An Exploration of the Natural History of the Scrub Oak Gall-Maker

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Abstract

This research focused on a Cynipid wasp, *Amphibolips ilicifoleae* found only on the scrub oak, *Quercus ilicifolia*. Nothing is known about the natural history of this gall maker and its gall. We explored the growth rate, histology, chemistry, and morphology of the galls. In addition, we are beginning to document the rate of mortality and the agents of mortality, which are mostly parasitic wasps of the Chalcidoidea. Twelve bushes with twenty incipient and small galls were selected randomly from previously located galls. To understand the cellular morphology of gall cells, cross-sections of the galls and oak leaves (for comparison) were observed under the microscope at 40X. The gall's mesophyll tissue is much larger (35-100 µm) than the leaf mesophyll (3-8µm). The leaves have greater chlorophyll concentration than the galls (235.0±23.0 and 126.0±11.0µgChl-a/gFwt.; 852.0±116 and 53.0±5.0µgChl-b/gFwt, respectively). By understanding the growth rate, morphology and development of the gall, we can begin to understand the life history traits that impact its success. Studying the gall system is an avenue to elucidating important biological concept such as plant-insect herbivore interactions. The Ecology of plant and insect interaction is fundamental to understanding community ecology and agriculture. In this study, we are beginning to understand the Biology and natural history of the galls. A major goal of this work is to develop testable hypotheses for the future about the ecology, evolution and physiology of the gall makers and their galls.

Introduction

The process of gall induction on the scrub oak is a parasitic relationship. Evidence, nevertheless suggests that gallers are parasites that control most aspects of the gall development [1]. The Wasp induces their galls on the plant tissues for the following reasons: The larvae feeds on the gall's tissue, the galls protect the larvae from external climate fluctuations such as dryness. The gall has a closed structure, which helps to reduce mortality rate by natural enemies and parasitoids. Galls do provide some protection against attack by non-specialist predators, but they are far from being enemy free space, most are attacked by fungi and parasitoids, and natural enemies that often inflict high mortality [1-4]. The development of cynipid gall's three phases: initiation phase, growth phase, and the maturation phase. A major goal of this work is to develop testable hypotheses for the future about the ecology, evolution and physiology of the gall makers and their galls in Long Island Pine Barrens, NY.

Materials and Methods

A total of twelve scrub oak bushes with incipient and small galls (twenty in total) were selected randomly, at 25 feet intervals, to measure the length and width to determine growth rate over a period of 32 days. A GPS eXplorist 200 series was used to plot the coordinates of the experimental site ($40^0$52'23-$40^0$52'11N; $72^0$39'17-$72^0$39'18W; Elevation 89 -104'). We measured the size twice a week using a caliper, and observed physically the gall's condition, whether it had an exit hole and whether it exhibited necrosis, sclerosis or both and its color (whether it is green or red). To understand the cellular morphology of the cells, cross-sections of the galls and oak leaves (for comparison) were observed under the microscope at 40X. Ten cells were randomly chosen in each of 10 cross sections to identify histological alterations in galls relative to leaf cells. We measured the difference in size (length and width) of mesophyll tissue. The chlorophyll concentration of the leaf and gall wall was analyzed, using spectrophotometer [1, 2]. Cryomicrotomy sections (30µm) of galls were used to scan tissues on X27A beamline to estimate elemental concentration and their distribution in various types of tissues.

Results and Discussion

GALL MORPHOLOGY

Layer of epidermal cells with stellate trichomes (Figure 1d)
Currently, no clear evidence of stomata

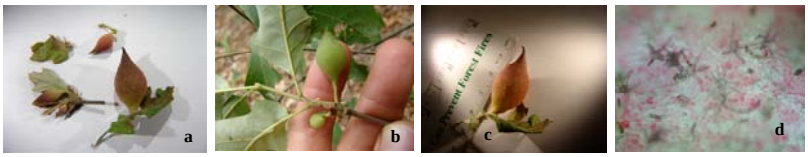


Figure 1: **a**. Red galls; **b**. Green galls; **c**. A full grown red gall; **d**. Stellate trichomes on gall wall

GALL HISTOLOGY

Presence of chloroplast noted (Figure 2b)
Parenchyma cells of gall wall larger than leaf cells in length and width.
Central capsule connected by vascularized fibers (Figure 2c and 2d)
Parenchyma cells of fibers contain chloroplast (Figure 2a)

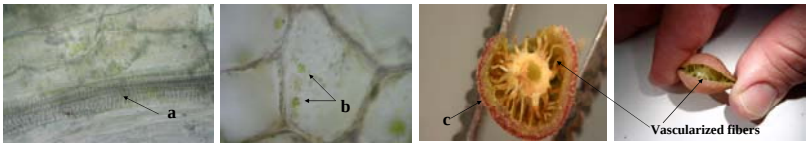


Figure 2: **a**. Vascularized tissue; **b**. Mesophyll with chloroplasts; **c**. Gall C.S.; **d**. Gall L.S.

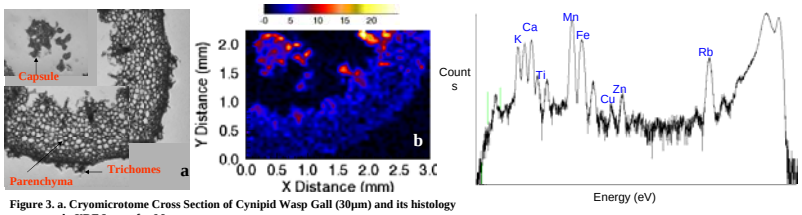


Figure 3. a. Cryomicrotome Cross Section of Cynipid Wasp Gall (30µm) and its histology b. XRF Image for Mn

sample	cell type	spot	K	Ca	Mn	Fe	Cu	Zn*	Rb
						ppm			
Gall Xsec (30um)	epidermal	1	3913	710	217	102	17	20	46
		2	7118	1521	413	154	42	20	68
	mesophyll	1	14400	1578	675	147	26	20	148
		2	19200	2830	970	222	27	20	149
	capsule	1	902	596	423	171	20	20	30
		2	2690	5240	776	90	22	20	65
	chamber	1	0	103	85	335	49	20	19
		2	0	141	66	119	58	20	34

GALL GROWTH and PHYSIOLOGY

- Chlorophyll a & b lower in galls
- Ratios differ; chlorophyll-b is higher in leaf than gall.
- Galls that remained green and intact showed a typical growth curve s- shaped (Figure 4 a and b)
- The s- shaped curve for green, growing galls was described with great accuracy by using 3rd order polynomial to generate a trend line (Figure 4 e and f)

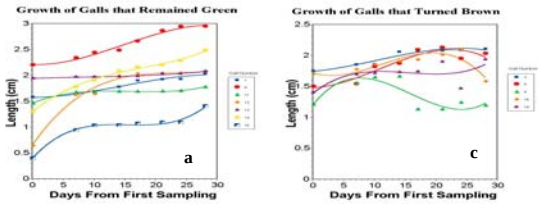
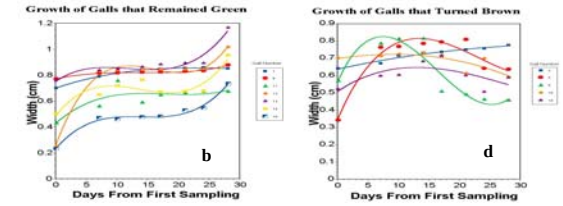
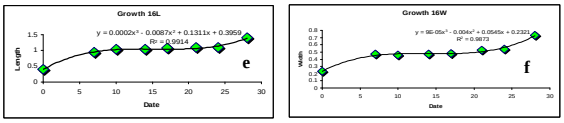


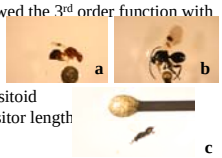
Figure 4: Gall Growth Patterns





- As best represented by gall 16, which was measured from an incipient stage (Figure 1c), there are 3 distinct growth patterns
  - **a**. an early increase in growth length and width
  - **b**. a middle period of slow growth
  - **c**. a late period of accelerated growth.
- Some of the gall we measured were large so we think we missed the early stage.
- When galls began to turn brown, they no longer followed the 3rd order function with the same accuracy (Figure 4 c and d).
- We have identified 3 parasitoids to the family level (a) Perilamphidae, (b) Torymidae, and (c) Eulophidae One cynipid inquiline and one other unidentified parasitoid
- Eulophidae and Torymidae have very different ovipositor length

Amphibilops ilicifoleae



CONCLUSIONS

1. Photosynthesis capability is not like that of the leaf, or is less than the leaf, for the following reasons: (a) No palisade layer in gall; (b) Less chlorophyll a & b; (c) Few, if any, stomata
2. Cells generally different in size and shape
3. Gall modification may be more directly related to structural housing of gall maker and vascular connections to other sources of photosynthate
4. If gall photosynthesis were important to gall-maker development, expect positive correlation between gall size and insect size, but no correlation was observed
5. The s- shaped curve appears to be a robust description of gall growth
6. We present a measure of gall-maker vulnerability to parasitoids called the Critical Parasitoid Distance (the distance from the outer wall to the larva in the chamber). The ovipositor of the parasitoid must be greater than this distance to be effective for egg deposit into cynipid larva
7. When they are larger, there is a thick parenchyma layer, air chamber and a capsule separating them from a parasitoid, still a Torymidae might have access due to long ovipositor. Thus, the growth patterns we observed may directly influence the whether and how long galls fall under the CPD
8. Gall chemistry need to be further explored to identify interrelationships between growth and development of galls and excessive accumulation of certain elements such as K, Mn, Ca, Fe, and Rb in its tissues

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