

# **EFFECT OF COLOR, SIZE, AND DENSITY OF *SARRACENIA PURPUREA* ON PREY CAPTURE**

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## **ABSTRACT**

Our objective was to study physical characteristics of the purple pitcher plant (*Sarracenia purpurea*) in northern Michigan to determine an effect on the amount (biomass) and richness of insect prey capture. We examined pitcher density, amount of red venation, and pitcher size (length, mouth diameter, and keel width) of 40 pitchers. The catch contained individuals from eleven different insect Orders, the most abundant being Hymenoptera and Diptera. Higher species richness was positively correlated to high-density pitcher groups and mouth diameter. The highest density of pitchers in a plant was 38 pitchers, one of which had 4 different species inside. The highest species richness in a pitcher was 7 different species and the largest mouth diameter was approx. 35mm. Biomass was also positively correlated to mouth diameter, but not to density, pitcher length or keel width. Color showed to be insignificant in determining prey capture. Morphological variation may hold some responsibility in attracting insect prey, but future studies examining an exhaustive scope of pitcher physical traits and their cumulative effect may be valuable in finding the exact mechanism of prey capture.

## **INTRODUCTION**

Evolutionary adaptations have allowed plants that live in nutrient-poor environments gain nutrients in other ways. Pitcher plants are carnivorous plants that live in nutrient-poor, acidic environments and lack digestive glands or enzymes (Ellison and Gotelli 2002). Thus, to absorb nutrients, specifically nitrogen, they decompose insect prey that is drawn in and captured in their fluid-filled pitcher-shaped leaves (Ellison and Gotelli 2002, Newell and Nastase 1998). Diptera larvae inhabitants, such as *Wyeomyia smithii* and *Metriocnemus knabi*, facilitate this

decomposition process which allows for faster nutrient uptake by the plant (Bradshaw and Creelman 1984). While insect capture can greatly depend on the environment (Brewer 1999) and geographic location (Ellison et al. 2004), morphological variation may also have a significant effect on the efficiency of prey capture (Green and Horner 2007). Green and Horner (2007) found that pitcher size in *Sarracenia alata* Wood (the yellow pitcher plant) was significant and positively related to daily mass capture of insects. Newell and Nastase (1998) found that potential prey were more likely to visit pitchers (*Sarracenia purpurea*) with a greater degree of red venation.

According to Ellison and Gotelli (2001), carnivorous plants have evolved mechanisms to attract prey, given their dependence on insect attraction as a main source of nutrient (nitrogen) intake. We based our study off of this principle. While another study found that certain factors contribute to the diversity of insects caught, including pitcher fragrance (for capture) and fluid viscosity (for retention) in *Nepenthes rafflesiana* (Di Giusto 2008), we predicted that overall pitcher attractiveness, such as the different physical variations in pitchers, may contribute to species richness and biomass of prey inside the pitcher.

The purpose of our experiment was to investigate these physical characteristics of attractiveness in *Sarracenia purpurea* (the purple pitcher plant) for their effect on prey capture, quantified by the total biomass and species richness inside of the pitcher. To quantify pitcher plant attractiveness, we studied the following characteristics of *S. purpurea*: pitcher density, amount of red venation, and size of pitcher, including keel width, mouth diameter, and pitcher length. Prey capture was measured by the undigested biomass and the number (and species) of whole insects inside of the pitcher. We hypothesized a) that biomass and insect species richness of the contents of pitchers will increase with pitcher density, b) that biomass and insect species

richness of the contents of pitchers will increase with more red venation on the leaves, and c) that biomass and insect species richness of the contents of pitchers will increase with pitcher size.

## **MATERIALS & METHODS**

### *In the field*

This study took place in Bryant Bog near Douglas Lake in Pellston, Michigan. The bog was located near houses and well traveled roads. Dominant species at the bog included leather leaf, spruce, and sphagnum moss. Leather leaf cover was very thick, and most pitcher plants were found under shrubs or spruce trees. We sampled over the course of a week, sampling 40 pitchers on two different days. We randomly selected both a) the pitcher plant group to sample from, and b) one single pitcher inside the group to measure. Pitcher density was a measurement of the number of individual pitchers in a group (group=less than 0.5m apart). We measured pitcher sizes, including keel width, mouth diameter, and pitcher length with digital calipers. Keel width was measured at the widest part of the pitcher, mouth diameter was measured at the top rim (mouth) of the pitcher, and pitcher length was measured from the top of the hood to the bottom of the pitcher 'bowl' (Fig. 2). We used turkey basters and medicine droppers to remove the fluid and organic matter from inside the pitcher. We rinsed the pitcher once with water and extracted the fluid and organic matter again to ensure accuracy of removal. Contents were stored in plastic bags until later that day for observation under microscopes. Finally, we noted color by amount of red venation on the leaves, on a numbered scale of 1-5 (Fig. 1).

### *In the lab*

We analyzed the pitcher contents under a microscope for number and species of whole insects (still undigested) to calculate species richness (number of different species) inside each pitcher. We separated the organic matter from the fluid by vacuum filtration, after which the

samples were dried for at least 48 hrs at 60°F in a drying oven and weighed to measure relative amounts of biomass.

We used linear regression analyses (as implemented by SPSS) to find correlations between species richness and biomass and each physical characteristic of the pitcher plant: pitcher density, mouth diameter, keel width, and length. A multiple linear regression was used to test all of these morphological traits against species richness to determine the effect of all factors together. We also used t-tests to determine if there was a significant effect of color on species richness or biomass.

## RESULTS

The most abundant Orders found inside *S. purpurea* were Hymenoptera (ants and wasps), Collembola (spring tails), Diptera (flies and mosquitoes), and Pulmonata (slugs; Table 1). Species richness, measured by number of whole insects, was significantly positively correlated with pitcher density (number of pitchers;  $p=0.001$ ,  $r^2=0.217$ ,  $df=44$ ) and with mouth diameter ( $p=0.017$ ,  $r^2=0.123$ ,  $df=44$ ; Figs. 3 and 4). Pitchers plants with a density of 20 pitchers or higher had approximately 5 different species inside of them, while plants with 1-5 pitchers had approximately 0-1 species inside of them. Pitchers with a mouth diameter of greater than 30mm had about 4 different species inside of them, while pitchers with mouth diameters of 10-15mm had about 0-1 species inside of them. Both variables (pitcher density and mouth diameter) were also tested together against species richness in a multiple linear regression; it was also found to be significant and positive ( $p=0.000$ ,  $r^2=0.305$ ,  $df=44$ ). Together they account for more of the total variation found in species richness than either density or mouth diameter alone. Mouth diameter was the only measurement of size that had a significant (positive) correlation with biomass ( $p=0.036$ ,  $r^2=0.096$ ,  $df=44$ ; Fig. 5). Pitchers with a mouth diameter of about 30-35mm

contained about 0.04g of biomass, while pitchers with a mouth diameter of about 10-15mm contained about 0.02g of biomass. Biomass had no relationship with pitcher density, pitcher length, or keel width ( $p>0.05$  for all). Color also had no correlation with biomass or species richness ( $p>0.05$ ).

## DISCUSSION

Hymenoptera and Diptera seem to be two of the most abundant insect Orders found in *S. purpurea* pitcher leaves (Cresswell 1991). Species richness increased with pitcher density, showing that there is a wider variety of species attracted to pitchers in higher density groups than in low density groups. This contrasts with Cresswell (1991) who found no variation in pitcher spatial variation and prey capture rates. More pitchers in a group may increase the attractiveness of the site, potentially drawing in more insects and leading to natural variation (and most likely an increase) in species.

It is interesting that the same correlation was not found between biomass and pitcher density. On the other hand, it is inaccurate to assume that an increase in species richness also corresponds to an increase in biomass. Our model also does not include the species richness of partially digested insects found in the pitcher. Future studies that quantify insect parts as well as whole insects will show a more complete picture of how species richness varies among different densities of pitcher groups.

Another limitation to account for in the biomass findings is that our study did not have a control for time. Variation in digestion times among pitchers, including length of time it takes to digest and when it most recently occurred, may have affected our data collection and the biomass values we calculated. If one pitcher had digested more of its contents more recently than another pitcher, this may have altered our results when measuring biomass. Bradshaw and Creelman

(1984) stressed the importance of pitcher plant inhabitants, sunlight, and temperature and their effects on plant metabolism, respiration, and digestion rates. Future studies that include these factors might be helpful in creating an overall picture of the mechanisms influencing biomass intake.

Species richness and biomass showed a significant, positive correlation with mouth diameter. Green and Horner (2007) also found this with *S. alata* Wood, concluding that larger capture areas (i.e., mouth diameter) should result in more prey captured. But, this contrasts the results found by Newell and Nastase (1998) that showed no correlation between prey capture and pitcher size, namely mouth diameter.

In addition, we found no correlation between species richness and biomass and pitcher color. This could be due to the minimal color variation found at our study site (only two color morphs out of five possible variations). Green and Horner (2007) found no effect of color variation on prey capture while Newell and Nastase (1998) found that prey were more likely to visit pitchers with more red venation. We also did not find correlations between species richness or biomass and pitcher length or keel width, which supports other studies with similar conclusions (Newell and Nastase 1998, Ellison and Gotelli 2002). Keel width is a function of the amount of nitrogen intake from prey already inside the pitcher, and not necessarily a determinant in the amount of prey captured (Ellison and Gotelli 2002).

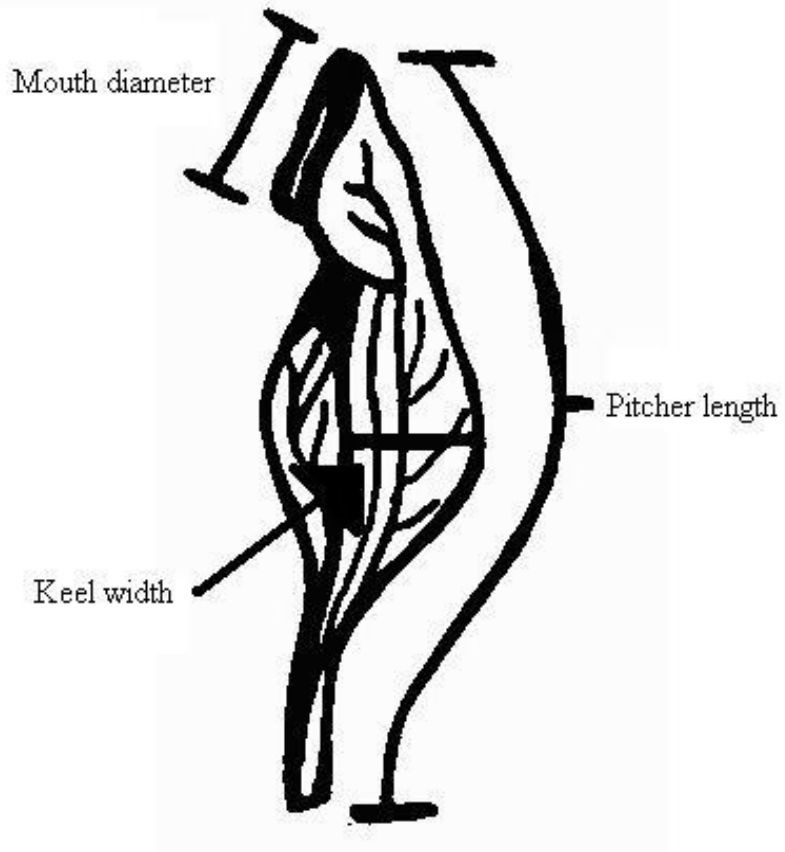
Contradicting results such as these show how little is known about the exact mechanisms that attract potential prey to pitcher plants, and it may mean that these mechanisms are environment-specific. Our results are true for Bryant Bog in northern Michigan for *S. purpurea*, yet the differences among geographic locations and environmental conditions are evident.

**Table 1.** Orders of insects caught by pitchers of *Sarracenia purpurea* listed with number of whole (undigested) in 40 pitchers.

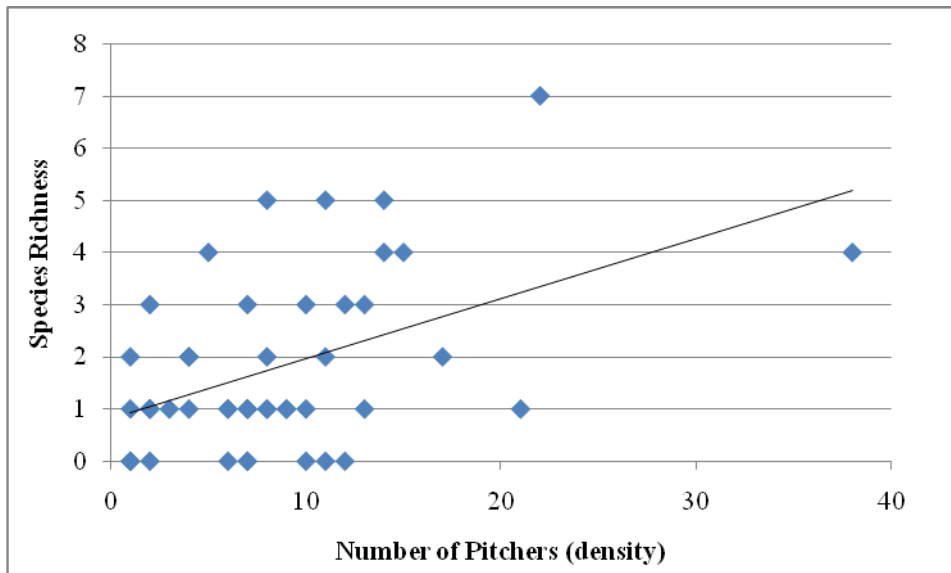
<b>Order</b>	<b>Abundance (whole)</b>
Arachnid	9
Coleoptera	5
Collembola	25
Diptera	17
Homoptera	4
Hymenoptera	59
Isopoda	3
Lepidoptera	3
Molluska	1
Orthoptera	1
Pulmonata	14



**Figure 1.** Color key used to measure variation in red venation of pitcher plant leaves during field sampling.

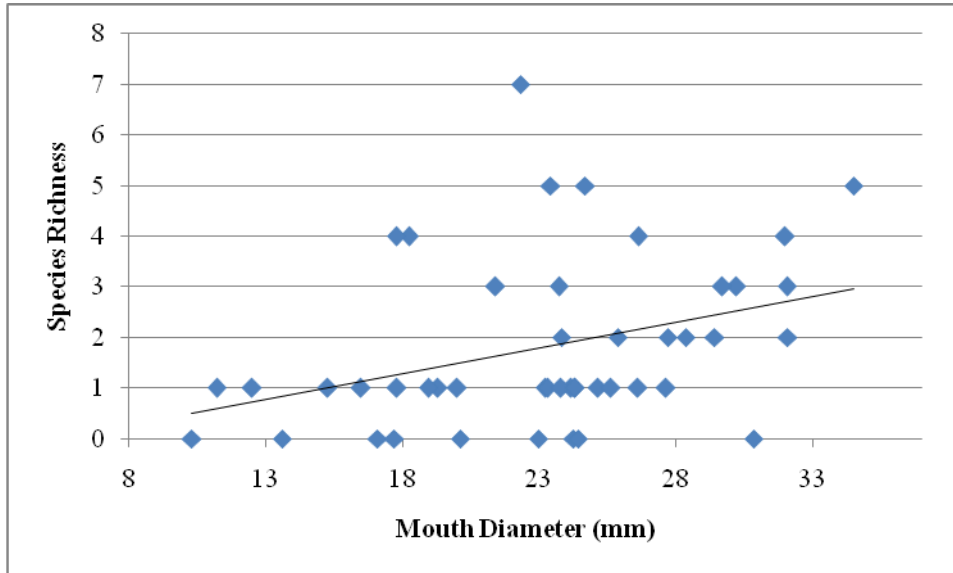


**Figure 2.** Diagram of the three size measurements used to quantify pitcher size.

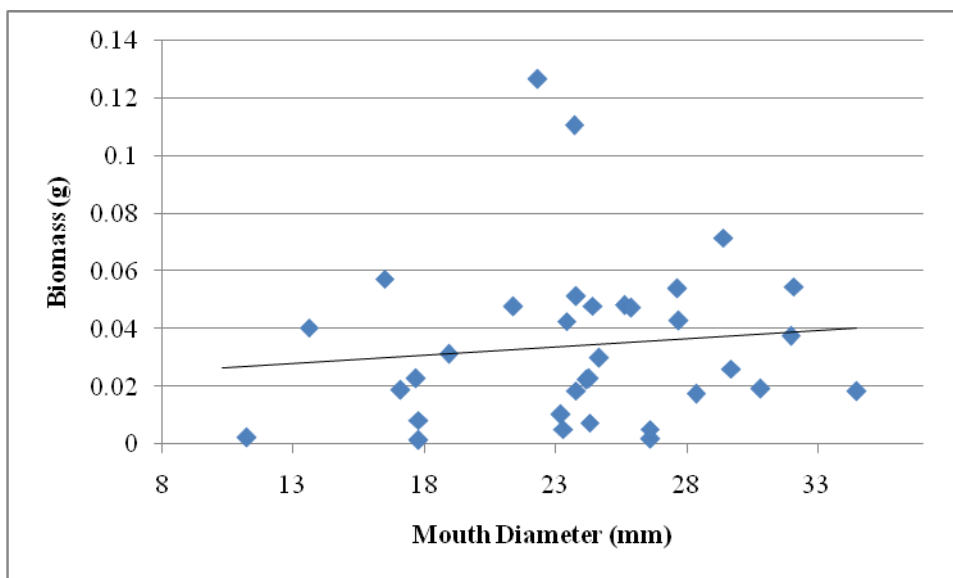


**Figure 3.** The species richness of whole insects found inside pitcher plant leaves by the number of pitchers per clump (a measure of density).





**Figure 4.** The species richness of whole insects found inside the pitcher plant leaf by the mouth diameter (mm) of the randomly selected pitcher in a group.



**Figure 5.** The total biomass found inside the pitcher plant leaf by the mouth diameter (mm) of the randomly selected pitcher in a group.

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