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Title: The effects of galls on *Solidago canadensis* (Goldenrod)

Introduction: *Solidago canadensis,* or Goldenrods, are one of the most common perennial flowers of North America. They provide a large variety of insect species with nutrition (nectar or pollen), shelter, and protection from predation. One particularly interesting aspect is its interaction with *Eurosta solidaginis*, the goldenrod gall fly. Goldenrod gall flies are parasitic, meaning they live on the Goldenrod, benefit from it, and potentially cause harm to it. The fly's entire life surrounds the Goldenrod; Adults walk along the stem, and eggs are laid in the unfolded leaves of the terminal bud (Werner et al. 1980). Upon hatching, the larvae bore into meristematic tissue at the base of the bud and the chemicals in their saliva cause the formation of an abnormal ball-shaped growth known as a "gall." Other than the Goldenrod gall fly, Goldenrods are parasitized by many species that stimulate gall production. The three commonly encountered types of goldenrod gall are the ball gall (*Eurosta solidaginis*)*,* spindle gall (*Gnorimoschema gallaesolidaginis*), and rosette gall (*Rhopalomyia solidaginis*).

The purpose of this study was to investigate the ecology of Goldenrods and the effect of galls on their height, distribution, growth, and reproductive capacity. Galls serve as food sources and provide a protective habitat that shelters the parasite from rain, wind and ice; however, they can alter overall plant fitness characteristics and generally have a negative impact on Goldenrods (Abrahamson and McCrea 1986). Since there is a finite amount of resources which the plant allocates to maintenance, growth and reproduction (Hartnett and Abrahamson 1979), these processes could be compromised due to a parasite and the subsequent resource requirement for the maintenance of galls. Plant growth limitations are important, especially when a herbivore such as a gallmaker is completely dependent on its host (Abrahamson and McCrea 1986).

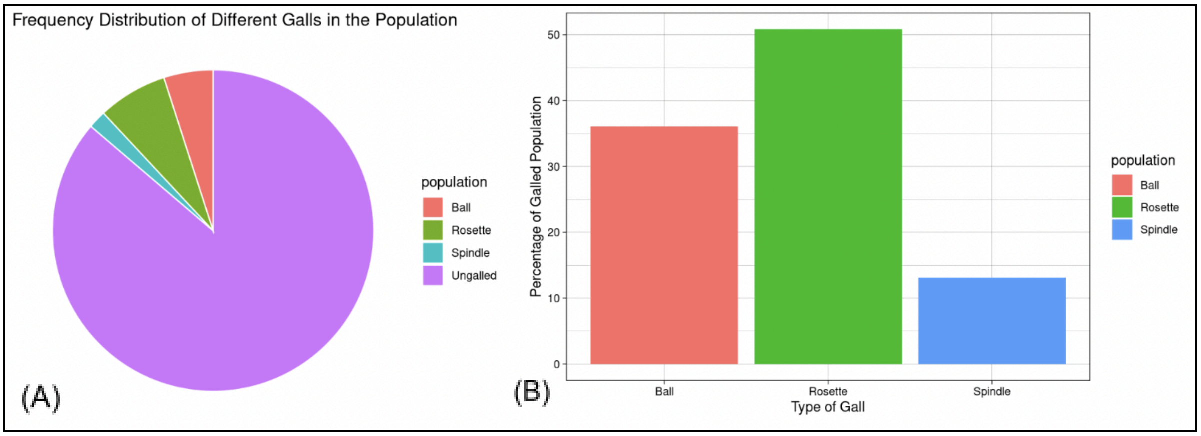

FIG. 1. Frequency distribution of different types of galls in the Goldenrod population. (A) Frequency of different galls in the goldenrod population including ungalled plants. (B) Relative frequency of different galls as a percentage of the galled population, excluding ungalled plants.

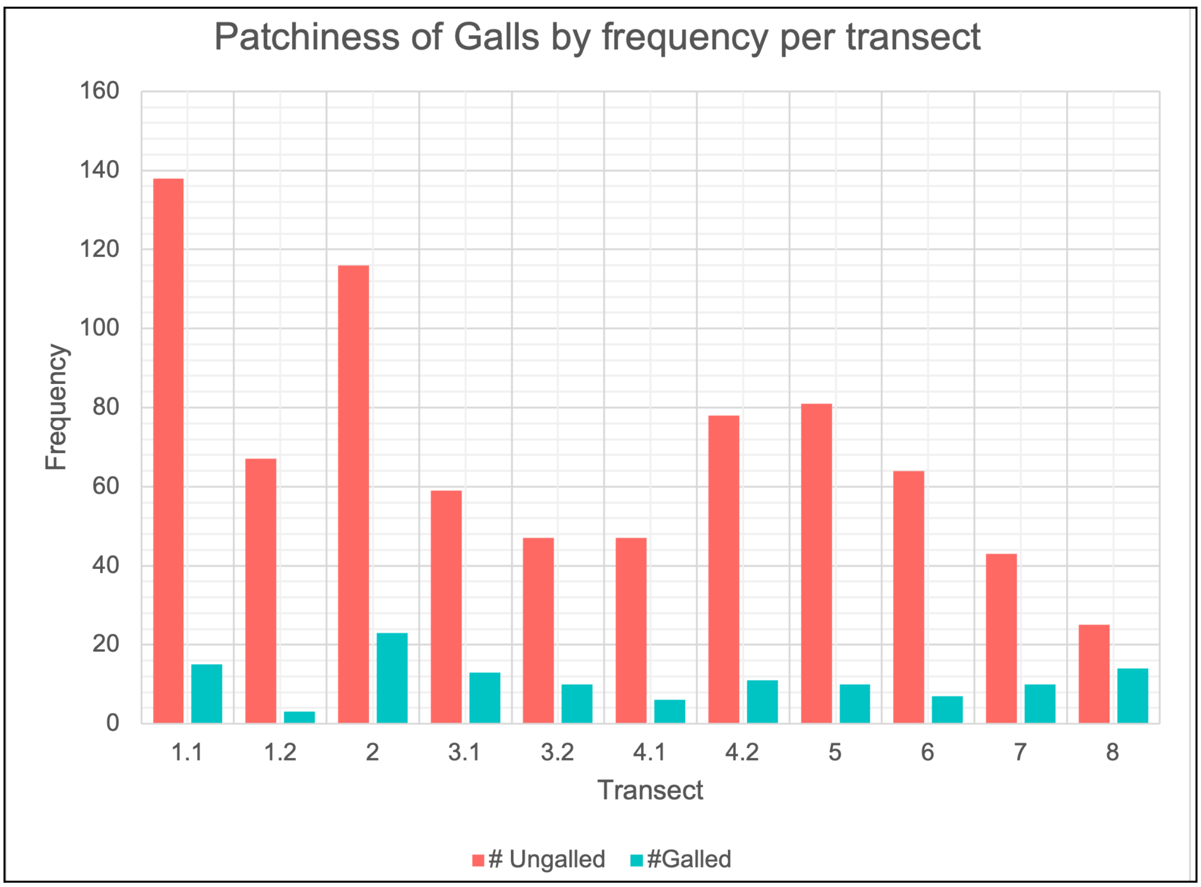

FIG. 2. Patchiness of galls as measured by frequency per transect. 1.1 = Group 1, Transect 1 etc.

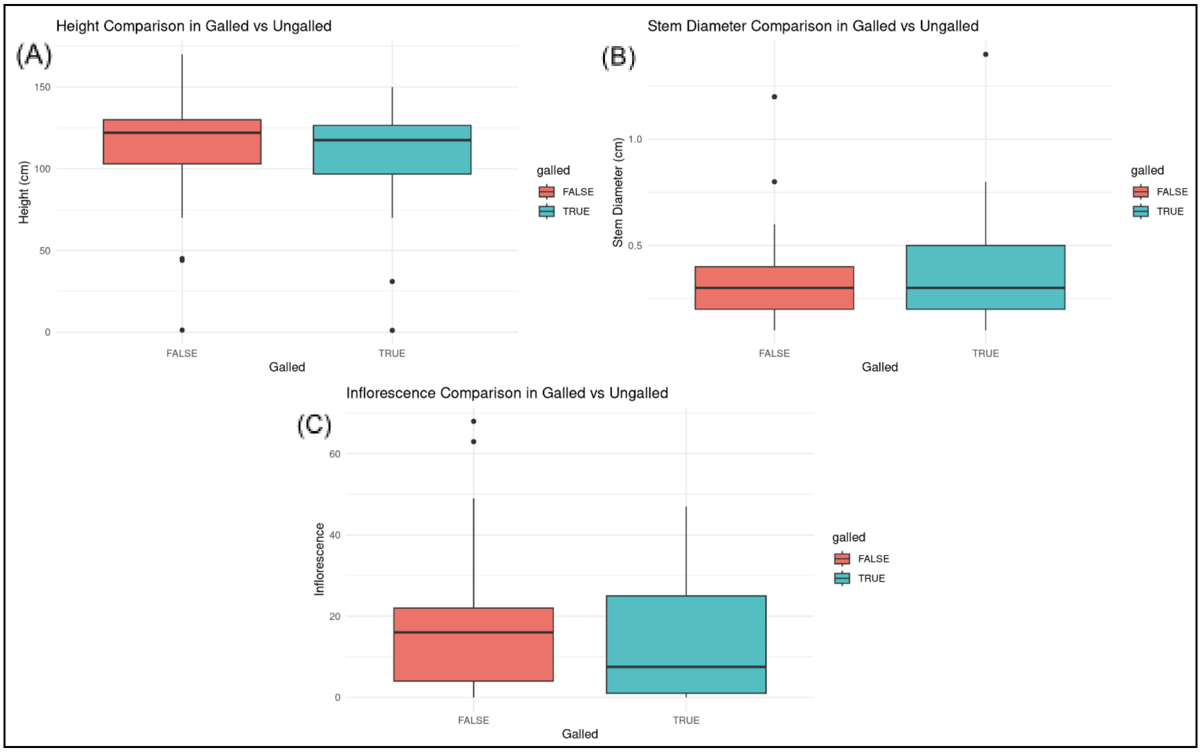

FIG. 3. (A) Comparison of the heights (cm) of galled versus ungalled plants. (B) Comparison of stem diameter (cm) in galled versus ungalled plants. (C) Comparison of the number of inflorescences in galled versus ungalled plants.

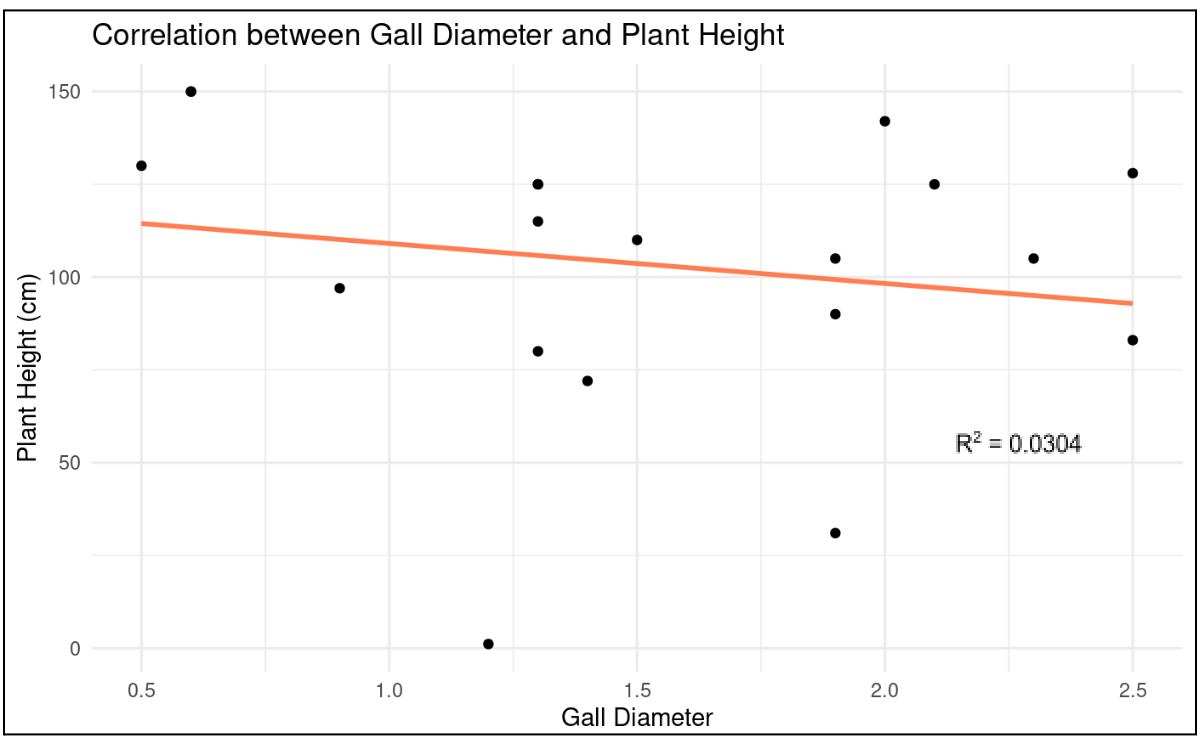

FIG. 4. Correlation between ball gall diameter and plant height.

Discussion: The overall frequency of galled plants was lesser than that of ungalled plants. Rosette galls appear to be the most frequent amongst the three types, accounting for about 50% of the galled population, followed by the ball gall at 36% and finally the spindle at 13% (FIG. 1). Transect 1.1 had the highest ungalled to galled ratio, whereas transect 8 had the lowest (FIG. 2). Overall, Goldenrods seem to have patchy distribution with large, dense clusters. This could be due to the presence of rhizomes, which is an underground stem, having nodes, that is capable of growing an individual plant close to the original one. The average height of galled plants was lower than that of ungalled plants (FIG. 3A). Although the difference is not large, some of this reduction in height may be accounted for by reallocation of a portion of the energy, or nutrient budget, to the growth and maintenance of galls (Hartnett and Abrahamson 1979).

The presence of a gall had no significant effect on the stem diameter as the average stem diameter for galled and ungalled plants was similar, ~0.2cm (FIG. 3B). Additionally, the range of stem diameters was higher in the galled plants relative to their ungalled counterparts, implying an ambiguous relationship between the two variables. Furthermore, the correlation between ball gall diameter and plant height shows a weak inverse linear relationship with an R^2 value of 0.0304 (FIG. 4). It can be reasonably inferred that the gall acts as a metabolic sink which depends on another part of the Goldenrod plant as a source for nutrients and energy (Abrahamson and McCrea 1986). As the gall becomes larger in diameter, the more nutrients are required, hence taken away from other plant tissue such as stems or leaves. The low significance of this relationship however, could be attributed to the dependence of ball galls on the stem: as the ball galls grow along the stem, they may not inhibit the stem tissue growth in any capacity.

The number of inflorescences was evidently lower in galled plants relative to ungalled ones (FIG. 3C). Hartnett and Abrahamson (1979) found a similar pattern where the galls resulted in significant reductions in the percentage of *biomass* allocated to inflorescence, implying an overall negative impact of galls on inflorescence on the Goldenrods in terms of both number and biomass. Albeit a gall might potentially decrease the plant's reproductive potential, they don't seem to have a debilitating effect on the goldenrods plants, which still bloom in great numbers despite the gall. This is a good sign indicating that the Goldenrods are not being driven to extinction by gall-forming insects.

This investigation appropriately identifies the correlations between galls and Goldenrods; however, it has strengths and limitations. Even though multiple transects were set up, a larger dataset would increase the accuracy of the data and inferred conclusions. As only measurement tools were utilized, plant maturity was impossible to determine - this could lead to unfair comparisons of height and number of inflorescences. This could be improved by measuring Goldenrods at different stages of the galling cycle and the Goldenrod life cycle. Moreover, the data that included multiple galls on the same stem were excluded in order to avoid confounding variables; a possible extension of the study could be to explore the interactions and effects of different combinations of galls on the same stem. Another fascinating aspect that could be studied further is the impact of parasitized galls on the growth of Goldenrods; Werner and Bradbury (1980) observed that if the gall larvae were parasitized, the plant expended 20-40% less energy on the gall. Predation of gall flies and attacks to the gall could be noted and the effects on Goldenrod could be investigated in terms of nutrient or energy allocation, or even physical characteristics like height or biomass.

Ultimately, galls are particularly important in examining the evolution and adaptive responses of the Goldenrod plant. Plant growth limitations should be studied further to enhance knowledge about the ecology of Goldenrods and more fascinating insect-plant interactions.

References:

1. Hartnett, D.C. and W.G. Abrahamson, 1979. The effects of stem gall insects on life history patterns in *Solidago canadensis*. Ecology 60: 910-917.
2. Werner, P.A, I.K. Bradbury and R.S. Gross, 1980. The biology of Canadian weeds. Canadian journal of plant science 60: 1393-1409.
3. Abrahamson, W.G. and K.D. McCrea, 1986. Nutrient and Biomass Allocation in *Solidago altissima*: Effects of Two Stem Gallmakers, Fertilization, and Ramet Isolation. Springer 68: 174-180.