Do the fused leaves of *Silphium perfoliatum* prevent flightless arthropods from reaching the top?

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Abstract

This study at Litzsinger Road Ecology Center evaluates the claim whether the fused leaves of *Silphium perfoliatum* prevent flightless arthropods from reaching the top. Statistical analysis indicates that that leaves are ineffective on a day-to-day basis, but not perhaps not collectively over a summer. However, correction of experimental design will help clarify the answer.

Introduction

Silphium perfoliatum is a common Missouri native plant that grows in prairies and low woods where it can find full sun. It is distinguished from other *Silphium* plants by its distinctive square stem and leaves that fuse into cups around the stem, hence it's common name "cup plant" (Missouri Botanical Garden Plant Finder).

Although multiple studies in recent years have been done on the relationship between *S. perfoliatum* and gall wasps, feasibility as a forage crop, and medicinal uses, virtually no studies have been done on its unique characteristic of the cups since 1887. W.J. Beal attempted to decipher the evolutionary advantage to having cups. He, as other since then, including the principal investigator, had noted the ecological niche that *S. perfoliatum* holds as a reservoir for water for birds and arthropods even in the driest parts of summer. They frequently hold water from dew or rainfall that birds or arthropods feed from. However, these serve purposes for other species, and not for *S. perfoliatum* in particular. Beal discovered that *S. perfoliatum* neither absorbed the water in the cups or gained nutrients from the drowned arthropods in the water. He hypothesized that the cups, when filled with water, prevented flightless arthropods from taking nectar, since they would be less likely to cross-pollinate with other *S. perfoliatum* than flying arthropods (Beal and St. John, 1887).

Litzsinger Road Ecology Center, managed by the Missouri Botanical Garden, is a 34 acre private property that has restricted access for educational purposes only. It is managed to maintain ecosystems native to the St. Louis area, within a fifty-mile radius. Within its property there are three prairies, all less than five acres, and all containing varying amounts of *Silphium perfoliatum*.

The intention of this study was to test the hypothesis that the cups of *S. perfoliatum* prevent flightless arthropods from reaching the apex of the plant.

Materials and Methods

Arthropods were identified from each *Silphium perfoliatum* (henceforth referred to as cup plants), in one of three sections: bottom quarter, top quarter, and middle half. Each plant's height was measured to help identify the quarters. Arthropods could be collected if necessary, otherwise identified by sight. Arthropods that were collected followed the procedure published online by the Entomology Department at the University of Minnesota (2014). All arthropods were identified to order, and if possible to family or superfamily. Only flightless arthropods were counted (and collected if not identifiable in the field) to stay in keeping with the hypothesis.

Identifying which cup plants to measure/count was facilitated by their tendency to grow in patches. A patch was defined as a group of cup plants where five or more grew together. Patches were identified in all three prairies: North (18), South (37), and Pasture (30). On the eastern edge of the South prairie, one patch was very large and not easily defined. In this area, previously existing 15-meter quadrants were used to delineate man-made patches, with each quadrant subdivided into four patches. For each day sampling, patches were randomly chosen by using the random number generator from Random.org. Two cup plants were sampled from each selected patch, one approximately on opposite sides of the patch. At least 24 hours prior sampling, plant surrounding the patch were cut to eliminate the possibility of arthropods climbing on to the plants without crossing the cups.

Cup plants were sampled twice a day (morning and afternoon), three times per week for four weeks. Once all data was collected one-way and ANOVA statistics were used to identify any results of significance.

Results

During 22 sampling sessions, 638 individuals were counted in total, representing seven orders of arthropods. However, 415 of the individuals represent the family Aphididae. The individuals found were flightless larva, found strictly on the apex of plants, and could have not reached there themselves. The aphid larvae must have hatched rom eggs laid by a winged adult, so when statistical analysis was done, these data were excluded. Thus, analysis was conducted on 222 individuals representing 6 orders as shown in Figure A. (Super) Families most represented within the orders were Formicidae (Hymenoptera), Agelenidae (Aranae), and Membracidae (Hemiptera).

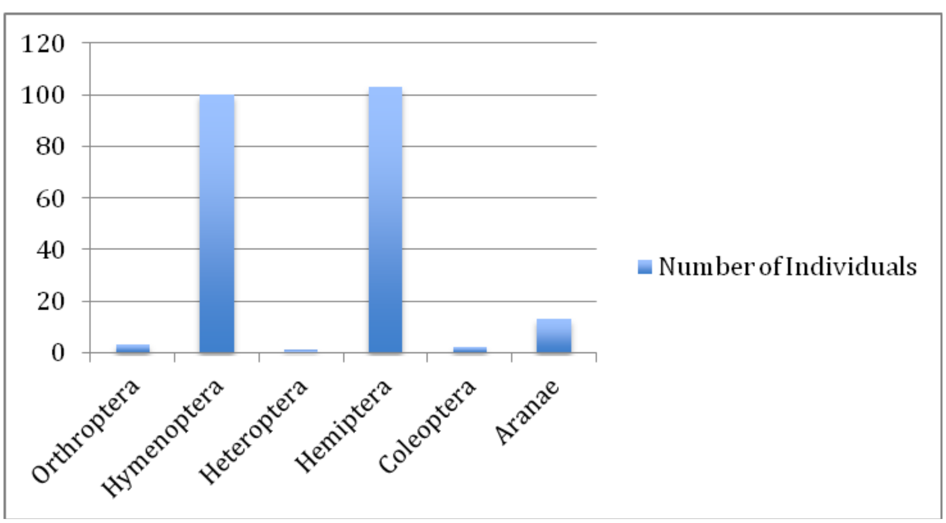

Figure A. Arthropods Collected by Order.

Separating the data by sections of the cup plant, the vast majority of arthropods were not found at the top, and two of the six orders were not represented at all in the top quarter of the cup plants (Graphs B and C). 162 of 222 arthropods were found in the middle 50% over the course of the sampling. One-way ANOVA was done on each one of the prairies, as well as combined, to determine if there was a difference between the top, middle and bottom of the cup plants on a daily basis (Table A-D). No significant differences were found.

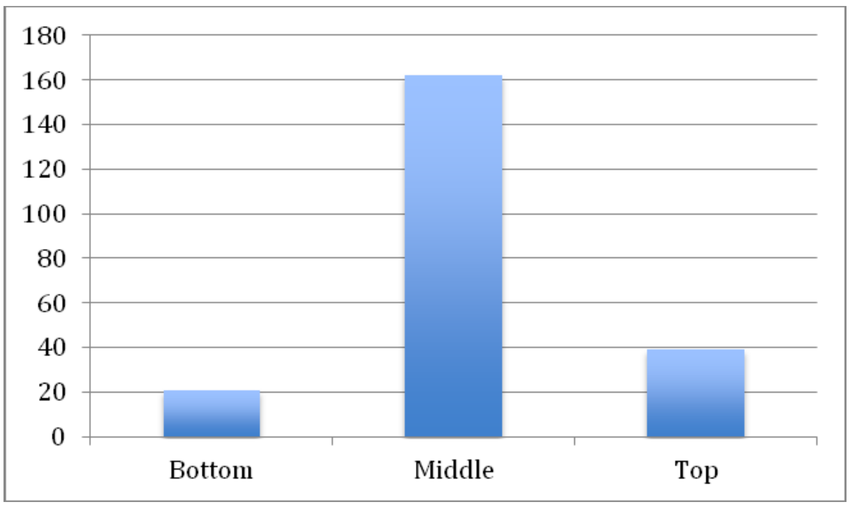

Figure B. Dispersion of Arthropods Combined.

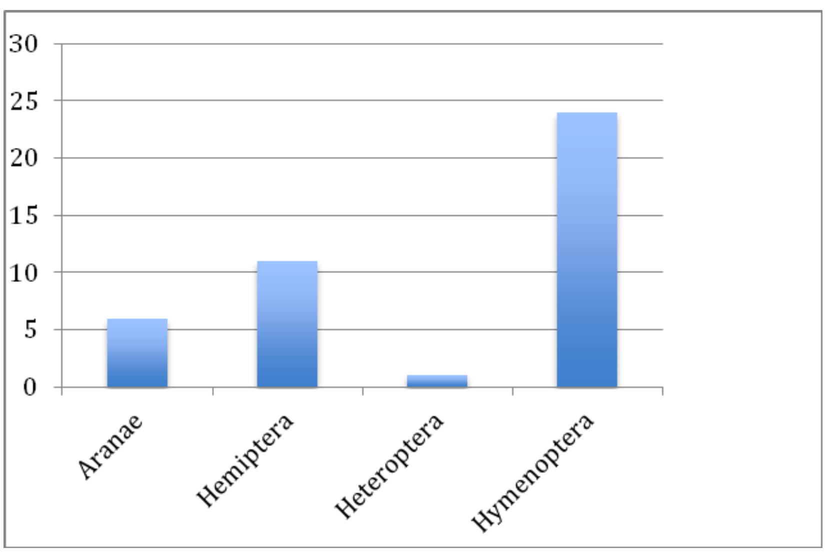

Figure C. Arthropods Found at the Top of *S.perfoliatum*. Breakdown of which orders were found at the top throughout the summer.

Discussion

Although the ANOVA statistical test denoted as no statistical difference on a day-to-day basis between regions of the cup plant, combined data from all three prairies showed that most of the arthropods were found in the middle 50%. This is especially representative of the South Prairie, unsurprisingly, because it is where the most arthropods were collected from over the entire sampling period.

It stands to reason that since growth around the cup plants were cut, that all arthropods had to climb up themselves, and few remained in the bottom section because of the lack of foliage, and surface area of where they could be. Moreover, when bottom and middle were combined to compare to the top 25% (not shown in this paper), there was still not a significant difference on a day-to-day basis.

However, the experimental design was innately flawed, and needs rectifying in future studies before rejecting the hypothesis. The primary investigator noted that as cup plants grew, often the lower "cups" would not longer be functional due to tears or shriveling of the leaves as the summer wore on, making them less effective at preventing arthropod movements. Additionally, plants grew in some cases more than two feet within two weeks, making the divisions of "bottom, middle, and top" somewhat arbitrary within and between patches. Peak bloom season also came later in the summer than usual this year, due to a late spring and little rainfall, therefore all data collected reflects the pre-bloom period. It is possible that some arthropods will not climb the cup plant until they receive a signal that it is blooming, and so if there had not been time constraints to the project, the sampling should have continued throughout the peak bloom.

There may be other flightless arthropods that usually reach the summit of the plant, but due to the cutting of nearby vegetation were unable to reach it. A control group that had no cutting of vegetation would have been a good reference point to know whether more arthropods depend on the cup plant that shown in this study, and whether there is an interest in arthropods to reach the top. There is the possibility that arthropods do not need to reach the top, but merely depend on the foliage (although no noteworthy insect destruction of the plant was noted), or the water in the cups.

Conclusions

Do the cups prevent flightless arthropods from reaching the top? This study suggests no, and alternative hypotheses for the evolution of fused leaves around the cup plant should be suggested. However, noting the experimental design flaws, this question cannot be answered with great certainty. This project should be considered as a preliminary data for more expansive and long-standing research on cup plants and insect diversity at Litzsinger Road Ecology Center.

References

Beal, WJ, & St. John, CE (1887). A study of Silphium perfoliatum and Dipsacus laciniatus in regard to insects. Botanical Gazette, 12(11), 268-270.

Hahn, Jeffery. “Collecting and preserving Insects.” University of Minnesota Department of Entomology Extension. <http://www.extension.umn.edu/youth/mn4-H/projects/environment/entomology/collecting-and-preserving-insects/>.

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Statistical Analysis

Table A. Comparison for North Prairie for Arthropod Dispersion by Day

Anova: Single
Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Bottom	22	6	0.272727273	0.303030303
Middle	22	56	2.545454545	38.83116883
Top	22	41	1.863636364	15.64718615

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	59.84848485	2	29.92424242	1.63874511	0.202393517	3.142808517
Within Groups	1150.409091	63	18.26046176			
Total	1210.257576	65				

$p > 0.05$, $F < F$ critical. Retain null hypothesis.

Table B. Comparison for South Prairie for Arthropod Dispersion by Day

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Bottom	22	61	2.772727273	131.4220779
Middle	22	85	3.863636364	57.17099567
Top	22	31	1.409090909	1.777056277

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	66.54545455	2	33.27272727	0.524337415	0.594507896	3.142808517
Within Groups	3997.772727	63	63.45670996			

Total	4064.318182	65

$p > 0.05$, $F < F$ crit. Retain null hypothesis.

Table C. Comparison for the Pasture Prairie Arthropod Dispersion by Day

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Bottom	22	8	0.363636364	0.813852814
Middle	22	11	0.5	0.833333333
Top	22	18	0.818181818	5.489177489

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.393939394	2	1.196969697	0.503184713	0.607011198	3.142808517
Within Groups	149.8636364	63	2.378787879			
Total	152.2575758	65				

$p>0.05$, $F<F$ crit. Retain null hypothesis

Table D. Combined Prairies Arthropod Dispersion by Day

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Total Bottom	66	75	1.136363636	44.18111888
Total Middle	66	152	2.303030303	33.22983683
Total Top	66	90	1.363636364	7.588811189

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	50.49494949	2	25.24747475	0.891089788	0.411872096	3.042229897
Within Groups	5524.984848	195	28.33325563			
Total	5575.479798	197				

$p > 0.05$, $F < F_{crit}$. Retain null hypothesis.