

CUYAHOGA VALLEY NATIONAL PARK:

FINAL REPORT ON PERMITTED RESEARCH 2018-2019

"Pollination ecology and the evolution of selfing in monkeyflower (*Mimulus ringens*)"

This Project explores the reproductive and pollination ecology of *Mimulus ringens* (Square-stem Monkeyflower). The specific focus is on how among-site variation in floral display size (number of flowers open at once) influences selfing rates, inbreeding depression, and floral traits associated with the mating system. We are also exploring how other aspects of ecological context, such as pollinator abundance and species composition influence pollen limitation and mating system. This work is funded by a grant from the National Science Foundation.

In 2018 we evaluated pollination and pollinators in 13 natural populations of *Mimulus ringens* (Square Stem Monkeyflower) across northeastern Ohio (Table 1, Figure 1).

These sites include two in the CVNP: **Cull Barn**, and **Wetmore Road**. They are abbreviated as **CBC** and **WET** in the general report below. Note that the two CVNP sites had fairly average daily floral displays (Number of open flowers/plant; Figure 2), but had much higher than average pollinator visitation rates and a high proportion of Bumble Bee visits (Figure 3).

Table 1. Locations for the sites used in this study.

Site	Code	County	Latitude	Longitude
Cull Barn Cuyahoga Valley National Park	CBC	Summit	41.252771	-81.548392
Wolf Creek Environmental Center Medina County Parks	ECM	Medina	41.116670	-81.737585
Hinckley Reservation Beaver Pond Cleveland MetroParks	HBP	Medina	41.206317	-81.691658
Lake Erie Bluff MetroPark Lake County MetroParks	LEB	Lake	41.785655	-81.183065
Liberty MetroPark Summit County MetroParks	LIB	Summit	41.29468	-81.401495
Lucia Nash Beaver Pond The Nature Conservancy	LNB	Geauga	41.438804	-81.180091
Mosquito Creek Wildlife Area Ohio Division of Natural Resources	MCW	Trumbull	41.425646	-80.817777
Morgan Swamp Beaver Pond The Nature Conservancy	MSB	Ashtabula	41.643450	-80.892086
Rising Valley MetroPark Cleveland MetroParks	RIS	Medina	41.259202	-81.694408
SKOK Meadows Lake County MetroParks	SKO	Lake	41.657295	-81.191728
Strongsville Wildlife Area Cleveland MetroParks	STR	Cuyahoga	41.318994	-81.809941
Windhover Bog Bath Nature Preserve	WBW	Summit	41.176049	-81.647164
Wetmore Road Cuyahoga Valley National Park	WET	Summit	41.21808	-81.55386

In each of these 13 natural populations we randomly chose 81 cells from a grid of 1m² quadrats and marked a single *Mimulus ringens* stem in each. Over the season we recorded number of open flowers on each ramet at least once a week, and also recorded abundance of other flowering species. We tested for pollen limitation by providing supplemental pollen to one flower for comparison to a control flower on 25 ramets/site. We also recorded pollinator visitation rates to a known number of flowers. To assess floral morphology, we measured flowers on 25 plants/site. We collected fruits from the pollen limitation plants, and also collected bulk fruits from at least 30 of the focal plants for estimation of the mating system.

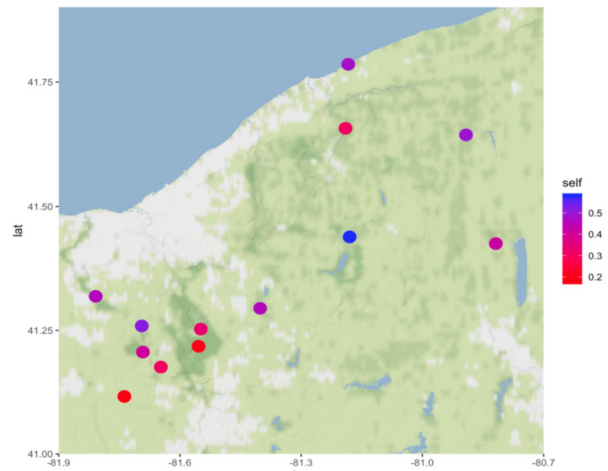


Figure 1. Geographical locations of 13 populations and associated selfing rates in Northeastern Ohio. Dot color indicates selfing rate.

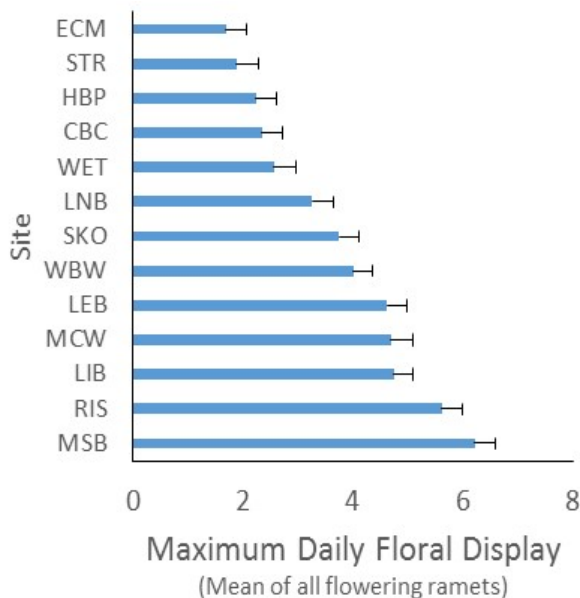


Figure 2. Floral display for 13 natural populations. Values shown are mean (SE) across 81 ramets/site for the maximum floral display on any single day. Ramets that did not flower are not included.

Note that order of sites differs between Figure 2 & Figure 3

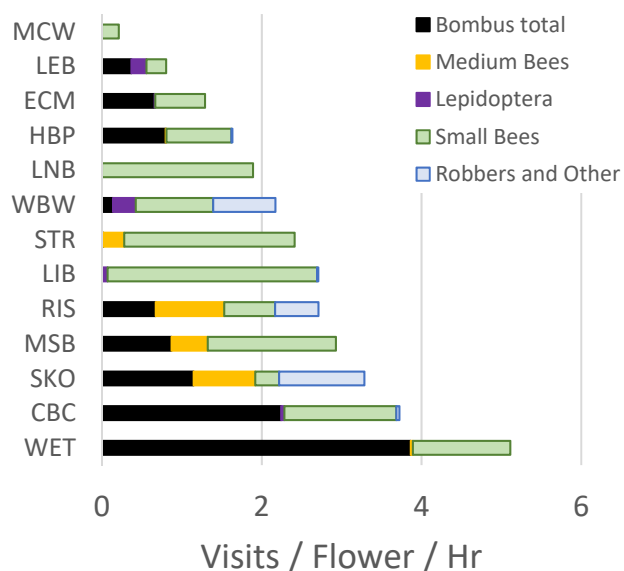


Figure 3. Visitation to *Mimulus ringens* in 13 natural populations in Northeastern Ohio, 2018. Bombus indicates bumble bees (4 spp), Medium Bee indicates *Apis* and *Anthophora terminalis*. Small Bees refer to bees smaller than *Apis* (mostly *Lasioglossum*, *Augochlora*, and *Ceratina*). Lepidoptera includes mostly *Skippers* and *Hemaris* spp). Robbers and Other is for all other visitors that may not contact reproductive parts (mostly *Xylocopa virginica*)

Floral display size varied over 3.5-fold across sites (Figure 2), providing the variation in ecological context required for this study to be informative. These sites also varied dramatically in pollinator visitation rates and species composition (Figure 3). There was no association between display size and visitation rate ($r = -0.04$, $P > 0.5$)

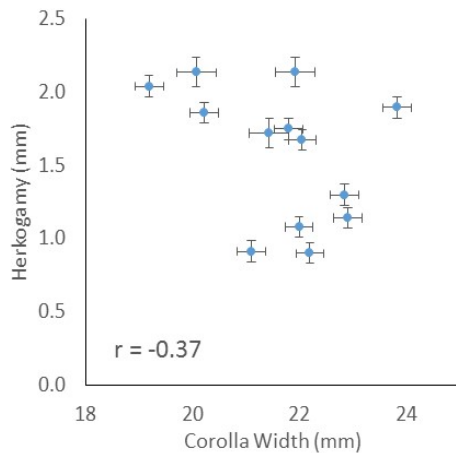


Figure 4 Relationship between two floral traits (Flower Width and Stigma-Anther Separation) across 13 natural populations. Values shown are Mean (SE) over 25 plants/site. $P > 0.2$

Floral morphology also varied greatly and significantly among sites for all traits we measured (Corolla Width, Corolla Height, Tube Length, Style Length, Anther-Stigma separation (Herkogamy)). Although most of these traits covaried mildly, much of the variation was independent of other traits (Figure 4). Studies in 2017 confirmed that these and other floral traits show substantial broad-sense heritability ($H^2 = 0.36$ for Corolla Width and 0.61 for Herkogamy).

At some sites a substantial fraction of fruits was damaged by small caterpillars (*Verbena Bud Moth*, *Endothenia hebesana*; Tortricidae). This varied

substantially across sites, from 0 to 80% (Figure 5).

Seeds from all sites were planted for genotyping, and that analysis is nearly completed. A map of selfing rates across the sites is in Figure 1. Preliminary results indicate that sites with larger floral displays and fewer visitors have higher selfing rates, confirming our expectations. Pollen limitation also tends to be greater when pollinators are less abundant, also confirming our predictions.

In 2019 we returned to all sites to assess fruit predation rates. Those samples are now being scored. A manuscript on this project is now in a rough draft stage, and should be submitted for publication during 2020.

Thank you for your permission to do research on your land, and your help in doing so.

February 18, 2020

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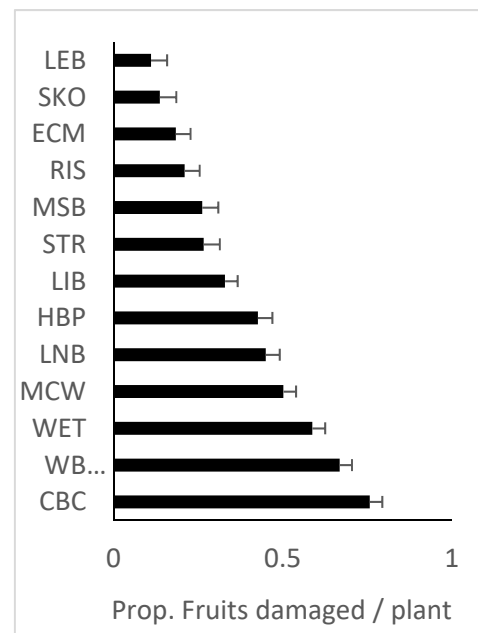


Figure 5. Fruit damage by lepidopteran larvae. 25-40 plants/site, 10 fruits/plant.