Danielle Grunzke

Annie Hawkinson

Katie Stedman

Jasmine Wagener

BIOL 3807

6/25/11

The Original Ant-Eaters:
The effect of ants on the health of *Sarracenia purpurea*

Abstract

Pitcher plants (*Sarracenia purpurea)*, a species of carnivorous plant found in bogs, are often preyed upon by herbivorous insects. A study done by Moon et al. has suggested that ants indirectly deter this herbivory. The relationship between *S. purpurea* health and presence of ants was investigated by observing ant activity around plants, measuring the contents of pitchers, and recording average height, diameter and color of the plants. We found that plants without signs of herbivory were more likely to have ants in the surrounding area.

Introduction

Bog ecosystems in northern Minnesota are home to many diverse types of flora, including carnivorous plants. Growth of these plants is facilitated by a unique combination of attributes of ombrotrophic (precipitation-fed) bogs, including low pH levels, low nutrient levels and the abundance of sphagnum moss. Carnivorous plants are defined by the fact that they prey on insects. One type of carnivorous plant that lives in northern Minnesota bogs and fens is the Northern Pitcher Plant (*Sarracenia purpurea*). This carnivorous plant is a long lived (30-50 years), perennial plant (Ne'eman et al. 2006). Pitcher plants such as *S. purpurea* capture their prey with bulbous pitcher-like structures that fill with rainwater. Structures on the outside of the pitcher called extrafloral nectaries (EFNs) create nectar which attracts insects to the pitcher opening (Moon et al. 2010). Once an insect has landed on the plant, it may slide down the smooth surface into the rainwater collected in the pitcher. Some species of pitcher plants have evolved mechanisms to prevent insects from escaping once they have fallen into the pitcher, such as the downward-pointing hairs on the inside of the pitcher present in *S. purpurea* (Heard, 1998). Once inside the pitcher, the insect is digested by proteolytic enzymes secreted by the plant as well as enzymes produced by symbiotic bacteria in the pitcher. The plant absorbs amino acids, peptides and other nutrients from the insects it captures (Fish 1978). It has been found that *S. purpurea* capture only around 1% of the ants which visit the pitcher and receive only 10% of the required nitrogen that is needed to survive (Moon et al., 2010). While the digested insects do provide the pitcher plant with some carbon, the majority of these plants' carbon is derived from photosynthesis (Moon et al., 2010). Pitcher plants derive a small nutritional benefit from predation and expend a great deal of energy being predators. Therefore, it is logical that pitcher plants derive non-nutritional benefits from predation.

There appears to be a mutualistic symbiotic relationship between the *S. purpurea* and certain species of ants. Moon et al. (2010) found a positive correlation between ant visitation/capture and nitrogen content, plant height, and the number of pitchers, as well as decreased herbivory. Not only did the ants supply the plant with additional nutrients, they also protected the plants from herbivory by other insect species such as caterpillars (*Exyra* *semicrocea*) by colonizing the rims of the pitchers and deterring predators from landing on the plant. In this study, we investigated whether the findings of Moon et al (2010) applied to *S. purpurea* in a bog near Itasca State Park. We hypothesized that *S. purpurea* that associate with more ants will exhibit greater health (e.g. greater height (cm), diameter (cm), number of pitchers) than pitchers that associate with fewer ants.

Methods

Our experiment took place at Rubbelke & Beisboer (R&B) Bog near Alice Lake in north central Minnesota with the help of the 2011 Itasca Field Ecology class and Professor Leif Hembre. A total of 30 *S. purpurea* were randomly flagged within a 25m^2 area, but only 29 were included in our analysis due to loss of a data sheet. At the flagged points the number of pitchers, whether or not herbivory was present, and whether or not the plant was flowering were recorded. If any ant activity around the plant was noticed, this was recorded. Signs of herbivory included dry gray patches or holes on any part of the plant. The diameter, height, and color of each pitcher were recorded. After these observations were recorded, pipettes were used to collect the contents of each pitcher. The samples from all pitchers of each plant were pooled in one sample jar. The pipettes were rinsed with water between plants. In the lab, samples were poured into Petri dishes and the number of ants, non-ant insects, ant parts, and non-ant insect parts were identified with a dissecting microscope and recorded. These numbers were totaled and later analyzed. In order to examine the relationships between the recorded observations, graphs and a two-sample t-test were done.

Results

Data were collected with the expectation of finding a correlation between plant health and ant presence. The main factor for determining plant health is the presence, or lack of, herbivory. Plants showing signs of herbivory and plants showing no signs of herbivory were graphed against the mean number of ants found within the combined pitcher contents of each plant. Standard error was calculated for error bars (Fig. 1). There were more ants, on average, within plants that showed signs of herbivory; however, a t test proved that this was not statistically significant ($p=0.060776 > 0.05$).

Herbivory was also graphed against the presence of ants in the area surrounding each plant. Ninety percent of plants with signs of herbivory had ants present in the surrounding area and 10% did not have ants present (Fig. 2). In contrast, 84% of plants without any signs of herbivory had ants present and 16% did not (Fig. 3).

Pitcher height and diameter were averaged for each plant. These averages were then graphed against the total number of ants found in each plant's pitchers (Figs. 4 & 5). For mean height the R^2 value is 0.0061 (Fig. 4). This value indicates that there was a large amount of variation in our data, and the relationship between the mean plant height and the total number of ants found within its pitchers is weak. For mean diameter the R^2 value is 0.0369 (Fig. 5). Once again, the variation in our data is too large for the relationship between the two variables to be considered significant.

In order to test the relationship between pitcher size and overall insect capturing ability we graphed the average pitcher height and diameter for each plant versus the different organisms counted in the lab (Fig. 6 & 7). These included: ants, non-ant insects, ant fragments, and non-ant insect fragments. The data demonstrates that there is not a strong relationship between pitcher height and the number of organisms found within a pitcher (Fig 6.). The same conclusion can be made about pitcher diameter (Fig. 7).

Qualitative data was omitted from this report because it was not found to be relevant; this includes whether or not the plant was flowering as well as the color of the pitchers.

Discussion

In this study, we examined various physical factors of *S. purpurea* to see if there was a correlation between health of the plant and the presence of ants. At the R & B bog, we created a $25m^2$ plot and flagged 30 plants. Height, diameter, presence of a flower, color and presence of ants were recorded for each plant, and the contents of each of the pitchers was collected and analyzed.

We found a significant negative correlation between herbivory and the presence of ants around the plant (Fig. 3). This finding is in accordance with the study done by Moon et al. (2010), which concluded that increased ant activity around *S. purpurea* deters herbivory by insects.

We found no correlation between average pitcher height and number of ants within the plant's pitchers (Figs. 4 & 6), despite our prediction that height would increase with number of ants, as height is an indicator of pitcher health. Similarly, we did not find the positive correlation that we had expected between average pitcher diameter and number of ants within the plant (Figs. 5 & 7). In addition, we found more ants in the pitchers with signs of herbivory, which is contradictory to the Moon et al. study as well as to our hypothesis (Fig. 1). Ants were abundant around all plants studied, regardless of whether or not the plants exhibited signs of herbivory (Fig. 2 & 3).

There are a number of potential sources of error in our study which could possibly account for these unexpected findings. First, pitcher height was measured beginning at the top of the moss in which the plant was embedded, rather than beginning at the bottom of the plant itself. Plants begin at variable depths below the surface of the moss, and we suspect that this oversight may have introduced systematic error into our data.

Second, we had difficulty identifying many of the pitcher contents. Many of the ants and other insects were in late stages of digestion and therefore unidentifiable, even with the aid of a dissecting microscope. This likely led to inaccurate counts of ants and other insects found within the pitchers.

Third, ant activity around the plants could have been observed more systematically. Rather than simply noting if ants were detected around the plant while other measurements were being taken, the plant should have been observed for a set period of time solely to look for ant activity. Also, it would have been helpful to count the number of ants associated with the plant.

Finally, it would likely have been helpful to keep the contents of each pitcher separate, rather than pooling the samples from all of the pitchers of each plant. Individual pitchers from the same plant often vary widely in height, diameter and herbivory status. Not combining the samples from the individual pitchers would have allowed us to more specifically correlate these characteristics with pitcher contents, and provided us with many more data points.

For future studies, we would suggest recording the approximate amount of vein coverage of each pitcher rather than the color of the pitcher. A positive correlation has been found between insect attraction and amount of red veins on the outside of the pitcher. The red veins contain EFNs and are UV reflective, both of which attract ants (Newell and Nastase 1998). We found no correlation between pitcher color and amount of ants, but if we had recorded amount of vein coverage instead it is possible that a correlation would have been found.

Although most of our data did not support our hypothesis, we found a noteworthy negative correlation between presence of ants and herbivory. It is likely that gathering more data and refining our techniques would better equip us to investigate the relationship between *S. purpurea* health and the presence of ants.

References

Fish D, Hall D. 1978. Succession & stratification of aquatic insects inhabiting the leaves of the insectivorous pitcher plant, *Sarracenia purpurea.* Am. Mid. Nat. 99: 172-183.

Heard S. 2006. Capture rates of invertebrate prey by the pitcher plant, *Sarracenia purpurea L.* Am. Midl. Nat. 139:79-89.

Moon D, Rossi A, Depaz J, McKelvey L, Elias S, Wheeler E, Moon J. 2010. Ants provide nutritional and defensive benefits to the carnivorous plant *Sarracenia minor.* Oecologia 164: 185 - 192.

Ne'eman G, Ne'eman R, Ellison A.M. 2006. Limits to reproductive success of *Sarracenia Purpurea* (Sarraceniaceae). American Journal of Botany 93:1660-1666.

Newell S, Nastase A. Efficiency of insect capture by *Sarracenia purpurea* (Sarraceniaceae), the Northern Pitcher Plant. American Journal of Botany 85: 88-91.

Appendix 1: Figures

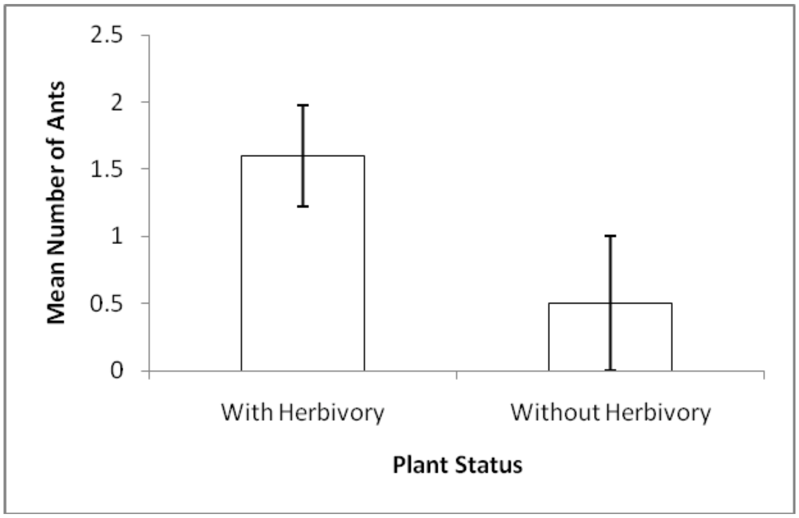

Fig. 1. Mean (+-SE) number of ants within the pitchers of plants with herbivory and plants without herbivory. (p= 0.060776).

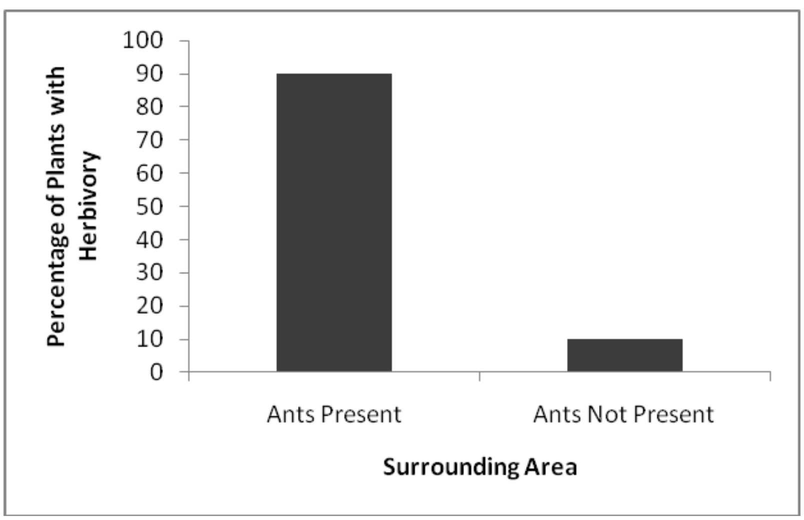

Fig. 2. Percentage of plants that show signs of herbivory with ants present in the surrounding area versus ants not present in the surrounding area. 90% of plants have ants present, while 10% do not.

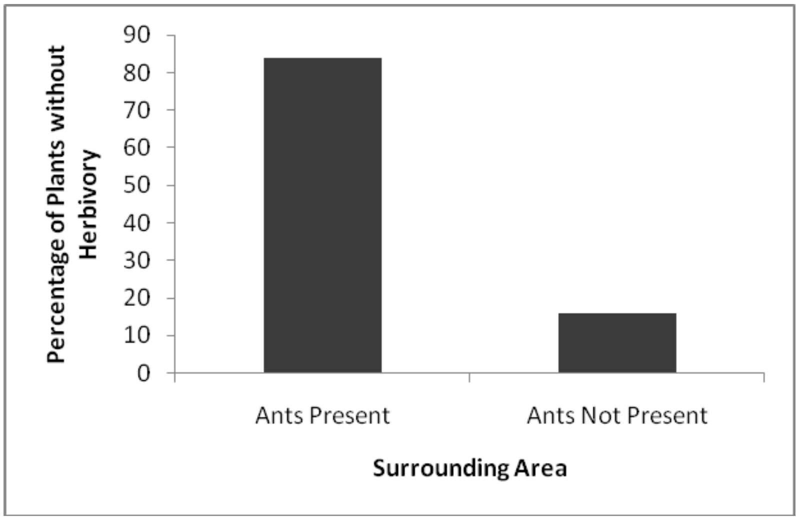

Fig. 3. Percentage of plants that show no signs of herbivory with ants present in the surrounding area versus ants not present in the surrounding area. 84% have ants present, while 16% do not.

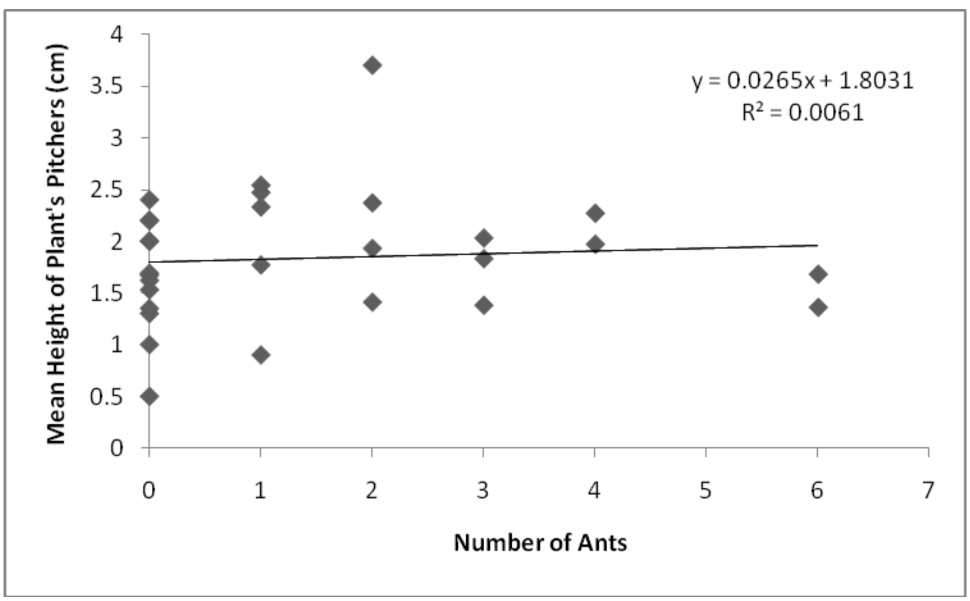

Fig. 4. Mean height of pitchers per plant versus number of ants found within plant's pitchers.

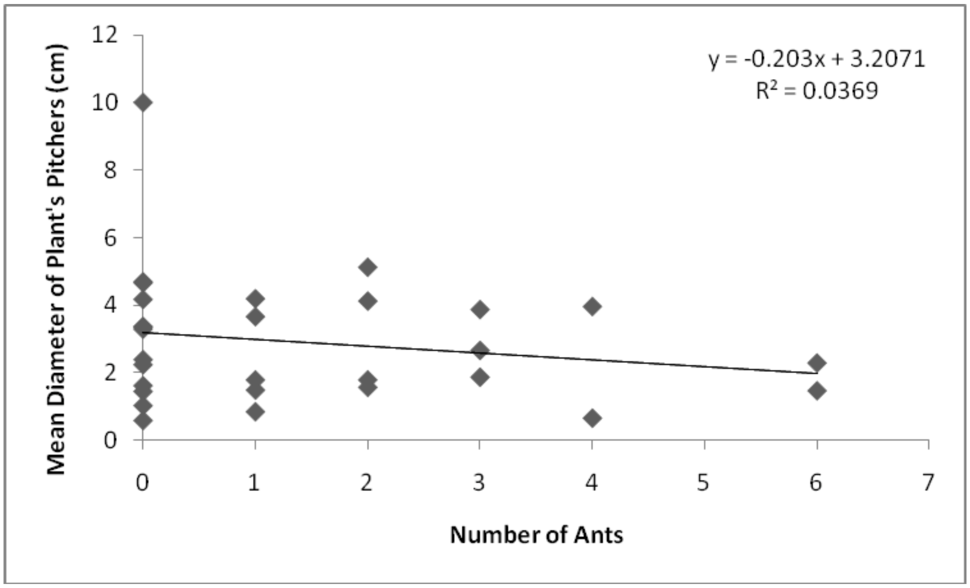

Fig. 5. Mean diameter of pitchers per plant versus number of ants found within plant's pitchers.

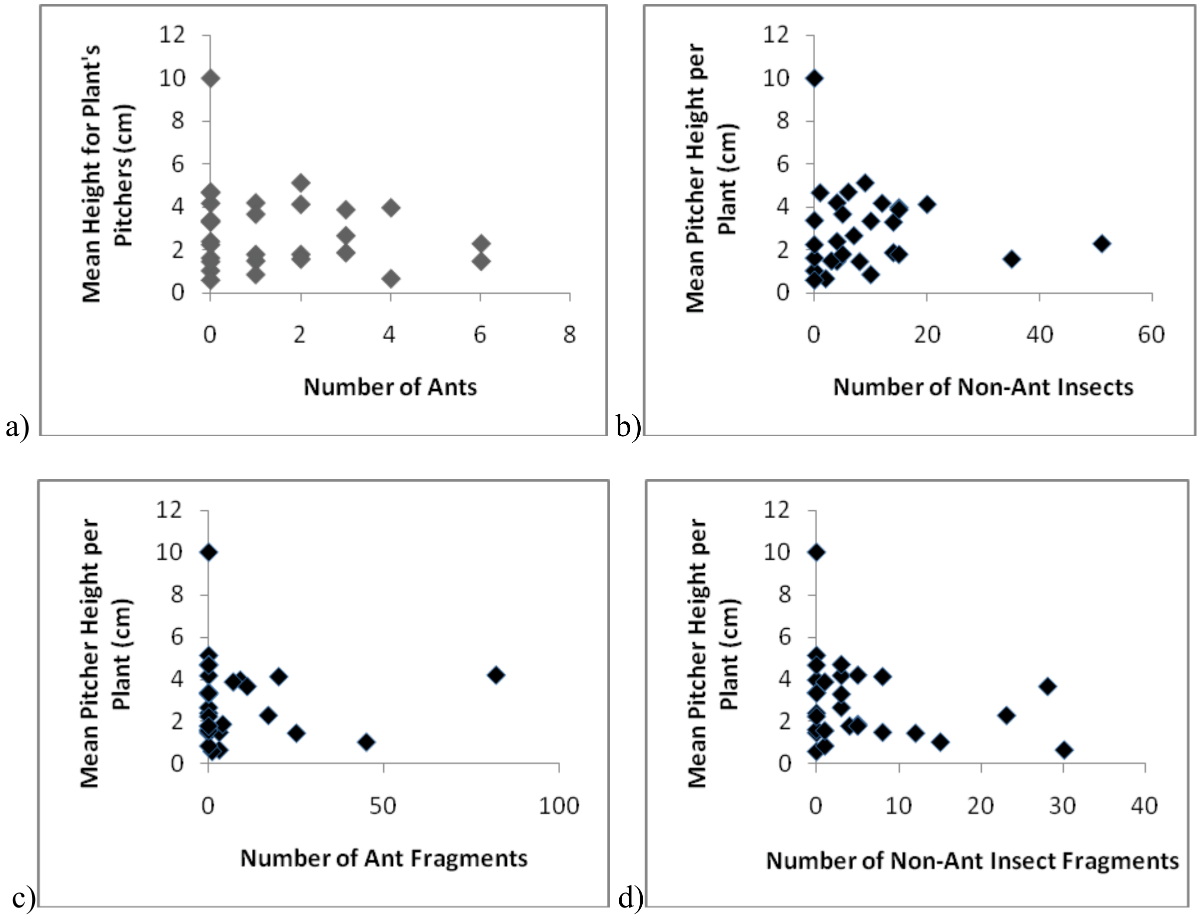

Fig.6. Mean pitcher height per plant versus insects and insect fragments found in combined pitcher contents.

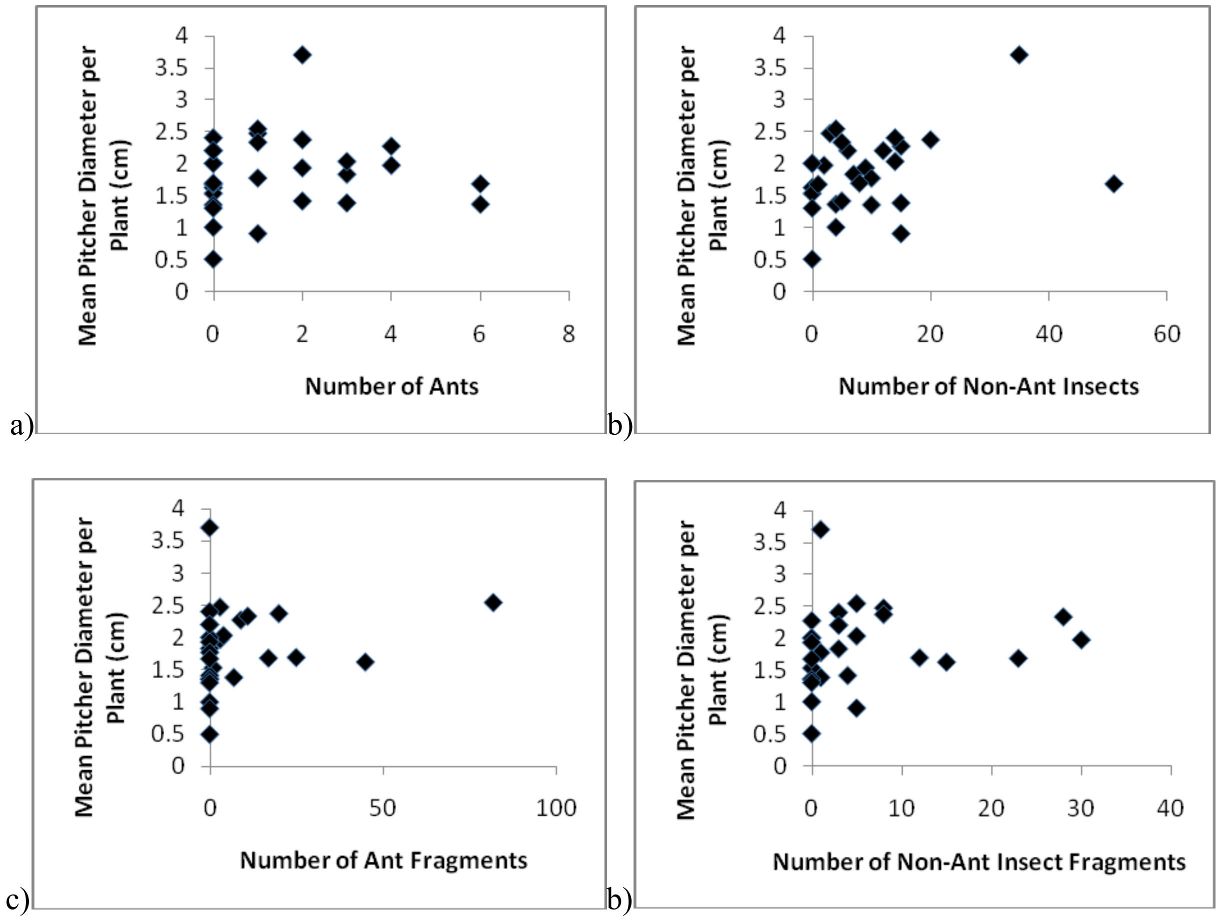

Fig. 7. Mean pitcher diameter per plant versus insects and insect fragments found in combined pitcher contents.