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Factors That Affect Eurosta Solidaginis Distribution in Naturalized Areas of Northeastern Illinois

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The Assignment: Conduct experimental research and author a paper about the project that follows a professional format.

ABSTRACT

This study examined possible factors relating to the distribution for *Eurosta solidaginis.* The abundance of its host, *Solidago altissima*, (counts/patch) was an expected factor relating to counts of *E. solidaginis*. Patch area as relating to counts of *E. solidaginis* per goldenrod patch was another factor. Due to the rarity of multiple galls it was found that competition with *Rhopalomyia salidaginis* and *Gnorimoschema gallaesolidaginis* did not appear to be so severe as to cause a negative correlation among the gall making insects. The last significant factor was surface soil temperature. All of these factors together were found have an impact on *E. solidaginis*.

INTRODUCTION

The tall goldenrod (*Solidago Altissimo*) is widely distributed across the continental United States from New England to the Gulf of Mexico to Washington State (Abrahamson et al, 1989). The perennial prefers drier soil that is frequently mechanically disturbed or very fertile soil that is free of competition (Swink and Wilhelm, 1994). However, the species can tolerate a wide range of habitats from woodlands to marsh edges to abandoned farmland.

Goldenrods have many insects that depend on it. Gall forming parasites are not commonly known to cause any significant long-term damage to the species overall (Cook, 2002; Zurovchak and Shealer, 1996; Maddox and Root, 1990), unless the insects oviposit eggs into the plant while the plant is still very young (Strong et al, 1993). When ovipositing *Eurosta solidaginis* are selective about which plant to insert the egg. Chemical signals, such as pheromones, appear involved in selection (Hess et al., 1996). This decision is crucial because it is irreversible, the young could be greatly affected by the environment in which the plant will provide (Craig, 1993). Young plants will sometimes not have the resources to recover since so much of resources are devoted to growing (Cook, 2002). The galls form sinks or a holding place for nutrients (Inbar et al., 1995); the larvae feed off of the continually replaced, nutrient rich layer on the inside of the gall (Hess et al., 1996). This sink prevents the plant from receiving the nutrients. Damage to a plant early in the season, (a young plant) may delay or reduce seed production (Cook, 2002; Hufbauer and Root, 2002). Mature plants are able to recover from the slight interference of nutrient flow as well as damage to the stem that occurs during the oviposition. Some plants have a genetic resistance to galls where they have acquired the resistance through the induction of phytochemicals. (Strong et al, 1993). These plants produce a hypersensitive response to the formation of the gall (Cappuccino, 1992).

The life cycle of *E. solidaginis* revolves around the goldenrod. They mate on the goldenrod; the female usually oviposits on that plant. When the egg hatches it grows inside the plant and is nourished by the plant. The next spring the new fly emerges to renew the process (Craig, 1993; Abrahamson et al, 1989).

The *E. solidaginis* nearly exclusively inhabits only the tall goldenrod (Abrahamson et al, 1989; Hess et al, 1996). It does share its host with *Gnorimoshema gallaesolidaginis* (goldenrod moth), and the *Thopalomyia salidaginis* (goldenrod midge) possibly suggesing competition among the gall making insects. The parasites do more damage when there are two on the plant than they would on two separate plants (Hufbauer and Root, 2002). However, according to Zurovchak and Shealer there is no benefit or

cost to adding a second *E. solidaginis* gall to the goldenrod (1996).

The effect of competition on the distribution of *E. solidaginis* is yet unknown, but is an objective of this study. In addition, physical factors were also addressed for their relationship to the distribution of the gall-making parasite.

METHODS

The study location was the naturalized areas on the campus of College of DuPage, Illinois (41°45'00" N, 88°00'00" W). These areas, which cover some 15 hectares, have been maintained for 30 years as successional plots and tallgrass prairie. The area was previously farmed. The stands tall of tall goldenrod consisted of early successional fringes to wetland, tallgrass prairie and woodland.

The study was done in April 2003. The sample size was 24 patches of randomly selected tall goldenrod. Ten $1m^2$ quadrants were taken when the patch size was large enough. If the patch size was not large enough, as many $1m^2$ quadrants as would fit in the patch were taken. *E. solidaginis* gall counts were taken along with counts of goldenrod and galls of *R. salidaginis* and *G. gallaesolidaginis* in each quadrant. Multiple gall counts were taken of multiple *E. solidaginis*; *E. solidaginis* and *R. salidaginis*; and multiple *R. salidaginis.*

Each of the physical measurements was taken on the same day. Surface temperature (within 3 cm), air temperature and light saturation were measured using a LogIt meter (DCP Microdevelopments Ltd., Norfolk, UK). Soil pH was measured using a Kelway meter (Kelway Instruments Co., Japan). Soil moisture was measured using an Aquaterr Instruments Moisture Meter (Aquaterr Instruments Incorporated, Costa Mesa, CA). Finally, the fraction organic content of the soil was determined as the loss in weight after oven drying surface samples at 60°C to a constant weight and then burning the samples at 600°C for 6 hours in a muffle furnace.

Height ranking was ranked on a scale of 1-5, where 1 was assigned when vegetation did not exceed 6cm, a value of 5 when height exceeded 15m and 2-4 for heights in between. Variability of floral environment ranking was ranked on a scale of 1-3, where one was assigned when vegetation failed to show variation in height and 3 when heights of flora were highly variable.

Relationships between counts of the goldenrod fly/patch and the selected biotic and abiotic variables were tested for significance using Spearman Rank Correlation.

RESULTS

There was a large amount of variation in many of the counts. This is likely explained by differences in patch size (Table 1). Multiple gall counts/plant/patch were found, but were relatively rare.

The variation seen in the physical measurements can be accounted for by the slight change in weather conditions throughout the duration of sampling. For instance, a rise in temperature as the sun rises higher.

As expected based on *E. solidaginis* being a specialist, goldenrod galls formed by the fly were positively and significantly correlated in the goldenrod counts/patch (Table 2). The *R. salidaginis* and *G. gallaesolidaginis* galls/patch were also correlated. Of the physical measurements, the surface soil temperature and light saturation were the only factors correlated to distribution.

DISCUSSION

The *E. solidaginis* is correlated to the goldenrod because it needs the goldenrod to live. The relationship of the fly to patch size may also indicate how *E. solidaginis* locates patches in the landscape where more plants are more visible. The posative relation of *E.* solidaginis to *R. salidaginis* and *G. gallaesolidaginis* can be explained by their common need for tall goldenrod but also that interspecific competition is not severe enough to influence the distribution of the goldenrod fly. However, the rarity of multiple gall/plant, regardless of gall-making species, suggests gall number per

plant has limits and that competition for the plant may still exist. More research must be done to be certain as to the largest number of galls, depending on type, that a goldenrod plant can safely support.

The surface soil temperature is also a factor of *E. solidaginis* distribution. Warmer areas could grow faster earlier in the season. This could effect the suitability of the host plant to infestation. The relationship could also be explained by the preference of tall goldenrod for in areas receiving full sun. The sun would then warm the surface of the soil, giving a positive correlation because the goldenrod is positively correlated the surface soil temperature and the fly is positively correlated the goldenrod.

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Table 1. Summary (x ± s; all n = 24 unless noted otherwise) of counts of various species and measurements that were tested as possible factors of the distribution of *Eurosta solidaginis*.

Variable	**x ± s**
Eurosta solidaginis counts/patch	125 ± 199
Solidago altissima counts/patch	1930 ± 2574
Rhopalomyia salidaginis counts/patch	634 ± 1317
Gnorimoschèma gallaesolidaginis counts/patch	7.87 ± 15.10
Multiple *E. solidaginis* counts/plant/patch	0.21 ± 0.66
E. solidaginis + *R. salidaginis* counts/plant/patch	1.33 ±3.42
Multiple *R. salidaginis* counts/plant/patch	1.54 ± 5.45
R. salidaginis + *G. gallaesolidaginis* counts/plant/patch	0.04 ± 0.20
Patch area (m^2)	77.7 ± 101.0
Soil surface temperature (°C)	12.4 ± 4.0
Air temperature (°C)	23.3 ± 3.0
Light saturation (%)	90.5 ± 3.5
pH	6.12 ± 0.21
Moisture saturation (%)	73.5 ± 7.6
Height ranking	2.40 ± 0.49
Variability of floral environment ranking	2.02 ± 0.71
Fraction organic content of soil	0.105 ± 0.039; n = 23

Table 2. Spearman rank order correlations (r) between counts of Eurosta solidaginis counts/patch and the various biotic and physical measurements. All df = 22 unless noted otherwise. Significance was determined at $p \leq 0.05$.

Biotic or physical measurement	**r**	**p**
Solidago altissima counts/patch	0.847	<0.001
Rhopalomyia salidaginis counts/patch	0.848	<0.001
Gnorimoschèma gallaesolidaginis counts/patch	0.505	0.012
R. salidaginis + *G. gallaesolidaginis* counts/plant/patch	0.850	<0.001
Patch area (m^2)	0.846	<0.001
Soil surface temperature (°C)	0.569	0.004
Air temperature (°C)	0.347	0.097
Light saturation (%)	0.408	0.048
pH	0.293	0.165
Moisture saturation (%)	-0.066	0.760
Height ranking	0.105	0.626
Variability of floral environment ranking	0.082	0.679
Fraction organic content of soil	-0.156 (df = 21)	0.478