Determining Position Preference of Different Species of Insect Galls in Relation to Each Other on the *Solidago altissima*

Galls are abnormal growths created by plants but induced by other organisms. Some of the most common galls are induced by insects; they provide nutrients and shelter for insect larvae. Two common insect galls on the goldenrod plant (*Solidago Altissima*) are the goldenrod ball gall created by *Eurosta solidaginis* and the goldenrod bunch gall created by *Rhopalomyia solidaginis*. However, little is known about the relationship/distribution of these two galling species at a field scale. The relationship between the two species could be categorized in three ways: positive association (the insects would prefer to create galls close to one another), negative (the insects would prefer to gall away from each other), and neutral association (the insects would not have a preference). The purpose of this project is to determine if the position of different species of goldenrod galls insects are negatively, positively, or neutrally associated with each other.

My hypothesis is that goldenrod galling insects are positively associated with each other; I think this because it is known that there are certain genotypes of goldenrod (within the same species) that are more prone to galling. Because plants of the same genotype are generally near each other and the two galling species would create galls on the same genotype, I predict the two species would be near each other.

The independent variable is the relative location of the galls, and the dependent variable is the overlap of the galls in a field.

My research will be done in 3 phases.

First, I will create an image/map of the actual gall positions on two fields of goldenrod (actual maps). I will use the application “My Maps” (by Google), which will allow me to create custom maps and will provide live GPS feedback. Using this application and a random number generator, I will randomly select and record (on the app) the exact locations of the sampling points. Then, I will locate each sampling point on the fields and record the number and identities of galls at each point. Using the positions of the points from “My Maps,” I will create a digital map of the exact locations of two species of galls on the fields.

Second, I will create simulated maps of the fields/galls assuming there is neutral association. I will keep the locations of the points constant. I will also keep the ratios of the identities proportionate; for example, if 20% of sampled points on the actual maps did not have galls, 20% would not have galls on the simulated maps. I then randomized the identities of the points (no gall, ball ball or bunch gall) according to the ratio in the maps of actual gall locations. This phase will be done solely through RStudios.

Third, I will quantify association to compare the actual and simulated maps. I will calculate the distance of each point to the nearest member of its own species and to the nearest member of the other species (for all maps). Thus the data will be split into two groups:

1. Distance of each ball gall to the nearest ball gall
   Distance of each bunch gall to the nearest bunch gall
2. Distance of each ball gall to the nearest bunch gall

Distance of each bunch gall to the nearest ball gall

From these two groups of data, association can be determined. If group 1 is generally less than group 2, there is more negative association because each species would be grouped together. If group 1 is generally more than group 2, there is more positive association because it means each species prefers to be near the opposite species rather than its own species.

Furthermore, a ratio will be created (for all maps), as another way to quantify association, by dividing the average of group 1 by the average of group 2. Ratios for simulated and actual graphs will be compared to determine association in the actual maps. By the logic in the previous paragraph, if the ratio of the actual maps are larger than the simulated ratios, there is positive association; if they are smaller, there is negative association.

Another method of association is the Monte Carlo P-value. The p-values will be calculated using all simulated ratios and the ratio of the actual map (for each map). If the p-value is less than .04, that means that there is a significant difference between the average simulated ratio and the ratio of the actual map to be considered either negative or positive association. If not, actual maps would be a neutral association.

A mentor, John Tooker (Penn State), will provide guidance and feedback on the planning of data collection and data analysis, but I will have the primary responsibility of executing the project.

Understanding the co-occurrence of galls can provide insight on the behavior and tendencies of galling insects. This can be used to inform studies using galling insects as biological control agents and studies attempting to minimize the damage of galls.

Bibliography

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