The Potential of Gender Ratio in Mason Bees (*Osmia spp.*) as an Indicator of Ecosystem Health

V. Lopes, A. Germaine, P. Sanon, F. Ajayi, A. Oguma, and M. Bankson

Division of Science and Math, Massasoit Community College, Brockton, Massachusetts, USA

Twitter: @MassasoitSTEM; Email: STEMresearch@Massasoit.edu

Introduction

- Bees are crucial to ecosystem function as they provide pollination services to wild flowering plants and around 70% of crops grown in the U.S. (Klein *et al.* 2006, Ricketts *et al.* 2008, Corbet *et al.* 2015).
- The genus *Osmia* (mason bees) are effective specialist native pollinators, ubiquitous across North America (Woodcock *et al.* 2013) .
- Previous research suggests that environmental stress causes female *Osmia* to allocate resources toward producing more male than female offspring (Heimpel & de Boer 2008, Sandrock *et al.* 2013).
- This trend in sex allocation suggests that the proportion of male to female *Osmia* may be an indicator of ecosystem health.
- The present study investigates the potential of *Osmia* sex ratios as an indicator of ecosystem health by assessing its consistency to other indicators in an urban to semi-urban setting in Southeastern Massachusetts.

Study Sites

Table 1. Assessment of land-use practices for six study sites located in Southeastern Massachusetts. Native Meadow and Beaver Brook are located on the Brockton campus of Massasoit Community College.

SITES→	Christos (CH)	Beaver Brook (BB)	Native Meadow (NM)	Sachem Rock (SR)	Dunrovin Farm (DF)	Leland Farm (LF)
% Impervious	46.9%	46.0%	32.0%	7.9%	1.9%	0.5%
Distance from powerline cut	949 m	579 m	173 m	519 m	0 m	301 m
Terrain type	Urban parking lot	Urban college campus	Urban college campus	Suburban park	Rural farm	Commercial farm
Sustainable practice	None	Riparian buffer, reduced pesticides	Native plantings, reduced pesticides	Community garden	reduced pesticides	None
Mowed	Never	Annually	Annually	Occasionally	Rarely	Plowed

Methods

- Samples were collected from early spring to late fall in the years 2016, 2017, and 2018.
- Bees were caught via sweep nets and pan traps to reduce collection bias (Roulston *et al.* 2007).
- Blue, white, and yellow pan traps (n = 10 per color) were deployed at each study site and retrieved after 24 hours (Droege 2015).
- Sweep netting was performed by two researchers along a 100-m transect for 30 minutes following pan trap collection (Popic 2013).
- Collection methods were normalized to sampling effort to account for damaged pan traps.
- Geographical Information System Software (ArcGIS) was used to estimate % impervious land cover (*e.g.* pavement and buildings) within a 300-m buffer zone around each study site.
- *Osmia* were sexed by visual identification of key morphological features, in addition to counting the antennal segments.
- A Cochran-Mantel-Haenszel test was used to test for effects of month and site, and Fisher's exact test was used to test for an effect of year, on *Osmia* sex ratios.

Results

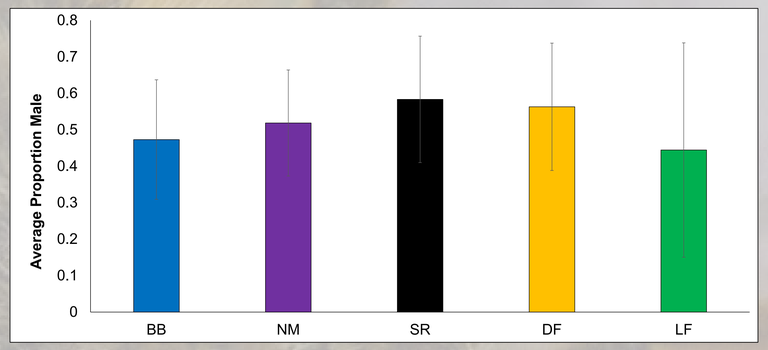

Figure 1. The average proportion of male *Osmia* sampled over three years (n = 3 per site) at five sites (only one *Osmia* was collected in three years at Christos, so it was excluded from the analysis; errors bars denote standard error). There was no significant difference in proportion of male *Osmia* among site *(Fisher's exact test, p = 0.727).*

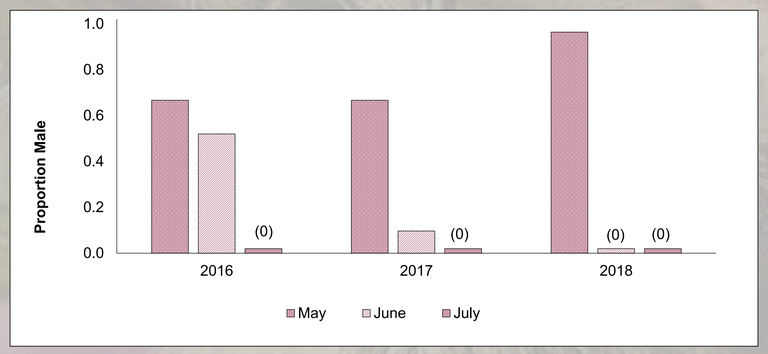

Figure 2. Proportion of male *Osmia* for the months of May, June and July, per study year. The Cochran-Mantel-Haenszel test showed a significant effect of month on *Osmia* sex ratios between all three years (χ^2_{MH} = 31.7, 2 *d.f.*, p < 0.001). Zeroes indicate months in which no *Osmia* males were collected.

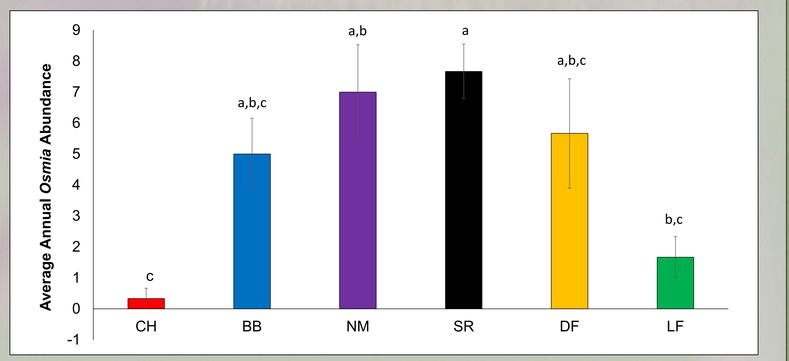

Figure 3. The average number of *Osmia* sampled over three years (n = 3 per site) at five sites (error bars denote standard error). There was a difference in average *Osmia* abundance among sites (ANOVA: $F_{5,17}$ = 6.4, p = 0.004). Sites that do not share letters differed in average annual *Osmia* abundances (Tukey's HSD). Only one *Osmia* was sampled at Christo's over three years (in 2017).

Discussion

- Three years aggregate sex ratios showed no effect of site. However, there was an effect of month on *Osmia* sex ratios, which is consistent with previous reports (Bosch and Kemp 2004, Sedivy and Dorn 2013) that a shift from male to female dominance occurs across the flight season.
- Mean *Osmia* abundance showed a significant effect of site, with the two most disturbed sites showing significantly less *Osmia* abundance. This suggests that *Osmia* abundance may have some utility to be used as an indicator of ecosystem health.
- There was no significant correlation between total *Osmia* abundance and either total bee abundance or bee diversity (data not shown), suggesting that *Osmia* may provide an additional method for evaluating the larger bee community and ecosystem health in urban settings.

Conclusion

- The current data set does not suggest that *Osmia* sex ratios may be an indicator of ecosystem health. However, total *Osmia* abundance may have potential as a marker.

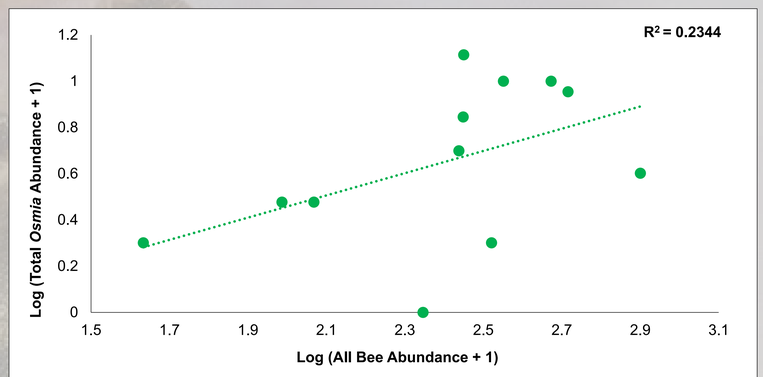

Figure 4. Correlation of total *Osmia* abundance and all bee abundance (including *Osmia*). The correlation was found not to be significant at alpha = 0.05 , with p = 0.110738 and R^2 = 0.2344.

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