower morphology could potentially explain the observed differences in preference, which will be discussed more in depth next.

The small beetles that made up a bulk of the 'other' category were only observed on RUHI and ECAN/ECPU, while syrphids were observed on all plants, but especially PLGR. Both HELI and PLGR are compound flowers, with just one inflorescence per bloom, but PGLR's corolla is much shallower than HELI's. RUHI and ECAN/ECPU on the other hand, are both composite flowers, with their nectar tucked into the tiny individual disc flowers that make up the bloom's head. From this, we can hypothesize that PLGR had the easiest to reach nectar, resulting in the highest number

of visitors overall, while RUHI and ECAN/ECPU may have provided pollen that was easily accessible and more popular with the small beetles of the 'other' category. HELI, with the fewest number of visitors boasted deep corolla and long, thin, possibly difficult-to-land-on pollen sources, which may have contributed to its low visitation numbers. A spider had also taken up residence in one of HELI's blooms part way through the study, but this did not seem to have a notable effect on its frequency of visits overall, as both HELI plants had similarly low visitations and only one was occupied by a predatory insect.

Another possible explanation for the varying degrees of popularity of the plants among insects, is that most of the insects observed in the study were bee-mimicking syrphid flies that originated in Europe and Northern Asia, and were not introduced to North America until the late 1800's (Pfiester & Kaufman 2018). PLGR, native to Russia, China, Japan, and Korea (Missouri Botanical Garden) could have had an upper hand in addition to its presumably more easily accessible nectar, by originating in the region that many of the species of visitors are also native.

Conclusion:

The results and data analysis of this research showed that the plant that appeared to have the most easy-to-reach nectar (PLGR: a nonnative species) was the most popular. Further research showed that this species is also native to the region in which many of the observed insects also originated before being introduced to North America at the end of the 19th century (Pfiester & Kaufman 2018). With these things taken into consideration, the findings of this study provide two important implications: First, that the morphology of the flower and the ease of accessibility of nectar and pollen sources may be more important for insect selection than either native status or color; and second, that a majority of the insects observed in the study were species that were not native to the area in which the research took place, which could be cause for additional concern regarding the health of insect native populations. Further research is necessary to determine the actual abundance and accessibility of nectar and pollen amongst plant species, and to assess the health of native insect populations relative to the observed abundance of non-native insects like syrphids and honeybees.

References:

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