Are Native Bee Foraging Behaviors Changing in the Urban Ecosystem?

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Introduction

- Native bees play a crucial role in pollinating flowers and food crops grown in parks and community gardens, contributing to local food production and the overall health of green spaces (Acharya et al., 2021).
- Rapid urbanization at the global scale has raised concerns that anthropogenic changes to the natural landscape may be negatively affecting vital keystone taxa within the ecosystem, specifically native bees (Prendergast et al., 2020).
- As urbanization continues, understanding how native bees are being affected becomes crucial for the creation of conservation strategies, as essential nesting and foraging resources may be lost (Acharya et al., 2021).
- Analysis of native bee foraging behaviors in an urban ecosystem may provide insight into their adaptability.
- Native bees' preference for pan trap color (or avoidance of pan traps) and its relation to foraging behavior is not well understood. Furthermore, published results show inconsistent relationships between pan trap color preference and preferred foraging targets (Leong & Thorp, 1999; Hall, 2016).
- In this study, we observed the total abundance of different native bee genera found in two collection methods (pan trap and sweep net), to determine if foraging behaviors are changing over time and if bees thought to be specialists are adapting their foraging behaviors and acclimating to the urban ecosystem.

Methods

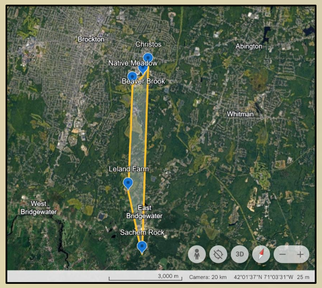

Figure 1: Map of six sites in Southeastern Massachusetts and their distances from one another, ranging from more urban in the North to more suburban in the South.

Site	Terrain	% Impervious Surface
Beaver Brook	Urban Campus	42.87
Christos	Urban Parking Lot	45.39
Dunrovin Farm	Suburban Powerline Cut	1.9
Leland Farm	Suburban Farm	3.89
Native Meadow	Urban Campus	34.85
Sachem Rock	Suburban Park	11.98

Table 1: Assessment of six sites located in Plymouth County and their percent impervious surface. Beaver Brook and Native Meadow are located at Massasoit Community College, Brockton campus.

- The current retrospective study analyzes seven years of data from an ongoing bee monitoring project to assess changing native bee foraging behaviors.
- Bees were sampled on 107 sampling dates at each of six sites across an urban to suburban gradient from 2016 to 2022 using pan trap and sweep netting techniques (Popic, 2013).
- Bees were dried and pinned, then identified to genus according to discoverlife.org before being added to a database of over 19,000 native bees. Only the top 18 most abundant genera were analyzed in this study.
- Bees were sorted by pan trap color or sweep in order to assess changing foraging behaviors over time.
- A two-way ANOVA was used to determine the significance of years and capture method on bee abundance.

Results

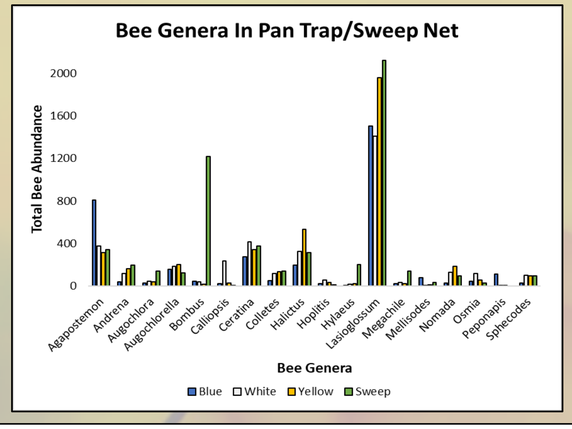

Figure 2: Top 18 most abundant bee genera from 2016-2022 and their total abundance sorted by pan traps (blue, white, yellow) and sweep net.

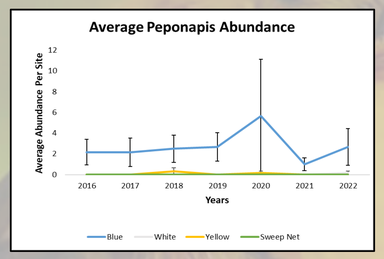

Figure 3: The average abundance of *Peponapis* spp. found per pan trap color/sweep net. Lines represent *Peponapis* abundance found in each pan trap color or sweep net for every year. Error bars represent SEM. Sample method effect on bee genera abundance was statistically significant ($p<0.05$).

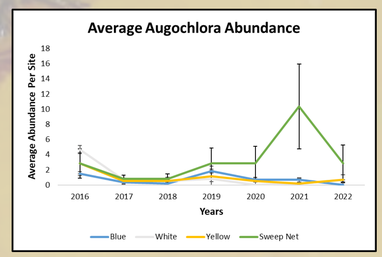

Figure 4: The average abundance of *Augochlora* spp. found per pan trap color/sweep net. Lines represent *Augochlora* abundance found in each pan trap color or sweep net for every year. Error bars represent SEM. Sample method effect on bee genera abundance was statistically significant ($p<0.05$).

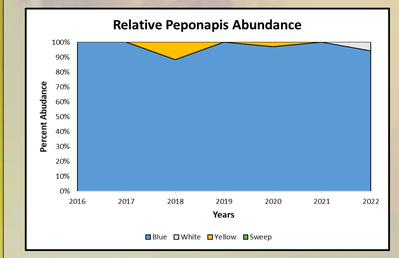

Figure 5: Change in relative abundance of *Peponapis* spp. found in pan trap color/sweep net between 2016-2022. Sample method effect on bee genera abundance was statistically significant (p<0.05).

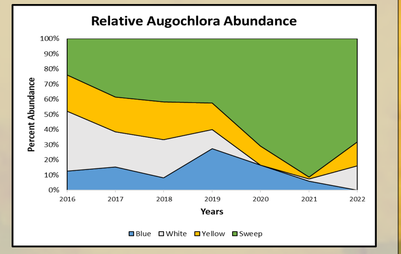

Figure 6: Change in relative abundance of *Augochlora* spp. found in pan trap color/sweep net between 2016-2022. Sample method effect on bee genera abundance was statistically significant (p<0.05).

Results

- 16,969 bees were collected and analyzed in this study with total abundance found in each collection method/pan trap color. There was a significant effect of sample method on abundance for *Peponapis* spp. and *Augochlora* spp.
- Bees with over 40% of their abundance found in blue pan traps were *Agapostemon* spp. (44%), *Melissodes* spp. (60%) and *Peponapis* (97%). Bees with over 40% of their abundance found in white pan traps were *Calliopsis* spp. (81%), *Hopilitis* spp. (46%) and *Osmia* spp. (47%). *Nomada* spp. was the only bee with over 40% of their abundance found in yellow pan traps (42%). Bees with over 40% of their abundance found in sweep nets were *Augochlora* (55%), *Bombus* spp. (92%), *Hylaeus* spp. (80%) and *Megachile* spp. (65%) **(Figure 1)**.
- Specialist bee *Peponapis* displayed a consistent trend of being found primarily in a single pan trap color as predicted in previous literature (Leong & Thorp, 1999). However, *Peponapis* were primarily found in a pan trap color (blue) different to their host flower (Cucurbitaceae) **(Figure 1)**.
- *Augochlora* showed a steady change in abundance found in pan traps to sweep net after a decrease in abundance in 2017. In 2016, only 23% of *Augochlora* were found in sweep nets, which increased to 68% in 2022 **(Figure 4)**.
- Two other bees experienced a change in abundance found in sweep net (*Andrena* spp: 29% difference from 2016-2022 and *Lasioglossum* spp: 21% difference from 2016-2022) though these differences only occurred between 2021-2022 without a steady increase like Augochlora.

Discussion

- *Peponapis* was found predominantly in blue pan traps – a color different to their host flower (yellow). This finding is unique among the specialist bees in this study and suggests that *Peponapis'* foraging behavior may be responsive to environmental cues other than color (Hall, 2016).
- The reportedly specialist bee *Peponapis* was found in more than one color pan trap, suggesting they may have the ability to forage outside of their assumed target plant.
- The temporary increase in preference for yellow pan traps shown by *Peponapis* in 2018 was not accompanied by notable changes in their total abundance, whereas changes in *Peponapis* total abundance for 2020-2021 were not associated with changes in the dominance of blue pan traps. This suggests that *Peponapis* foraging habits are not predicted by changes in their total abundance or vice versa.
- The increase in *Augochlora* abundance from 2016-2021 was accompanied by a dramatic increase in the dominance of sweep netting capture, suggesting that increases in abundance are predictive of a reduced tendency to be found in pan traps.
- The generalist bees *Augochlora*, *Andrena*, and *Lasioglossum* displayed variability in the ratio of pan trap abundance to sweep net abundance and provide additional examples of foraging behavior shifts.
- Our findings were contradictory to published data that suggest specialist bees will only appear in pan traps similar in color to their host flower (Leong & Thorp, 1999) while corroborating a report that squash bees showed a preference for a color (blue) different to their host flower (yellow) (Hall, 2016). This may reflect behavioral adaptation to different environmental conditions.
- Changes in foraging behavior as represented by pan trap color preference or variability in pan trap to sweep net ratios may represent important behavioral adaptations that impact pollination services and add uncertainty to estimations of bee abundance over time.
- Insight into natural or anthropogenic changes to the wild bee community may be enhanced by the addition of behavioral data to complement taxa abundance when assessing community composition in the urban ecosystem.

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