SMART
CENTER
Science / Math / Agriculture / Related Technology

Blueberry Stem Gall Wasp Project

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Grade level: 4-6th grade

Time required: 4 weeks (first 2 weeks observing time 30 min.-1 hr. each week),
2nd -3rd week - emergence week - 2 or 3 half hour classes.
4th week, habitat/feeding study
Please start the project within days of the kit delivery. This project should **not** continue through a vacation period.

Objectives:

Students will be able to:

√ use the scientific method to plan and conduct an experiment
√ observe and record data
√ understand life cycles and identify metamorphosis
√ utilize the basic classification system
√ learn vocabulary related to this project
√ design an environment for the emerging insect

Life skills learned:

√ learning to learn
√ planning and organizing, sequencing
√ applied science and technology to everyday life
√ record data as observed
√ make interpretations depending on data collected and studied
√ shared decision making when working in a team
√ career discoveries

Teacher Information:

Background material on the Blueberry Stem Gall Wasp Project:

What is a gall?

A gall is a tumor on plant tissue caused by stimulation by fungi, insects, or bacteria. In this case the gall is formed by a wasp that lays its eggs in the new growth on the blueberry bush.

Note: there is no health danger to students working on the project.

History:

The blueberry stem gall is a **real** problem on a two acre (an acre is about the size of a football field) highbush blueberry field at Pat and Dan LaPoint's farm in Pavilion, NY. The field is situated on the crest of a high hill that has a deep valley on the western side. Four varieties of blueberries make up this acreage (map included). A study to understand the life cycle of this pest has been in effect for four years. We encourage you and your students to take part in the project to better understand that life cycles appear all over, if one investigates and inquires.

This is the fourth year the gall has been observed on new plant growth. The galls were observed in years 1 & 2 in the first two rows (in the back of the field where air currents are strongest from the valley below). In the third year galls were observed in the first three rows and include two of the four varieties. Each year we have cut off the galls and burned them so the insect can't emerge and spread. But...each year more galls appear.

Our fields are organic (we do not use spray to control insects). The wasps lay their eggs in the new growth of the blueberry stems which is where the blueberry production takes place. (See cartoon drawings of wasp and description of what is happening) Cutting off the new growth means that production is restricted on that part of the bush. This problem has been researched; at this point in the research it has been a problem usually observed in low bush blueberries, seldom in high bush varieties. (See research page). This experiment has been designed to aid our understanding of the life cycle of this wasp and pass on all pertinent information to other berry growers. It will also enable your students to take part in a real study that is helping other blueberry growers to discover more about this wasp.

You will be helping your students focus on:

- √ the life cycle of this pest
- √ determine how temperature affects the life cycle
- √ discover whether there is a parasitoid involved in this wasp's life cycle. (The research done by J. F. Shorthouse in Ontario, Canada have identified six parasitioids that lay eggs with ***hemada nubilipennis***).
- √ discover the work involved with people who help agriculture and are involved in I.P.M. management (integrated pest management) and entomology.

The following people have helped with this project;

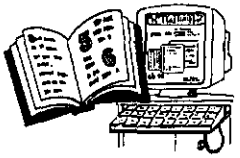
My thanks to you.

Cornell University Plant Science Department - Dr. Marvin Pritts
Laurentian University, Sudbury, Ontario Canada, Dept. of Biology - Dr. J.D. Shorthouse
NYS Agricultural Experiment Station of Geneva, NY - Dr. Greg English-Loeb, entomologist
Genesee Community College, Batavia, NY, Dept. of Biology - Marirose Ethington
Batavia High School, Batavia, NY, advice from Science Chair Gary Heim

Teacher's pages

Purpose:

Study the Life Cycle of the Blueberry Stem Gall Wasp *(hemada nubilipennis)* We need to determine the life cycle of the Blueberry Stem Gall Wasp in order to understand how to eradicate it. In order to complete this life cycle study in a timely manner, we will alter the temperatures of the gall to try to accelerate the dormant period and make the wasp emerge from the gall in 5-6 weeks.
(See life cycle sketch-supplement)



RESEARCH:

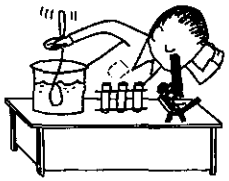
Field Observations: The adult gall wasp (Hemada nubilipennis) has been observed laying eggs (ovipositing) in the new stem growth of the blueberry. She lays 12 - 15 eggs in two or three rows beside each other. Above the eggs she stabs the plant horizontally, which stops the nutrients the plant produces, from going to the rest of the plant stem. The eggs turn into a larvae in about 10 - 15 days. The trapped nutrients, at this time have stopped and started forming a round kidney shaped gall that forms around the larvae. This essentially forms the home for the larvae where they over winter and remain dormant as a mature larvae until spring time temperatures stay constantly warm. The larvae then start to change into the adult wasp stage, when temperatures are warm enough (late May-mid June) they emerge and the cycle begins again.

Scientists, called **taxonomists**, study the relationship, or grouping of species into categories **taxa**, (singular **taxon**). Species within each taxon share a set of characteristics that define each group and yet each has its own unique characteristics too. The first major taxon is **Kingdom**. Most biologist use the **five kingdom system** (Animalia, Plantae, Fungi, Protista, and Monera.) Each kingdom is subdivided into **phyla** (singular **phylum**) or **divisions**. Insects are a major part of the **Phylum Arthropoda** (arthro=jointed or segmented, poda=foot or appendage) and also of the next smaller subgroup **Class Hexapoda** (hexa=six, "six-legged") (**Insecta**). Classes are further divided into **orders**. The **order Hymenoptera** includes ants, bees, wasps, and saw flies. Each order is sub-divided into **Families**, Family names can always be identified because they always end in the suffix, -idea (think idea!). Each family is then divided again into **Species**; in this case we are look specifically at ***hemadas nubilipennis.***

Classification System:

KINGDOM: Animalia	PHYLUM: Arthropoda
CLASS: Insecta	ORDER: Hymenoptera
FAMILY: Pteromalidae	SPECIES: Hemadas nubilipennis

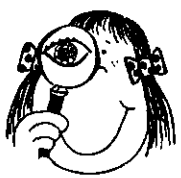
Hypothesis:
Cold temperatures will retard the emergence of *Hemadas nubilipennis* *(Hymenoptera: Pteromalidae)*



Experiment: Good science technique has a control and one variable: Our control will be room temperature (away from sudden heat such as hot sun coming in a window, or cold drafts). Our variable will be different temperatures. Place four galls (sizes should vary) in each of four covered containers. Place them in the following situations: Label your containers appropriately.

CONTROL	EXP. #1	EXP. #2	EXP. #3	
4 galls at room temp-erature, away from sunlight and drafts	4 galls warmer climate (use the heat lamp and styro container)	4 galls in a colder climate (-10) maybe a refrigerator	Class choice	Observations:
Control	#1	#2	#3	Observations Week 1
				Week 2
				Week 3
				Week 4

Procedure: Discuss metamorphosis (life cycle supplement) and consult the following directions using your discretion as to timeliness of each observation. The more data the better. (You can average the data from all group or single observations)



Observation: Students should use their journals to record exact observations. Record the date & time of day, temperature, draw what they see (size, color, motion), what they see under the scope, label sketches and write observations.

List of supplies contained in kit:

You will use all of these supplies during your experiments.

- ★ Curriculum notebook and related materials.
- ★ SMART Center posters (please have students sign one and post on your door or outside your room. Use the other two as an evaluation tool, to be returned to us. Ask students to make appropriate comments about their involvement in the kit study. You may include photos. We will laminate these and use as further SMART Center visuals.
- ★ Individual journals for each student. Please encourage them to use these as this will be a tool needed in later scientific studies.
- ★ One lab notebook to be used by teacher and students as the control journal.
- ★ Zip lock bag containing galls you will use for the study.
- ★ 4 covered plastic containers for experiments as listed in grid.
- ★ Self stick labels to describe experiment containers.
- ★ Rulers, bug box, tweezer, wooden examining tool, thermometer, graph paper.
- ★ Heat lamp and styrofoam container for experiment #2
- ★ TEACHER ONLY - utility knife to be used to cut the gall in half for larvae observation. Please cut on hard surface carefully
- ★ Five clear plastic cups for habitat study mentioned in related activities. Also zip lock bags to cover container during the study.
- ★ Laminated posters with careers related to this kit topic. See reverse side to have detailed career information explained by a person in the field and student information.
- ★ **PLEASE PUT NON CONSUMABLE MATERIALS IN THE KIT TO BE RETURNED FOR THE NEXT CLASSROOM USE.**

★Thank you in advance - hope you enjoyed this.

Procedure and Observation:

Monday: Day 1:

- Cut one gall open lengthwise with utility knife.
- Students should use their journal - please label -day one, day two, etc.
- Observe, count and measure a larvae inside the cut gall.
- Remove several larvae from the gall and place on the lines of the graph paper. (Does the larvae move? Use the graph paper square as a focal point to measure from.
- Describe the look of the gall, inside and outside. Describe a larvae (see research on page 9, bottom right section in regards to parasitoid larvae that may also be in the gall). Put the larvae and gall inside the plastic bag the galls were delivered in and observe daily; does the cut gall seem to dry out, does the larvae separated from the gall live? Record what happens to the gall, to the larvae removed from the gall, the remaining larvae in the cut gall.
- Put four galls in the containers as described in the table on page 5. Have your students record each placement as labeled, each on separate pages in their journals, leaving space for observations and drawings.

Monday: Day 8:

- Remove one gall from each container keeping them labeled. Cut open and observe and measure, record changes in larvae according to labeled containers.

Monday: Day 15:

- Repeat above experiment, cutting gall and recording observations and measurements. Can you see the larvae change into pupae form yet?

Daily from here on - observe remaining galls to see if anything emerges. When emergence occurs, count wasps for total emergence (about 1 full day). Record total. Observe to see if they look alike, different.

Conclusion:

What is the answer to the problem. Did we guess right? What did we learn? What other studies need to be performed?

Application:

How does this experiment help anyone? Does the scientific method have application to other projects we will be involved in?

Careers: You will find several laminated posters that describe science careers that may be involved in life situations. Turn the poster over to discover how to prepare yourself for your chosen field.

Additional activities:

★Try this!

1. Choose 4-5 habitat teams in your class. Give each team a clear plastic glass and a ziploc bag (let students know there will be plenty of oxygen in the habitat container to keep the insect alive). Have them discuss what is needed to keep an insect alive. Decide what they(practically) can provide in the glass to sustain the wasp. Develop a hypothesis and provide the environment the best they can. Observe and record what happens in the experiment. Graph the class results. **(Please note: when the experiment is over freeze any live wasps to kill and then dispose , do not release outside!)** According to the NYS Agricultural Experiment Station this is the method of disposal they use.

★Try this!

2. Make a blueberry snack! Some simple ideas:
   A. Mix a container of whipped topping and ready to use pudding. Spread on a graham cracker and spoon blueberry pie filling on top.
   B. Using a package of lemon or blackberry Jell-O, use hot water and substitute the cold water with a can of blueberry pie filling. Refrigerate and serve when set.
   C. Enjoy fresh, newly cooked maple syrup and blueberry pancakes

★Try this!

3. Talk about where agriculture products are grown near you. Encourage the students and their families to buy local products. Be proud of the FACE of the farmer that grows the food, their PLACE they grow the food we eat and the TASTE of that food. (Enclosed is a copy of The NYS Farm Fresh Guide, which will help you locate producers in your area.)

★Try this!

Looking at a North America map; locate the places this that have been involved in this project.

- ✓ (NYS Agricultural Experiment Station), Geneva, NY
- ✓ (Cornell University), Ithaca, NY
- ✓ (Laurentian University), Sudbury, Ontario, Canada
- ✓ The State of Maine (where the first blueberry stem gall was studied low bush blueberries).
- ✓ Pavilion, NY (Genesee County) where this study is taking place

★ Try this!

4. History and the importance of galls.

Today galls are of interest because they are unique. Before the arrival of modern medicine and the development of the newer types of dyes, galls were an important item of commerce. As late as 1945; 550,367 pounds of galls were imported from Turkey. These galls were used in medicine or the chemical substances they contained were extracted and used in industry. Gall ink was made by mixing ferrous sulphate with crushed oak gall. Gum arabic was added to give the ink its adhesive quality. Such ink is permanent and is used for official use by the USA Treasury and other countries.

Almost all old court records were written with quill pens using gall ink. It is thought that this ink has been made for nearly 1000 years, probably first used by the monks in the copying of manuscripts.

From: Galls and Gall Insects by Ross Hutchins

Research:

The following summaries are from books written on the subject of Blueberry Stem Gall Wasp. They are research studies done in correlation with the gall problem in low bush blueberries (remember our similar problem is with high bush blueberries).

I have sent the same galls that you are using to Dr. Shorthouse at Laurentian University. He is doing similar experiments with our galls at the same time you are doing yours. If I have a report from him, I will share it with you.

The Blueberry Stem Gall in Maine

by L.C. McAlister, Jr. & W.H. Anderson:
test done in the summers of 1930 - 1931

Summary: A study was done on the typical kidney-shaped, purplish of galls found on low bush blueberries (Vaccinium angustifolium) Observation of 5 possible insects that may have been the cause proved Hemada nubilipennis was the only one of five species capable of reproducing the galls. Other Hymenoptera are present in the galls as either parasites or "guest" flies.

Structural Damage by Female Hemadas nubilipennis (Hymenoptera: Pteromalidae) as a Factor in Gall Induction on Lowbush Blueberry by J.D. Shorthouse, A. West, R.W. Landry and P.D. Thibodeau Laurentian University, Ontario, Canada 1986

Summary: A study was done to determine the damage done by Hemada nubilipennis on the new shoots of the blueberry. Eggs are laid in straight lines in the new shoot growth of the blueberry. The wasp then stabs the stem at the top of the eggs laid, which terminates growth to the shoot. This in turn redirects the nutrients back to the egg area, the gall tissues are formed by the nutrients. This shelters the insect egg whic and larvae) in the plant cells, and also involves the insect's ability to alter the chemical composition of gall cells and interfere the flow and distribution of plant nutrients. (Fourcroy and Braun 1967).

which overwinters as a larvae within the galls. The next stage in the life cycle is to pupate in the spring, and the adult wasp, all females, emerge and chew their way out of the galls between May and early July (depending on the heat units). After emergence the female taps her chosen new blueberry shoot with her antennae and then positions herself to insert her ovipositor into the shoot and an egg is deposited. She moves a few millimeters and repeats the process until all eggs are deposited. After stabbing the top of the egg area the gall forms. (The life cycle begins again;) The eggs hatch in 12-14 days and the larvae begin feeding on cells lining their chambers. Each larvae is in their own chamber. This seems to be a higher degree of intricacy than most associations between gall insects and their host plants. This is because the insect has the ability to control the development of nutrients to the gall instead of toward production of foliage and new shoot growth. This eventually prunes the plant, such effects have been reported elsewhere but in those cases insect feeding causes the host damage.

Role of Parasitioids Associated with Galls Induced by Hemadas nubilipennis (Hymenoptera: Pteromalidae) on Lowbush Blueberry
by J.D. Shorthouse, I.F. Mackay, and T.J. Zmijowskyj

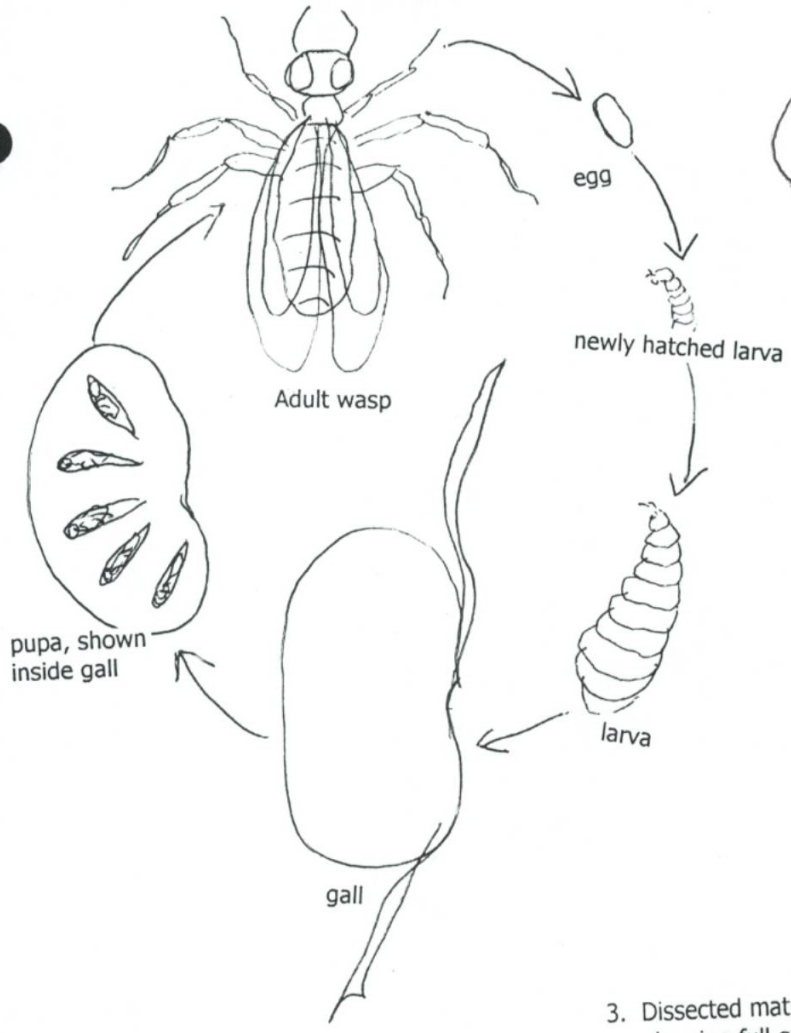
Summary: Six parasitoid species attack galls of Hemadas nubilipennis found on the vegetative shoots of blueberries (Vaccinium angustifolium). Each species emerges from galls near the emergence period of H. nubilipennis and oviposits in immature galls. It is suggested that parasitioids do not feed on or kill the H. nubilipennis larvae before they are mature; therefore, parasitioids do not influence either the shape or size of attacked galls.

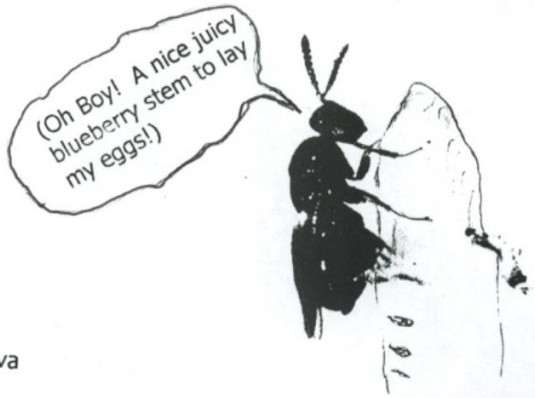
None of the parasitioids could be identified to species in the gall, but could be distinguished from the gall inducers because of the following identifiers. Larvae of H. nubilipennis have two peg-shaped sensilla on the head segment and are without hairs on all parts of the body. Parasitoid larvae do not have pegs on their head segments, and all have hairs on at least the anterior segments.

GLOSSARY	MEANING
accelerate	To speed up or develop a process more quickly
applied science	The art of using science practically in life situations
anterior	Toward the front
classification system	A system used to standardize biological categories
dormant	Inactive or asleep
emerge	To come forth into view
gall	A tumor on a plant caused by stimulation of an insect
habitat	A place where a naturally grown plant or animal lives
hypothesis	An unproved theory that will provide a basis for further study
larvae	A young insect that hatches from an egg
life cycle	The series of changes in form undergone by an organism in development from its earliest stage to the recurrence of the same stage in the next generation.
metamorphosis	The distinct stages an insect goes through to complete its life cycle. 1.(Complete or holometabolous, in which there are 4 distinct stages-egg, larvae, pupa, adult). 2. (Simple or hemimetabolous, in which there are only three stages-egg, nymph, adult).
ovipositor	The insect that lays the eggs (oviposition is the process of laying the egg).
parasites	A plant or animal that lives on or in another organism at the expense of it without giving useful assistance.
parasitoid	A parasite that consumes its host.
retard	To slow down; delay

Supplemental Drawings

Life Cycle of hemada nubilipennis

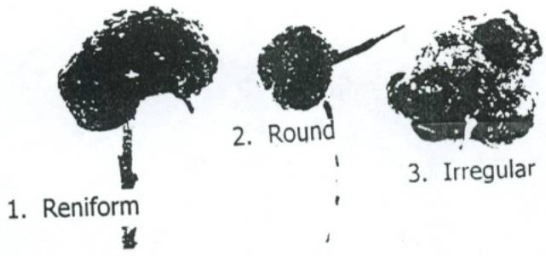




1. Adult wasp on a Blueberry stem

2. Gall on blueberry ste

3. Dissected mature gall showing full grown larvae in their chambers.



Galls can be three shapes:
1. Reniform
2. Round
3. Irregular

This happens, depending on how the wasp lays its eggs. The gall forms around the eggs, making these 3 shapes. Sort and count the types of galls in your kit. Have your teacher cut one of each open, how do the larvae differ in each gall?

Each larvae is in its own chamber, Parasitoids lay their eggs with the Hemada nubilipennis, when the eggs Change into the larvae the parasitoid Larvae eat the hemada nubilipennis and live in the chamber along with H. nubilipennis and emerge within days of H. nubilipennis.

So far none of the parasitoids can be identified according to species but can be distinguished from H. nubilipennis which has two peg-shaped sensilla on the head segm They are also without hairs on all parts of their body.