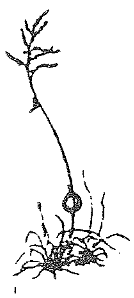
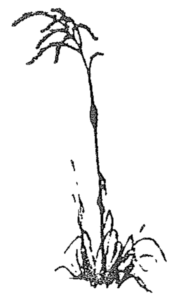
Do Galls Effect the Fitness of Their Hosts?





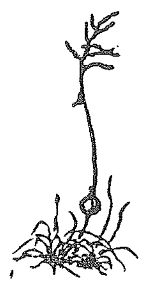
Do Galls Effect the Fitness of Their Hosts?

Introduction:

Goldenrod (*Solidago* sp.) is one of the most common of late summer and early fall wildflowers. It takes over old fields nearly to the exclusion of other plants. Its golden beauty is unfairly tarnished by the widespread misconception that it causes hayfever. Actually, it just happens to bloom at the same time as the real culprit, ragweed (*Ambrosia* sp.) Goldenrod's pollen is carried by insects and isn't airborne like that of ragweed.

Goldenrod is a member of the composite/aster family, along with the daisy, Black-eyed Susan, and aster. Although it doesn't look much like these others, goldenrod has both ray and disk flowers in each head. *Be sure to take a close look at the flowers with a microscope or handlens!* There are many species of goldenrod in our area, but by far the most common is Tall Goldenrod *(S. altissima)*. This species is home for a number of insects including pollinators, predators and herbivores. Pollinators, of course, are beneficial to the plant; several other insects have a different effect on it. By boring into the plant and feeding on its tissues, some insects cause the plant to produce an abnormal growth, known as a gall. (Other kinds of galls may be caused by mites, aphids, nematodes or fungi.)

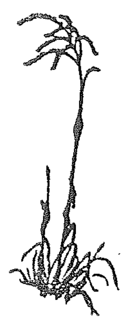
Tall goldenrod is home to three gall-makers, each of which causes a characteristically shaped growth: round (or ball), elliptical, and rosette (or bunch).



Round Gall

The common round galls on *Solidago altissima* are caused by one species of tephrifid fly, *Eurosta solidaginis.* The adult fly emerges in May from the gall and lays eggs in the stem of *Solidago.* The hatched larva bores into the meristematic stem tissue and a gall forms. The larva is full grown by mid-September and cuts a tunnel to the surface. It enters a larval diapause (resting state) over the winter and pupates in the spring. There are two hymenopterous (wasp) parasitoids which can cause 40-60% mortality of the fly larvae. *Eurytoma obtusiventris* causes the fly to pupate in mid-August, consumes the fly and remains inside the puparium until the spring. *Eurytoma obtusiventris* consumes the fly larva and also eats some of the gall before pupating and emerging in the spring. A coleopteran (beetle) larva, *Mordellistena unicolor* (Mordellidae), bores in the wall of the gall and may occasionally eat the fly larva. Small dipteran (fly) larva (Cecidomyidae) may be found living in the gall walls as inquilines (causing no harm to the larva). Other predators, including birds, occasionally eat the larva.

Elliptical-shaped galls on *Solidago* are caused by the lepidopteran (moth) larva, *Gnorismoschema gallaesolidaginus.* This elliptical-shaped gall is usually found lower down the stem of the goldenrod than the ball gall indicating the earlier penetration of the eggs into the plant. The moth bores a longer, hollow burrow inside the stem.



Elliptical Gall

Rosette Gall

A third common gall, (rosette or bunch gall) of *Solidago altissima* is caused by the midge (a fly-like insect), *Rhopalomyia solidaginis.* This midge causes a proliferation of leaves at the tip of the growing stem forming a dense rosette of leaves. Inflorescence production on stems with this gall usually results only from the production of side branches from the main stem.

Because the larvae of these species form galls (which function in thermoregulation and protections from the elements), it is fairly easy to determine mortality factors of the goldenrod fly due to parasitoids, predators, etc. We can also ask questions about the effect of the galls on the goldenrod plants. In particular, we can determine if the presence of a stem gall affects the reproductive potential of the goldenrod. In short, does the presence of a gall (and, of course, its inhabitants), cause the plant to produce fewer flowers? Fewer flowers means fewer seeds, which in turn would lower the reproductive fitness of the plant. We can investigate this by simply collecting goldenrods both with and without stem galls and making some comparisons. The plants are separated into their component parts, dried, and weighed. The reproductive effort (ratio of inflorescence biomass to total biomass), stem biomass/total biomass, and leaf biomass/total biomass can then be calculated.

Methods:

1) Collect at least 100 ball galls at random from the field. Carefully dissect each and record parasitoids, predators, inquilines, and mortality (use Uhler's 1951 paper as a reference). Use the following classes to organize your findings. These are the expected inhabitants of *Solidago altissima* in the eastern U.S.:

a. *Eurytoma obtusiventris* (Hymenoptera) (See Figure 1a). An internal parasite, this wasp causes the host to pupate prematurely about mid-August and then consumes the host. It remains inside the empty puparium throughout the winter. The puparium produced is several times smaller than the true puparium of the host.

b. Normal *Eurostra solidaginis* (Diptera). (See Figure 1b).

c. *Eurytoma gigantea* (Hymenoptera). (See Figure 1c). As an external parasite/predator, this wasp consumes the host by the end of August. Larva of the wasp are found naked in the central cavity throughout winter and pupate there in the spring. The fly's cavity is enlarged and usually filled with large black frass (fecal) pellets.

d. *Mordellistena unicolor* (Coleoptera). (See Figure 1d). As an inquiline, this grub usually does not harm the fly larva. When acting as a predator, it will break into the cavity and consume the *E. solidaginis* pupa.

e. Birds (especially Downy Woodpecker and Black-capped Chickadee). Some species of birds break into the gall and eat the *E. solidaginis* larva or pupa.

f. Natural mortality. All those larvae that are found dead for reasons such as improper development of the gall, imprisonment in plant resins, etc.

2) Collect four groups of 25 stalks of *Solidago altissima*, each at random, by harvesting at ground level:
   a. 25 normal gall-less stalks
   b. 25 ball gall stalks
   c. 25 elliptical gall stalks
   d. 25 rosette gall stalks

   Return these to the laboratory and label each specimen (N-1 to N-25, B-1 to B-25, etc.). Measure each stalk for the following characters: total above ground height (in mm), diameter of stem at ground level. Separate each of the stalks into its component organs: stem, leaves, and inflorescence. Keep each stalk labeled and its parts together. Place these specimens in a drying oven for at least 24 hours at 95 degrees C. (We use the dry weights to eliminate the highly variable water content of the plants.) When dried, weigh each stalk and its parts.

Analysis of Data:

1) Determine the fate of *E. solidaginis.* Classify them into the groups (a-f) described above.

2. Calculate for each sample of 25 stalks the mean height, and the mean weights of stems, inflorescences, and leaves. Compare the data from the gall-bearing plants against normal plants using the t-test.

3) Write this study up in "journal" form using the journal *Ecology* as a guide. Refer to the writing guide (which is on library reserve), too.

References: (many others are available)

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Acknowledgement: This lab is modified from one written by Dr. Warren Abrahamson, Bucknell University.

USEFUL CRITERIA FOR INTERPRETATION OF EVENTS OCCURRING WITHIN GOLDENROD GALLS

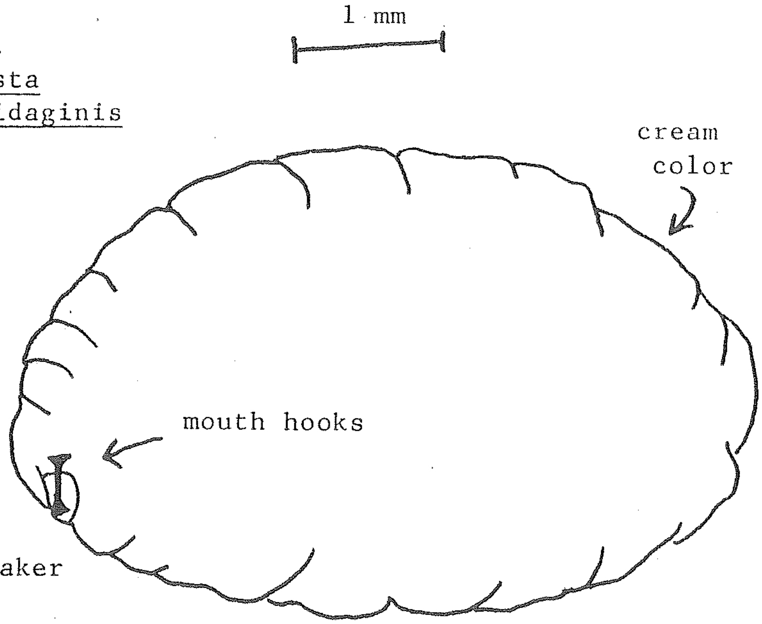
Events	Criteria
gall fly (*Eurosta solidaginis*) present	1. exit tunnel present 2. larva present: barrel-shaped; pearly white in color with black mouth hooks evident; size 4 x 6 mm or pupa present: uniform tan in color except for dark brown mouth region; shaped like larva; size 3.5 x 7.0 mm
Eurytoma obtusiventris parasitized the gall maker	1. no exit tunnel present 2. small, dark brown gall fly puparium present; size 2.2 x 7.4 mm 3. wasp larva inside fly puparium; larva with mandibles, no mouth hooks
Eurytoma gigantea parasitized the gall maker	1. no exit tunnel present 2. no puparium present 3. naked wasp larva present; larva with mandibles, no mouth hooks 4. central chamber enlarged with black fecal pellets
Mordellistena unicolor preyed on *Eurosta solidaginis*	1. no exit tunnel present 2. fly larva absent 3. beetle larva present: small, tubular in shape with 3 pairs of tiny legs at anterior end
Mordellistena unicolor preyed on *Eurytoma obtusiventris*	1. no exit tunnel present 2. small gall fly puparium present, but <u>empty</u> 3. beetle larva present (see above) 4. cavity filled with fine sawdust
Mordellistena unicolor preyed on *Eurytoma gigantea*	1. no exit tunnel present 2. no puparium present 3. wasp larva absent, but enlarged cavity filled with black fecal pellets 4. beetle larva present (see above) and fine sawdust also found
Mordellistena unicolor living in same gall with fly or either wasp species	1. beetle larva usually not found in central cavity, but more peripherally 2. see above criteria for identification of central cavity occupant
Bird predation on fly, either wasp species, or beetle	1. exterior of the gall pecked open 2. central chamber empty

KEY TO THE CONTENT AND FATE OF *Eurosta solidaginis* GALLS ON *Solidago altissima* AND *S. gigantea* -- AUTUMN & WINTER

by Arthur E. Weis

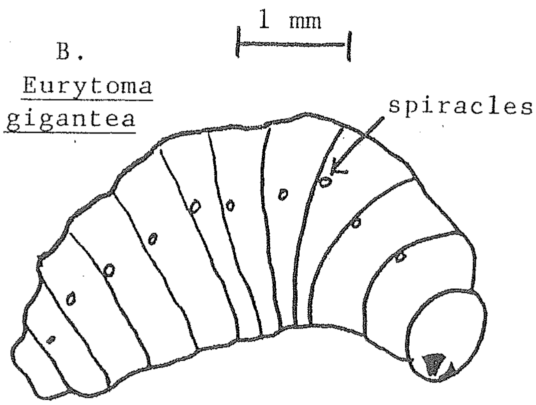
1	Gall with hole	2
1a	Gall with no hole	3
2	Hole large (3-8 mm), conical and irregular	Bird attack
2a	Hole small (<2 mm), and circular	*Eurytoma gigantea* (emerged)
3	Gall empty	4
3a	Gall with insect larva or pupa inside (larva may be tunneling)	5
4	Gall chamber contains frass	-- Killed by unknown insect
4a	Gall chamber brown, but without frass	-- Early larval death
5	Brown pupal case (4 mm) in chamber (fig. D)	-- *Eurytoma obtusiventris*
5a	Cream colored larva; in chamber or tunneling in pith region	6
6	Cylindrical larva; 4-5 mm long, <1 mm wide; three legs; hairs on posterior segments; galls show signs of tunneling through pithy region; larva usually in tunnels (fig. C)	-- *Mordellistena unicolor*
6a	Larva globular in shape; always in chamber	7
7	Larva drop-shaped; distinct, white head capsule with darkened mandibles, brown spiracles apparent under microscope; highly variable in size (2-5 mm); gall chamber frequently contains brown frass (fig. B)	-- *Eurytoma gigantea*
7a	Larva ovoid; no distinct head capsule; mandibles modified to anteriorly directed mouth hooks; general appearance of a maggot; gall chamber lined with tightly press, gray frass, exit hole excavated up to but not through gall epidermis (fig. A)	-- *Eurosta solidaginis*

A.
Eurosta solidaginis



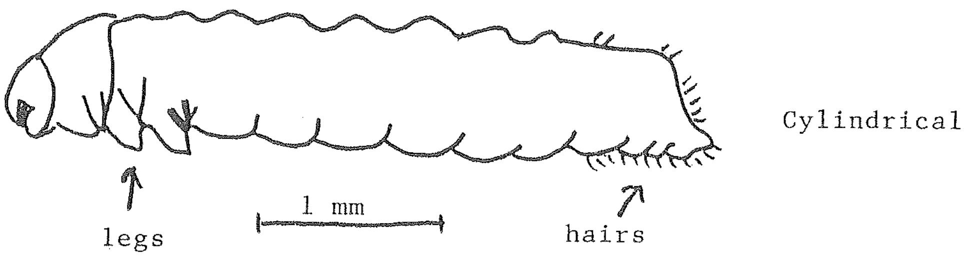
Gallmaker

B.
Eurytoma gigantea



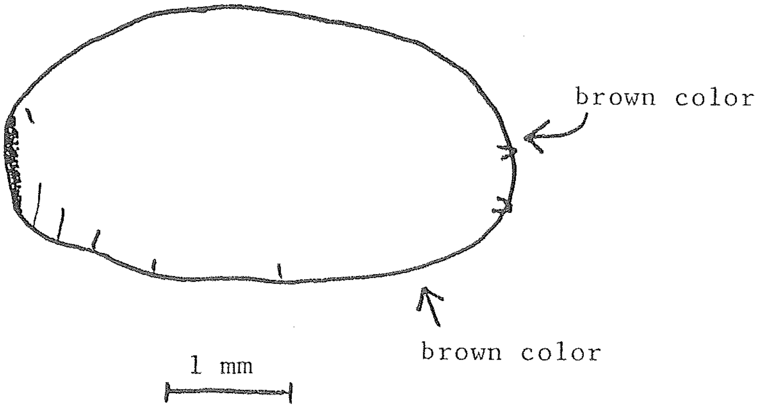
Parasitoid

C. Mordellistena unicolor



Inquiline

D. Eurytoma obtusiventris



Parasitoid

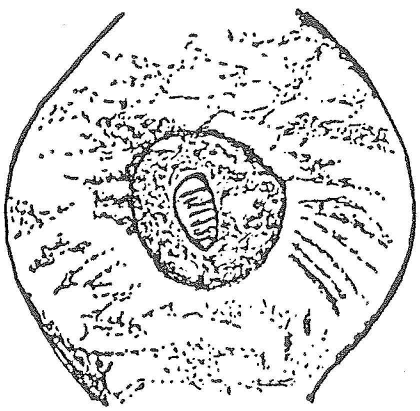


Figure 1a. Eurytoma obtusiventris: brown prepuparium of the internal parasite.

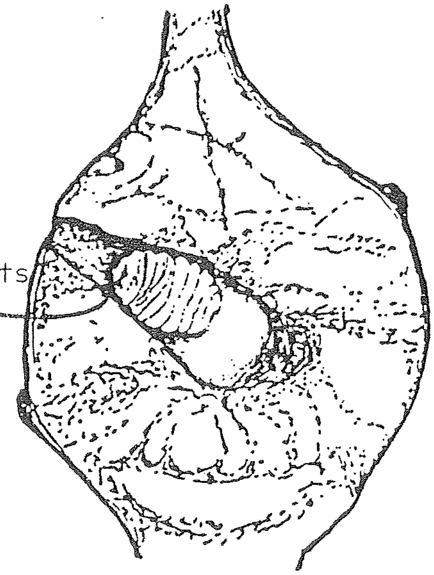


Figure 1b. Eurostra solidaginis: white fleshy gall-fly larva. Note characteristic black mouth parts.

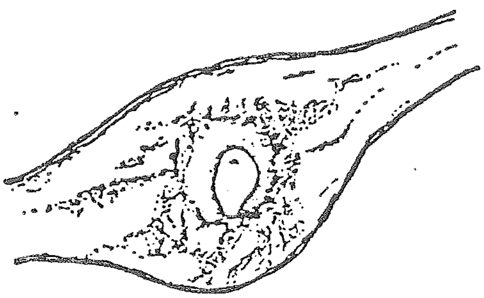


Figure 1c. Eurytoma gigantea: white fleshy larval parasite.

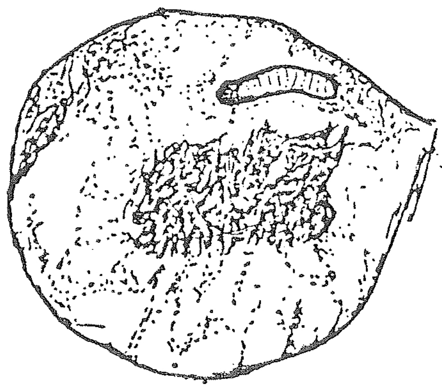


Figure 1d. Mordellistena unicolor: slender white coleopteran larva. Note small appendages.

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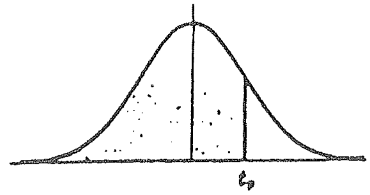
Appendix III

PERCENTILE VALUES (t_p)
for
STUDENT'S t DISTRIBUTION
with ν degrees of freedom
(shaded area = p)



t.995 t.99 t.975 t.95 t.90 t.80 t.75 t.70 t.60 t.55

ν	$t_{.995}$	$t_{.99}$	$t_{.975}$	$t_{.95}$	$t_{.90}$	$t_{.80}$	$t_{.75}$	$t_{.70}$	$t_{.60}$	$t_{.55}$
1	63.66	31.82	12.71	6.31	3.08	1.376	1.000	.727	.325	.158
2	9.92	6.96	4.30	2.92	1.89	1.061	.816	.617	.289	.142
3	5.84	4.54	3.18	2.35	1.64	.978	.765	.584	.277	.137
4	4.60	3.75	2.78	2.13	1.53	.941	.741	.569	.271	.134
5	4.03	3.36	2.57	2.02	1.48	.920	.727	.559	.267	.132
6	3.71	3.14	2.45	1.94	1.44	.906	.718	.553	.265	.131
7	3.50	3.00	2.36	1.90	1.42	.896	.711	.549	.263	.130
8	3.36	2.90	2.31	1.86	1.40	.889	.706	.546	.262	.130
9	3.25	2.82	2.26	1.83	1.38	.883	.703	.543	.261	.129
10	3.17	2.76	2.23	1.81	1.37	.879	.700	.542	.260	.129
11	3.11	2.72	2.20	1.80	1.36	.876	.697	.540	.260	.129
12	3.06	2.68	2.18	1.78	1.36	.873	.695	.539	.259	.128
13	3.01	2.65	2.16	1.77	1.35	.870	.694	.538	.259	.128
14	2.98	2.62	2.14	1.76	1.34	.868	.692	.537	.258	.128
15	2.95	2.60	2.13	1.75	1.34	.866	.691	.536	.258	.128
16	2.92	2.58	2.12	1.75	1.34	.865	.690	.535	.258	.128
17	2.90	2.57	2.11	1.74	1.33	.863	.689	.534	.257	.128
18	2.88	2.55	2.10	1.73	1.33	.862	.688	.534	.257	.127
19	2.86	2.54	2.09	1.73	1.33	.861	.688	.533	.257	.127
20	2.84	2.53	2.09	1.72	1.32	.860	.687	.533	.257	.127
21	2.83	2.52	2.08	1.72	1.32	.859	.686	.532	.257	.127
22	2.82	2.51	2.07	1.72	1.32	.858	.686	.532	.256	.127
23	2.81	2.50	2.07	1.71	1.32	.858	.685	.532	.256	.127
24	2.80	2.49	2.06	1.71	1.32	.857	.685	.531	.256	.127
25	2.79	2.48	2.06	1.71	1.32	.856	.684	.531	.256	.127
26	2.78	2.48	2.06	1.71	1.32	.856	.684	.531	.256	.127
27	2.77	2.47	2.05	1.70	1.31	.855	.684	.531	.256	.127
28	2.76	2.47	2.05	1.70	1.31	.855	.683	.530	.256	.127
29	2.76	2.46	2.04	1.70	1.31	.854	.683	.530	.256	.127
30	2.75	2.46	2.04	1.70	1.31	.854	.683	.530	.256	.127
40	2.70	2.42	2.02	1.68	1.30	.851	.681	.529	.255	.126
60	2.66	2.39	2.00	1.67	1.30	.848	.679	.527	.254	.126
120	2.62	2.36	1.98	1.66	1.29	.845	.677	.526	.254	.126
∞	2.58	2.33	1.96	1.645	1.28	.842	.674	.524	.253	.126

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