ILLUSTRATED GUIDE TO THE PLANT GALLS OF THE ROEMER ARBORETUM AT SUNY GENESEO

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Abstract- The Roemer Arboretum on the SUNY Geneseo Campus is an excellent area to study the formation of galls on a variety of plants. This paper was produced from field and literature research on galls and gall-inducing organisms during a directed study, and is a catalog and guide for students. I observed and sketched the galls in the Arboretum over a semester. Gall producers change from year to year however, the most common ones, including those found on Oak trees, are listed here. The purpose of this guide is to provide a reference for future work studying galls. Future experiments in the spatial distribution of galls would also be well suited to the Arboretum.

Introduction

A gall is an abnormal growth or tumor on plant host tissue caused by the irritation of an insect, bacterial, or fungal parasite. Gall-inducing insects lay their eggs in the spring on the surface of plants, or insert their ovipositor directly into the plant. Throughout the spring, summer, and sometimes even into the fall, the presence of the insect causes the plant to produce a protective gall full of nutritive tissue that can vary in sizes from microscopic to as large as an apple. The parenchyma cells of the plant's mesophyll are induced to form a gall by both the insect's actions (Giuntoli 1985) and chemicals produced by the insect. The insect egg hatches into a larva, and usually feeds on the nutritive plant tissue during the winter before pupating. Parasitism by other insects also occurs. Some species of insects lay their eggs in galls that have already been formed. The parasite organism will then feed on the original gall maker. I focused on identifying the primary gall maker in this study. The following spring, the new adult excavates a perfectly round exit hole in the protective gall and emerges to mate and begin the cycle again. Some insects emerge the same year they are formed. Galls caused by fungi produce spores that are carried by the wind to other plants.

The exact mechanism of gall formation is not known. The mechanical irritation of insect larvae growing within the plant may induce the formation of the gall, which is essentially scar tissue. The irritation may be exacerbated by viral symbionts in the growing insect's saliva. (Giuntoli 1985) As the insect feeds on the gall, its actions cause the gall to grow larger. The insects also produce chemicals that induce the formation of galls. It has been theorized that insects can mimic the plant's own growth hormones in order to induce gall formation. One such hormone is Indole Acetic Acid (IAA). (Giuntoli 1985)

Interestingly, some insects have the ability to become phloem sinks within the plant, channeling some of the plant's nutrients directly to the growing larvae. (Larson 1997) The insect takes advantage of source-sink relationships in the plant, and thus becomes a competitor with the plant for resources.

Gall insects are plant parasites, or in the best cases, merely commensalists. If the

host plant is not harmed by the presence of the gall, then the relationship is a commensalism. (Giuntoli 1985) However, if the plant suffers because of a particular gall, then the insect is considered a parasite. Despite their wide distribution, galls usually do not have a large detrimental effect on their hosts unless they are highly concentrated on one plant. Gall formation may stunt the growth only on the particular part on which it grows. For example, goldenrod stems that contain galls usually have fewer infloresences at the top than their counterparts in the same area without galls. (Felt 1940) Too many galls on one host will harm the plant; it is in the best evolutionary interest of the gall not to totally destroy its host because of the shelter and nutrients the plant provides over a long-term basis. If the host dies, the insect, bacteria, or fungus living within it will also die. Therefore, feeding on plant tissue must be gauged as to stimulate growth of the plant without killing too many plant cells. (Felt 1940)

The most common sites for galls are fruit, seeds, stem tips, shoot tips, and foliage. Notice the trend in location; the sites that galls form on are those that are undergoing the most rapid growth. Using the plants own meristematic tissue, the gall-maker can quickly induce the formation of the rich nutritive tissue in the gall. Galls such as Oak Bullet galls (illus. #4) and Crown Gall bacteria are also formed on twigs and branches, but they are usually much harder and thicker than galls formed on other tissue.

Because galls are formed from the plant's own tissue, a gall takes its form not only from the organism that initiated its creation, but also the location of the gall on the plant. For example, many galls that form on leaves are fuzzy because leaves often have tiny hairs; the gall is an abnormal growth of the plant's own cells. Another example is the oak bullet gall. Even though other galls on oak trees tend to be fairly soft, bullet galls are very hard because they form from the tough cells that make up twigs, and are just an aberration of those cells.

Some gall wasps do not actually create their own galls, but lay their eggs in the already formed galls of other insects. During the winter, the predatory wasp larva will feed on the original grub inhabitant. Thus, in the spring, many of the insects emerging from the galls are not the architects of the galls, but other insects that have taken advantage of a gall's protection and food supply. The predatory wasps are not completely safe in their new home either. Many species of birds can recognize certain galls, and peck holes inside to reach the tasty insects. A hole made by a bird can be identified by the rough edges around the hole. The hole is quite large on the outer surface, then gradually tapers down as it nears the center of the gall.

Identifying even microscopic gall-makers is not as hard as it seems, because each gall-maker produces a uniquely shaped gall. In fact, many times it is easier to identify the tiny insect or organism by the gall it produces, rather than by its own anatomical features, as the characteristics are quite specific. (Giuntoli 1985) However, this method of identification has led to different names for the same insect because of differing host species and life cycle. This aspect can make identification difficult. Galls are usually found in patches; you will probably find a number of similar galls in an area, or none at all. However, the distribution of galls is spatially dependent. Galls may be clumped in a small local area

such as a stand of trees, but evenly dispersed overall throughout a forest.

Study Site and Procedures

All observations and drawings of galls were made in the Roemer Arboretum on the SUNY Geneseo campus. The Arboretum is a 20-acre area of land that was previously grazing land, and is now specifically set aside for field study. It is an excellent place to find galls. The large old trees show a "wolfed", or outspread growth form, and so leaf and twig galls are easier to reach from the ground. Also, since the area is undergoing secondary succession after being pastureland for many years, there are many small trees and shrubs. Rapidly growing plant tissue is where most galls are formed. Many of the plants in the Arboretum are often hosts, and a number of interesting galls are easily found on a walk. Since I was not doing a statistical survey, I did not have to worry about a random sampling, but instead concentrated on covering as much of the area as possible. I paid special attention to the Oak trees because so many different types of galls are found on these trees. I used the basic tour map to find the locations of the larger oaks. There is a group of White Oaks just after the bridge at the entrance to the Arboretum. There are Red Oaks as well as White Oaks on the lower poison ivy trail, and near the study plot. I went out about once a week to gather galls while the weather was good. My study lasted from September to December 1999. Since the leaf galls are made of the same tissue as leaves, they did not keep well, and so I did not preserve the galls after I sketched them. To identify the galls I found, I relied on the books included in the Reference section. Plant Galls and Gall Makers by Ephraim Porter Felt was particularly useful because it contained a key to many galls. I also accompanied Dr. Briggs on a walk through the Arboretum. He helped me identify trees and other plants that commonly housed galls. I spoke with Dr. Vasey about the anatomy and behaviors of the causal insects, especially *Eurosta Solidaginis*.

Results and Discussion

List of Galls

Common gall name	Gall inducer
Ash leaf gall	*Lasoptera fraxinifolia* gall midge
Cedar-Hawthorne (Apple) rust	*Gymnosporangium globosum* fungus
Cedar stage (illus. #1)	
Hawthorn stage	
Goldenrod gall (leafy) (illus. #2)	*Rhopalomyia solidaginis* midge fly

Goldenrod gall (spherical stem) (illus. #3)	*Eurosta solidaginis* gall fly
Goldenrod spindle gall	*Gnorimoschema gallaesolidaginis* moth
Grape: phylloxera gall	*Phylloxera vitifoliae* aphid
Hawthorn: bud gall	*Gymnosporangeum* fungus
Oak: bullet gall (illus. #4)	*Disholcaspis globolus* gall wasp
Oak: leaf midrib fuzzy gall(clustered)	*Biorhiza mellea* gall wasp
Oak: leaf midrib gall (illus. #7)	*Callirhytis flavipes* gall wasp
Oak: transverse leaf gall	*Andricus singularis* gall wasp
Oak: peach gall	*Cynips capillata* gall wasp
Oak: saucer gall (button gall) (illus. #5)	*Neuoterus umbilicatus* gall wasp
Oak: spangle gall (illus. #6)	*Cecidomyia poculum* midge fly
Oak: striped peach gall	*Cynips dimorphus* gall wasp
Oak: hedgehog gall	*Acraspis erinacei* gall wasp
Oak: hairy oak gall	*Acraspis villosa* gall wasp
Oak: spiny vase gall	*Xanthoteras* gall wasps
Oak: spotted oak apple gall (illus. #8)	*Cynips centricola* gall wasp
Oak: wooly fold gall	*Cecidomyia* midge flies
Rose bud gall	*Diploepis sp.* gall wasp
Rose: mossy gall	*Diploepis rosea* gall wasp
Willow blister gall	*Oligotrophus salicifolius* gall midge

Dichotomous Key for Oak Galls in the Roemer Arboretum

1.	Found on leaves	3.
	Found on twigs or at base of leaves	2.
2.	Brown, round, and hard; found attached to twigs	Oak Bullet Gall (illus.#4)
	Thin-walled, spotted, fibrous inside; attached to twigs or base of leaves	Spotted Oak Apple Gall illus.#8)
3.	Found directly on veins	6.
	Found anywhere else on leaf	4.
4.	Flat, round	5.
	Any other shape	10.
5.	White color	Oak Spangle Gall (illus.#6)
	Brown color	Oak Saucer Gall (illus.#5)
6.	Found on main vein	Oak Leaf Gall (Main Vein) (illus.#7)
	Found on any other vein	7.
7.	Oblong, fuzzy	Wooly Fold Gall
	Round, fuzzy	8.
8.	Peach colored, clustered	9.
	Brown	Fuzzy Oak Gall

9. Striped
   Plain
10. Has spiny or wooly emergences
    Smooth
11. Spiny emergences
    Wooly appearance
12. Round
    Vase-shaped

Striped Peach Gall
Peach Gall
11.
Transverse Oak Leaf Gall
12.
Hairy Oak Leaf Gall
Hedgehog Gall
Spiny Vase Gall

Guide to the Galls of the Roemer Arboretum

Ash Leaf Gall (Causal organism: *Lasoptera fraxinifolia* gall midge)

Tiny (0.1 centimeters) fuzzy yellow galls are found on the underside of Ash leaves. Multiple galls form on each leaf, but the galls are spaced out upon the leaf. There is an indentation in the center of the gall, and the entire gall resembles a tiny crown. This gall occurs along the leaf veins as well as the spaces between veins.

Cedar-Hawthorn (Apple) Rust (Causal organism: *Gymnosporangium globosum* fungus) Illustration #1

Cedar stage: Light brown gall with rounded bumps all over. The gall may have lobes and has a large range in size, anywhere from 1 to over 4 centimeters in diameter. They are most often found on the ends of branches. In the spring, the galls have horn-like projections. When it rains, the gall absorbs moisture, and the projections enlarge into gelatinous, spore-bearing horns. (Hutchins 1969) In the fall, the horns are missing and the rather lumpy shape of the gall can best be seen.

Hawthorn Stage: The spores released by the cedar stage are carried by the wind to hawthorn trees, where small projections surrounded by rust-colored spots appear on the leaves. The spores will later be released from the leaves, and blow back toward the cedar trees. (Hutchins 1969)

Cedar trees also share a similar relationship with apple trees, transferring a fungus called cedar-apple rust in the same way.

See also: Hawthorn bud gall.

Leafy Goldenrod Gall (Causal organism: *Rhopalomyia solidaginis* midge fly) Illustration #2

This gall looks like a rosette, and is composed of a large cluster of stunted leaves at the top of the stem. Goldenrods that house these insects produce fewer inflorescences. The gall itself is contained within the cluster of leaves. Look carefully at the tops of goldenrod stems in the summer and early fall to find these galls. They are much larger than normal clusters of leaves.

Spherical Goldenrod Gall (Causal organism: *Eurosta solidaginis* gall fly) Illustration #3

This is the most common gall found on goldenrod plants. Gall flies lay their eggs in the center of the stem, causing it to become bulbous and enlarged. They are the same color as the stem, and may have tiny leaves attached to the outside. These ball-

shaped galls can be collected in the winter since the insect affects the tracheid cells, and the internal structure of the entire stem is changed. This means that during the fall and winter, the bulbous forms of the galls can easily be seen on the stems after the leaves have died (senesced). Each gall usually contains one insect that emerges in the spring, boring a round hole out of the gall. However, many species of birds prey on the wasps by pecking holes into the galls. Galls that have been preyed upon by birds can be identified by the large, jagged, roughly round holes made by the birds that taper down until the insect is reached. See the illustration for examples of insect-made and bird feeding holes. The smaller, round hole on the right was made by the emerging insect. The larger, jagged hole was made by a bird looking for a meal. Goldenrod galls are also parasitized by gall wasps, who lay their own eggs inside already-formed galls. The young wasp will eat the fly larvae and then emerge in the spring. So, even though the shape of the gall it produces can identify the causal organism, the insect that emerges is not always the insect that produced the gall.

Goldenrod Spindle Gall (Causal organism: *Gnorimoschema gallaesoligaginis* moth)

This gall is formed on the stem of goldenrod plants and is elliptical in shape. In all other respects it looks very much like the gall produced by *Eurosta*. The female moth lays an egg on the stem. It soon becomes a larva that crawls up the stem and burrows in. The larvae is believed to excrete a "cecidogenetic substance" (gall producing) that then causes the elliptical gall to form. (Meyer 1987)

Grape Phylloxera (Causal organism: *Phylloxera vitifoliae* aphid)

Grape Phylloxera galls are one of the few types of gall that can be economically important and destructive. Too many *Phylloxera* galls has seriously harmed fruit output and the wine industry of France in the past. (Hutchins 1969) The insects create galls on both the roots and the leaves, damaging both. Dozens of galls will form on one leaf, seriously depleting the leaf's nutrient supply and photosynthetic ability.

Hawthorn Bud Gall (Causal organism: unknown, a fungus, perhaps closely related to the one that causes Cedar-Hawthorn rust)

The tips of hawthorn buds become enlarged when this gall is present. The tough petioles are also enlarged and project out. The gall is the same dark color as the branches and is greater than a centimeter in length. This gall may be related to the Cedar-Hawthorn rust, but the causal organism is not known.

Galls on Oak Trees

The Oak family supports the greatest diversity of gall producers, over 800 species of insects and mites form galls. Bacteria, fungi, and viruses also form galls. Gall wasps are the most common gall producers on Oak trees. Tiny Cynipid wasps, less than 1/8 inch in length affect roots, flowers, acorns, and especially leaves and twigs. (Day 1996) These wasps, which will not sting humans, have complex life cycles of alternating generations. Different generations may produce galls that look completely different. In the past, scientists did not recognize the different generations as the same insect, and so gave them different scientific names. See the description of the

hedgehog gall for an example of a wasp life cycle.

Galls formed in the fall are usually much harder than those formed in the spring. They fall to the ground and the wasps may not emerge until the next year. In some cases, the insects may not emerge for up to five years. (Hutchins 1969)

Oak Bullet Gall (Causal organism: *Disholcaspis globolus* gall wasp) Illustration #4

Bullet galls are found on small oak twigs that are usually less than a centimeter in diameter. The galls are spherical and very hard, and may be found in pairs or even groups of three. They are the same color as the twigs and are covered in tiny bumps. Multiple exit holes can be found on the larger galls.

Transverse Oak Leaf Gall (Causal organism: *Andricus singularis* gall wasps)

These oak galls are round, protrude from both the top and bottom of the leaf in the spaces between the veins, and grow on Red Oak. The gall itself is sandwiched between the outer membranes of the leaf, and is smooth and green, about 1 – 1.5 centimeters in diameter. Exit holes are found on the underside of the leaf. Light brown and smooth on the upper surface of the leaf, the gall changes to an even lighter shade on the underside, punctuated with small black dots. They are closely related to oak apple galls (discussed later.)

Oak Peach Gall (Causal organism: *Cynips capillata* gall wasp)

Peach galls form in clusters along a leaf's midrib, on the underside of the leaf, and look very much like small peaches. They are usually light pink in color and about 0.5 centimeters in diameter. Most commonly, they form on White oaks. They may be plain or striped; the **Striped Peach Gall** is formed by a *Cynips dimorphus* gall wasp.

Oak Saucer Gall (Button Gall) (Causal organism: *Neuoterus umbilicatus* gall wasp) Illustration #5

Saucer galls are brown and found on the upper surface of oak leaves. The gall is circular with raised edges and an indentation in the center. White marks can be found on the underside of the leaf opposite the gall. They are usually a little less than 1 centimeter in diameter.

Oak Spangle Gall (Causal organism: *Cecidomyia poculum* midge flies) Illustration #6

Spangle galls are tiny and white, and when they cover the leaf, they look like sequins or spangles. They are usually clustered on the underside of the leaf. They are round, raised on the edges, and indented in the middle except for a tiny bump in the very center where the midge larvae is. Exit holes are seen near this bump. Each gall typically contains one fly, but there may be many galls covering each leaf.

Oak Hedgehog Gall (Causal organism: *Acraspis erinacei* gall wasp)

These galls are found on the leaves of white oak, and are round with short spines evenly spaced around the exterior. Usually, they are about _ inch in diameter and green in the spring. In the fall, they turn brown. Inside each gall lives one to eight wasps. *Acraspis* wasps have a complicated life cycle of alternating generations. In the spring, male and female wasps mate, then the female lays her eggs in oak leaves. These eggs will

cause the large hedgehog gall to form slowly during that summer. In late autumn, the insects emerge from the hedgehog galls. They are all females with smaller wings and, through parthenogenesis they lay their eggs on oak leaves, causing tiny galls on the bud scales that last through the winter. The wasps that then emerge in the spring are both male and female, and the cycle begins again. (Hutchins 1969) One explanation for the all-female generation in the cool weather is that it might be difficult to find mates during this time; if the females can lay fertile eggs without mating, the problem is solved. (Hutchins 1969)

Oak Leaf Midrib Fuzzy Gall (Causal organism: *Biorhiza mellea* gall wasp)

These galls are green, and found in clusters on the upper surface of oak leaves. They are small (usually about .25 centimeters in diameter) and round, and are covered with tiny fuzzy dots that are very close together. They are soft and fleshy.

Oak Leaf Midrib Gall (Causal organism: *Callirhytis flavipes* gall wasp) Illustration #7

This gall occurs singly, and is a swelling of the leaf's midrib. Galls are hard and green, and are usually centered on the underside of the leaf. They are usually found in the spring, (Felt 1940) but persist in the leaf until it senesces (dies and drops off the tree) in the fall.

Hairy Oak Leaf Gall (Causal organism: *Acraspis villosa* gall wasp)

This gall is hairy and green in the spring, and turns a rusty brown color in the fall. It looks like a little ball of wool. They are usually a little over one centimeter in diameter and are found on the upper sides of the leaves. The insect larvae is hidden within the wooly mass.

Spiny Vase Oak gall (Causal organism: *Xanthoteras* gall wasps)

Spiny Vase galls are complex structures that resemble tiny vases and are covered with tiny red or yellow spines. These unusual galls are found in clusters on oak leaves. They form in the late autumn.

Spotted Oak Apple Gall (Causal organism: *Cynips centricola* gall wasp) Illustration #8

These large (2.5 cm or more) round galls are found attached to either oak leaves or twigs. They have thin shells and when cut open, reveal fibrous strands radiating from a central core. In this core the wasp larva, or grub, spends the winter. When first formed in the spring, they are green with brown spots; during the summer and fall, the green parts turn brown, but the distinctive spots are still visible. In the spring the adult wasp will gnaw its way out of the gall, then mate and lay eggs, continuing the cycle. Look high up the oak branches for these galls. They are common, but sometimes difficult to find.

Wooly Fold Oak Gall (Causal organism: *Cecidomyia* gall fly)

These galls form on the top side of the oak leaf, directly along a vein. The vein becomes enlarged and fuzzy. Usually the gall is light green, a lighter shade than the leaf itself. They are hollow, and inside the gall numerous midge fly larvae spend the winter.

Rosebud gall (Causal organism: *Diplolepis sp.* wasp)

Rosebud galls are swellings of the buds. The female wasp inserts her

ovipositor into the bud (Meyer 1987) and lays an egg. The galls are tough, brown and scaly, and can be found even into the winter, especially once the leaves have been shed.

Mossy Rose Gall (Causal organism: *Diploepis rosea* wasp)

Mossy rose galls can be found anywhere on the rose, not just the ends (as is the case for the rose bud gall.) Their green color turns to brown in the fall. The gall consists of a central portion that contains the larvae, and "supple, branched emergences" (Meyer 1987) that completely cover the core.

Spiny rose galls, caused by *Diploepis bicolor* are also formed on rose bushes and blackberry bushes. They are covered with long, slender spines and range from light green in color to pinkish. None were found in the Arboretum this season, but it is very likely that they would form here.

Willow blister gall (Causal organism: *Oligotrophus salicifolius* gall midge fly)

Galls on willows are found in the leaves, transverse to both sides of the leaf. They are green with fuzzy orange dots, spherical, and the portion of the leaf past the gall to the tip dies and turns brown. The galls are formed next to the leaf vein, and have a relatively straight side adjoining the vein. A large (0.18-cm) exit hole is apparent on the underside of the leaf.

Acknowledgements

I wish to thank my mentor, Dr. George Briggs, for his help in researching and writing this guide, and also Dr. Carey Vasey.

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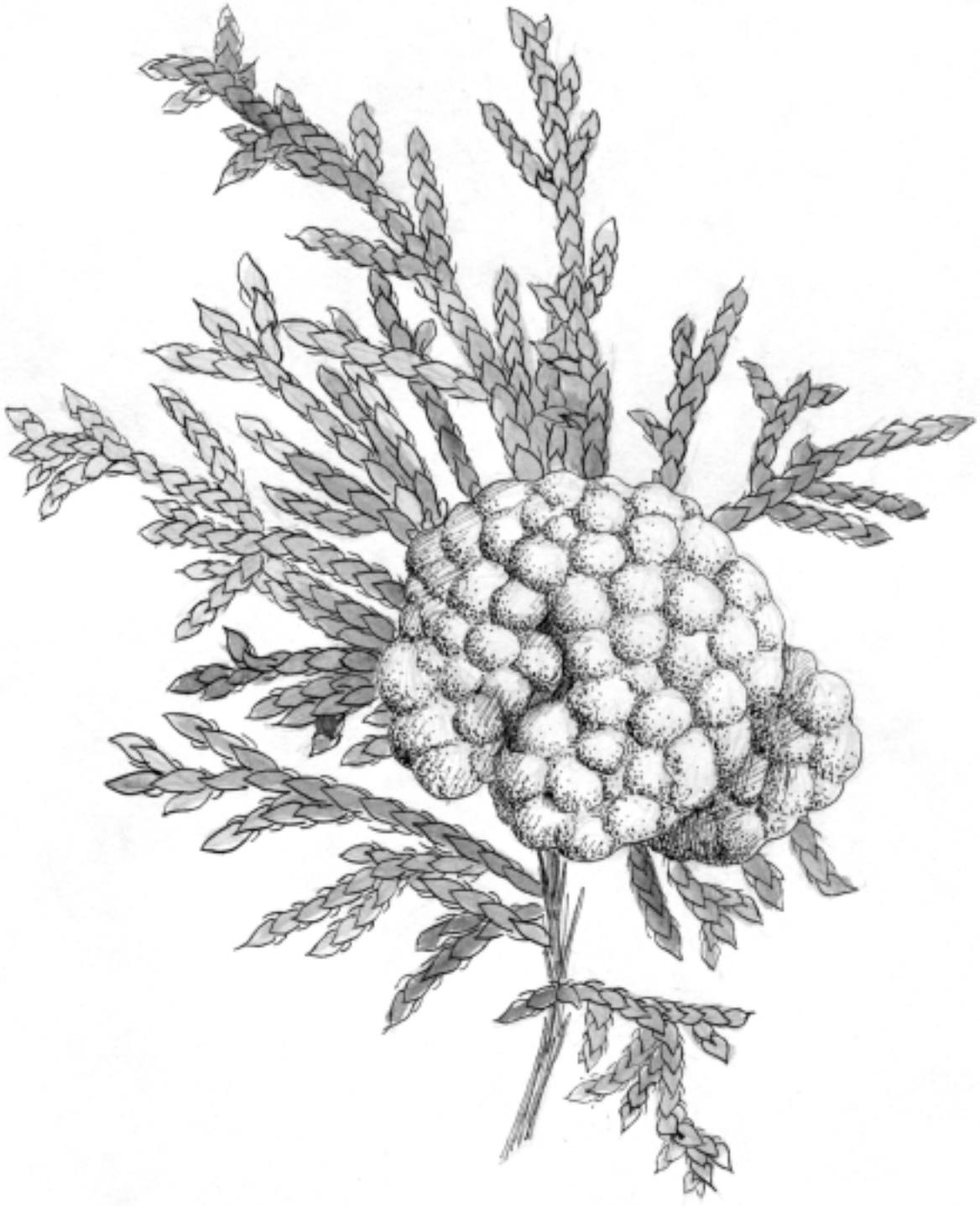
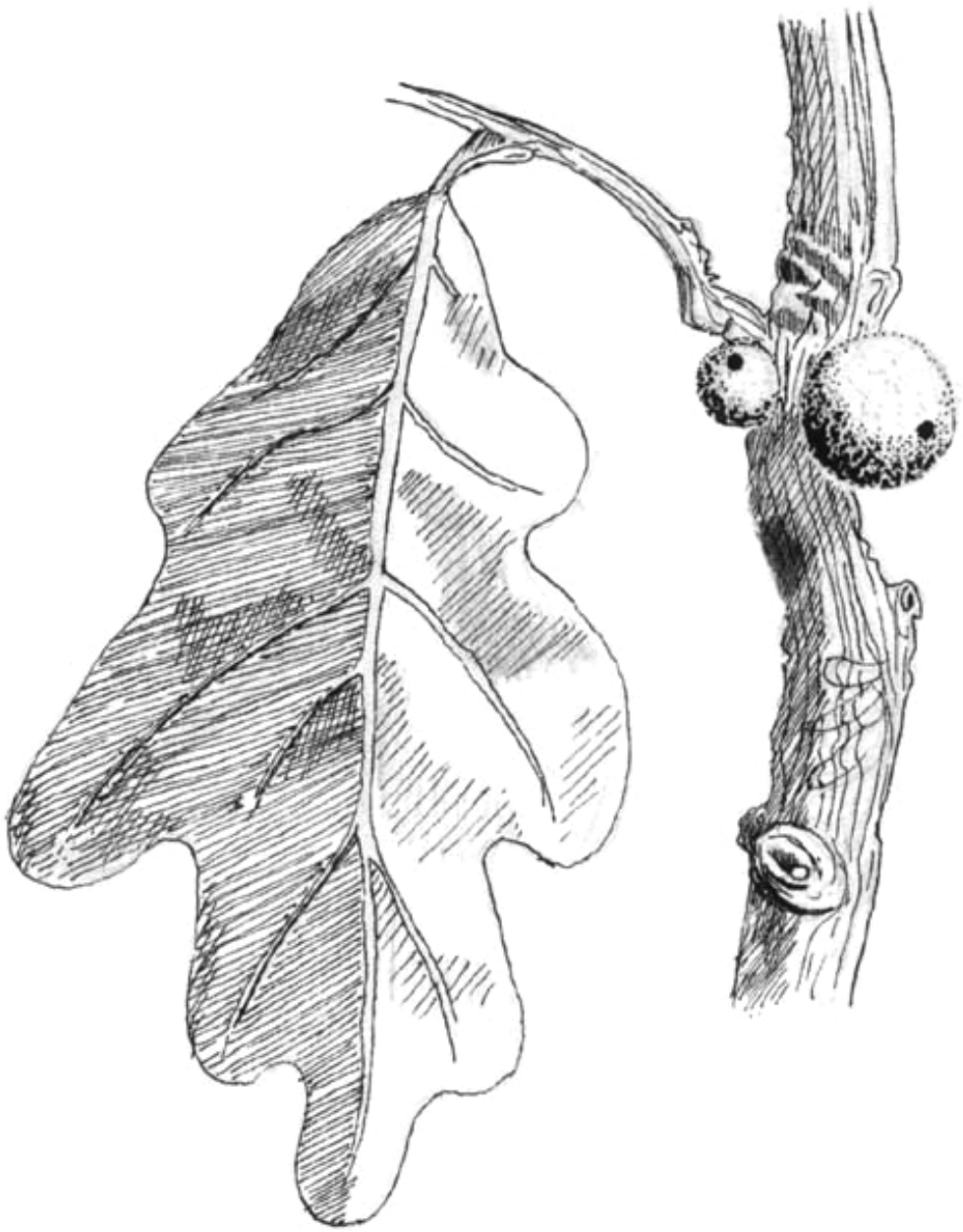
Cedar-Hawthorn Rust
Caused by *Gymnosporangium globosum*



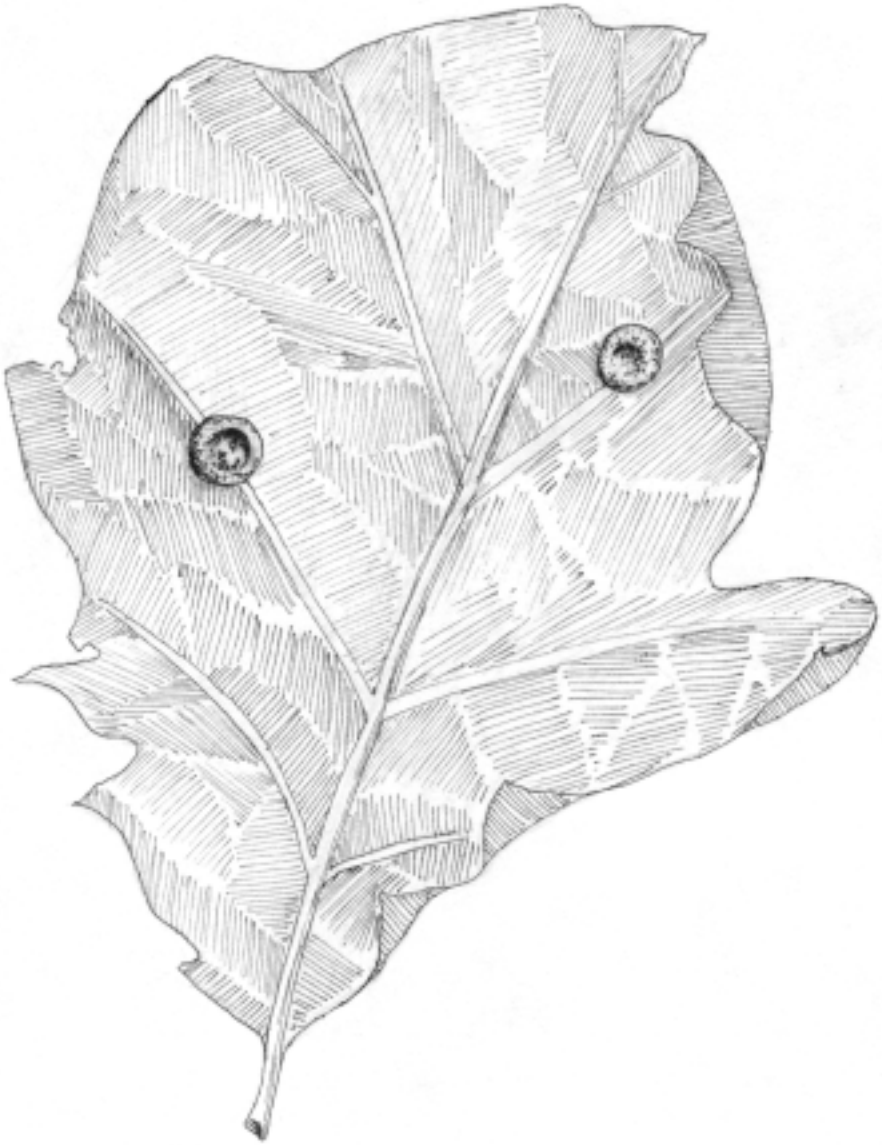
Leafy Goldenrod Gall
Caused by *Rhopalomyia solidaginis*

Spherical Goldenrod Gall
Caused by *Eurosta solidaginis*

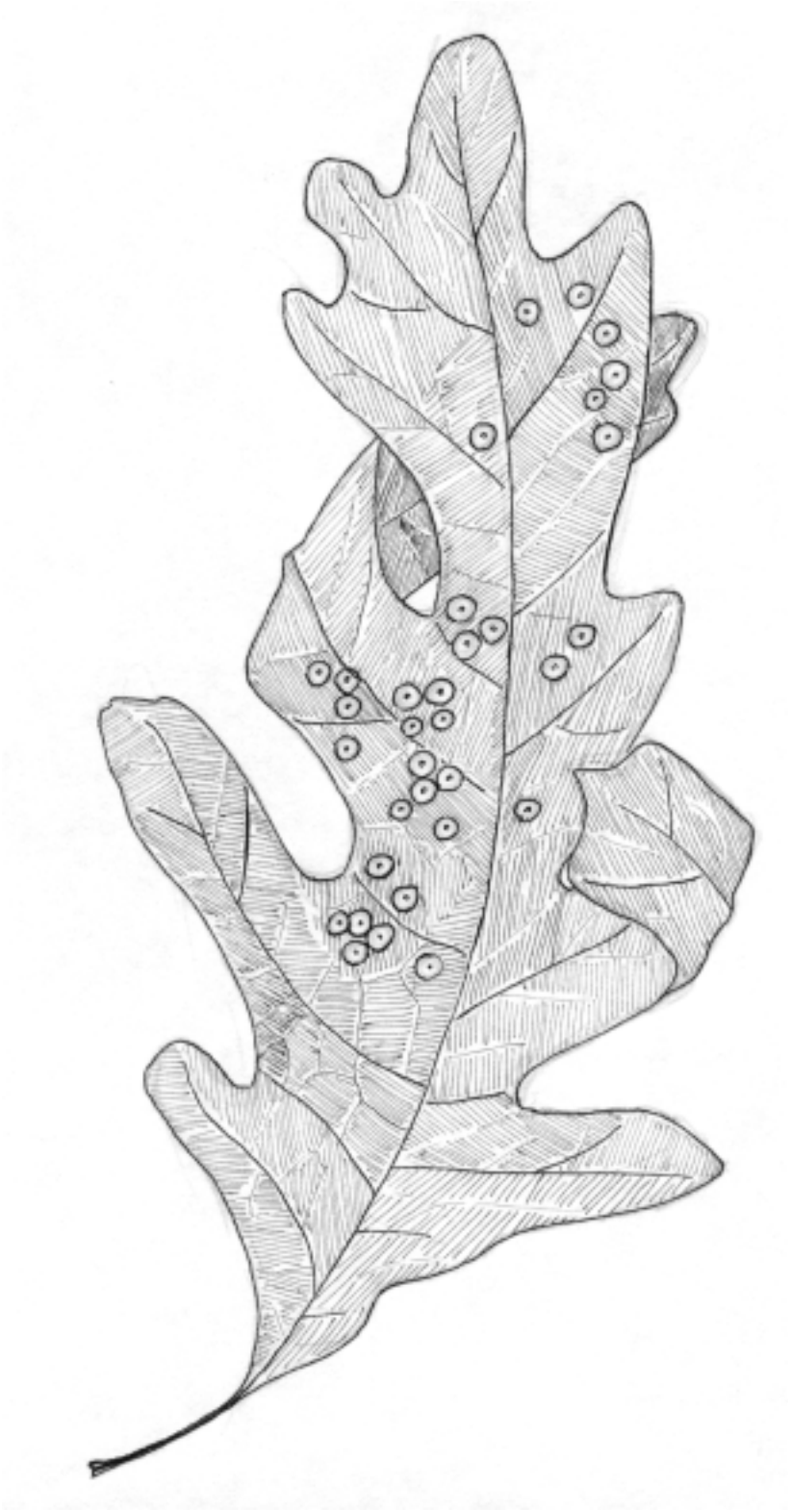
Oak Bullet Gall
Caused by *Disholcaspis globolus*



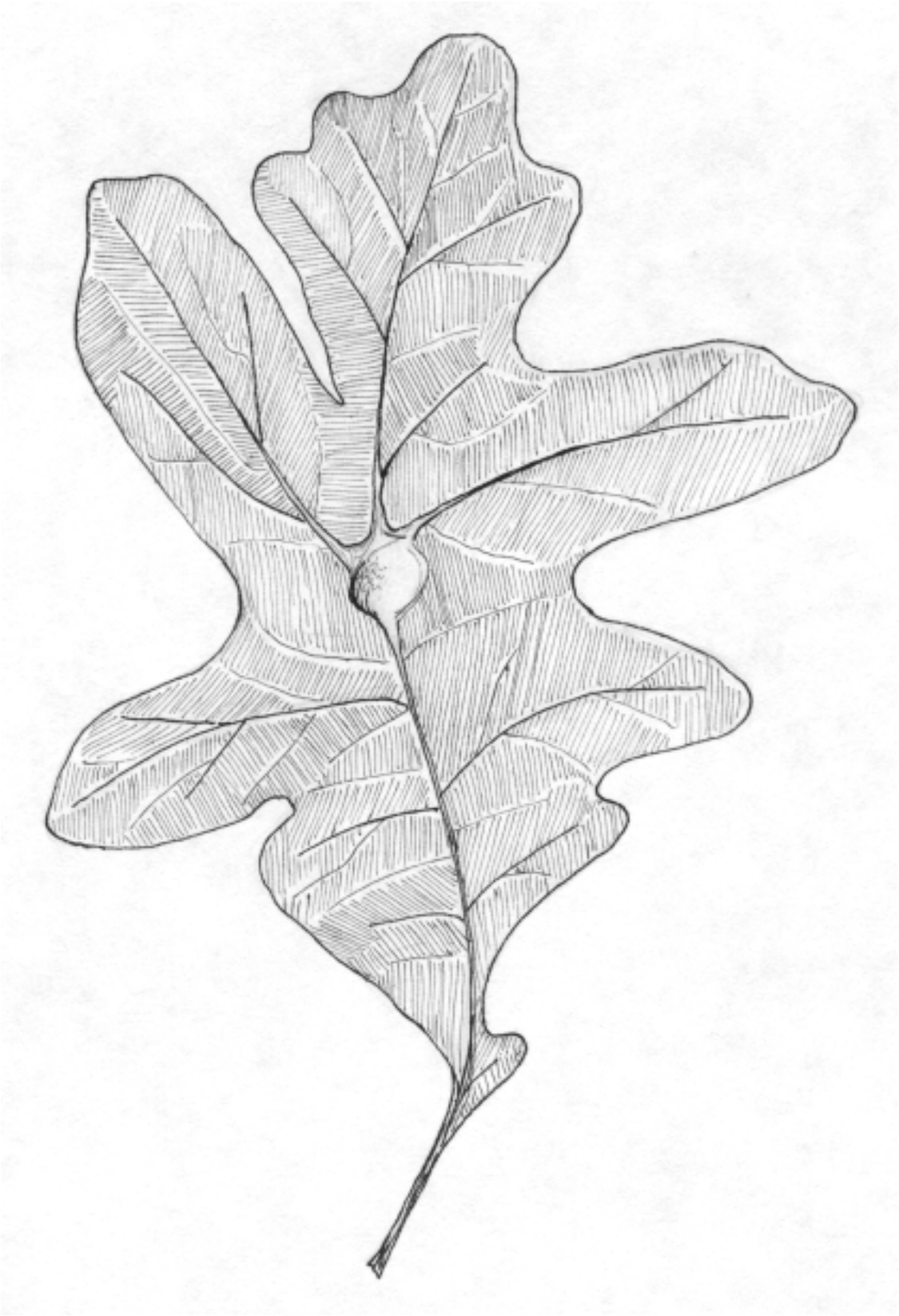
Oak Saucer Gall
Caused by *Neuoterus umbilicatus*



Oak Spangle Gall
Caused by *Cecidomyia poculum*



Oak Leaf Midrib Gall
Caused by *Callirhytis flavipes*



Spotted Oak Apple Gall
Caused by *Cynips centricola*