Beyond Folivory: Three Types of Interactions between Plants and Insects in the Pine Barrens Community of Long Island, New York

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ABSTRACT

In our research, we have focused on three types of plant-insect interactions that have received less attention than Folivory. The secondary community of abandoned galls, the galls and the Allegheny mound building ants. Galls are formed in response to eggs laid on scrub oak trees by Cynipid wasps. We studied the secondary community of abandoned galls, in which the wasps emerge through an exit hole, the galls then become a refuge for ants and spiders. In addition to these two gall interactions, we are examining the relationship of Allegheny mound building ants with plants. Ants aggressively keep their mounds free of plants to maintain high temperature for the development of their eggs. Abandoned galls, fresh galls and oak leaves were collected twice a week from the field. We dissected them under the microscope at 40X. The Fresh galls were taken to the X27A beam line at the National Synchrotron Light Source (NSLS) to analyze the elemental concentrations of the galls and leaves. The results showed high concentration of Mn in both leaf and gall. 100% mortality of Petunias was observed when plants were planted on the ant mounds and death zone. However, we have observed healthy plants (bearberry -Vaccinium macrocarpon and Pennsylvania sedge - Carex pensylvanica) living on the mound. We are interested in this marked pattern of ant-induced plant death and why bearberry and Pennsylvania sedge seem to escape the attack

INTRODUCTION

Plant and insects are omnipresent in terrestrial ecosystems. Because of the vital role that insects play as herbivores, most plant and insect ecology studies focus on that interaction, particularly Folivory. The interaction between plants and insects is dynamic and it is subjected to continual variation and change[1]. The secondary community of abandoned galls, the gall and the Allegheny mound building ants were the three types of plant and insect interactions studied in this research.

Abandoned galls are old galls which serve as habitat for some arthropods. Gall and oak leaves were imaged and compared at the NSLS. We also studied the interaction of Allegheny mound building ants with plants around their mound. Allegheny mound building ants (Formica exsectoides); is found in the Pine Barrens forest, because the soil is well drained and there are a lot of open spaces; a 19 inch mound may contain 250,000 individuals and 1,000 eggs [2] and [3]. After mating, the male dies and female lose their wings and return to the ground to start a new colony [4]. They feed on other insects including wasps for protein and aphid honey dew for sugar. This ant attempts to kill any vegetation that may grow on the mound or shade the area except bearberry and Pennsylvania sedge.

The goal of this research is to study how plants and insects interact and become familiar with the natural history of the gall-makers and from this generate a testable hypothesis for future research.

MATERIALS AND METHODS

- A. Secondary Community:
- Scrub oak leaf, gall, and secondary community samples were collected twice a week
- ÷ The abandoned galls were dissected under the microscope at 40X magnification.
- The arthropods were placed in vials with 70% ethanol (C_2H_5OH) ٠

B. Gall and Oak Leaf Tissue Elemental Concentrations:

- The fresh galls and leaves were embedded in optimal cutting temperature embedding medium and cryotomed to 30µm thick at -12°C. The cross sections were mounted on ultralene (an x-ray transparent material).
- Cryotome cross sections (30 $\mu m)$ were exposed to the X27A beam line to estimate the elemental concentration and their distribution in the various types of tissues in the galls and leaves especially manganese (Mn) and Rubidium (Rb).

C. Allegheny mound building ant studies:

- Store-bought annuals (Petunias) were planted on the ant mounds for mortality and behavioral studies.
- Three mounds were selected randomly and a total of 54 Petunias were planted.
- Six Petunia plants were planted on the ant mound (AM), dead zone (ZD) and outside the mound ٠ respectively
- ٠ The ants response to the Petunias planted on their mound was observed twice a week.
- We also planted Pennsylvania sedge and bearberry on 5 ants mounds, they were watered and observed twice a week as well.

RESULTS AND DISCUSSION

A. Secondary Community:

It has been observed that scrub oak sclerotize after active growth ceases.

*Exit hole is created when a Cynipid wasp chews its way out, parasitoids chews its way out, caterpillars chew its way in and birds damage the gall.

Many but not all galls remain on bush through to the next season.

Ants, caterpillars and spiders were found in abandoned galls, and they have been identified to the family level. The spider and ants were identified as Dictycidae and Leptothorax spinosae respectively.

*Results also showed that the more spider webs in galls, the less arthropods as shown in Figures 1 and 2. below.













Figure 2: (a) Cynipid Wasp, (b) Scrub Oak Gall, (c) Exit Hole, (d) ants, and (e) parasitoids

- **B.** Gall and Oak Leaf Tissue Elemental Concentrations:
 - It has been observed that galls have high mortality rate, and the agents of mortality were identified to the family level; they are Eulophidae, Torymidae and Perilamphidae
 - At the National Synchrotron Light Source (NSLS), various tissues of the gall and leaf were scanned randomly. We scanned the parenchyma, mesophyll, etc. Result showed that they have excess amount of Mn in both galls and scrub oak leaves as shown in figure 3.



Figure 3. a. Cryomicrotome Cross Sections of Cynipid Wasp Gall (30µm) and its histology, b. XRF Image for Mn, c. Cross section of Scrub Oak leaf (30µm), (d) Parasitoids, and (e) Elemental concentrations in scrub



C. Allegheny mound building ant studies:

The mortality rate of Petunias planted on the ant mound (AM) and dead zone (DZ) is 100%. Ants aggressively attack the petunias [see figure 2 for before and after]. They bite the plants and secret formic acid, they also work together as a group. Allegheny mound builging ants do not attack bearberry and Pennsylvania sedge on their mound. They attack Pitch pine, Scrub oak and Huckleberry. As shown below



Figure 4: (a) Allegheny mound building ant mound, (b) Allegheny mound building ant, (c) Petunia on Day 1, and (d) Petunia after four days CONCLUSIONS

A. Secondary Community:

- 61% of the galls we collected from the field had evidence of other non gall-maker's inhabitance.
- The two most common groups were spiders, Dyctinidae and ants Leptothoras spinosus.
- 13.2% of the abandoned galls had spiders; ant colonies accounted for 5% of the total numbers of
- Abandoned galls make an excellent hiding place for spiders to wait for prey and it serves as a breeding space for ants.

B. Gall and Oak Leaf Tissue Elemental Concentrations:

- * Results from The National Synchrotron Light Source (NSLS) showed high Mn in oak leaf and gall which plays a critical role in photosynthesis.
- Previous studies showed that leaf has higher chlorophyll concentrations than galls. The gall has a spindle shape; it has no palisade and no stomata. These two things are important for photosynthesis to be effective.
- Therefore we can say that a gall is a modified leaf and it does not require all the essential elements needed by a regular leaf to survive.

C. Allegheny mound building ant studies:

- Ants aggressively defend their mound from any disturbance.
- They attack and kill some plants including scrub oak plants and Petunias.
- Due to the high frequency of Allegheny mound building ants in Pine Barrens forest, there would be a possibility to lose scrub oaks and eventually the cynipid wasp.
- Scrub Oak tree has excess Mn from the soil which might be attracting the wasp to lay its egg on the tree, to form a gall. Wasp emerges and other insects live in the abandoned gall. Allegheny mound building ants kill the scrub oak tree and feeds on the wasp that lives in the gall.

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abandoned gall with organisms.