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Preliminary Report

Investigation of castor bean investment in extra-floral nectary glands and reproduction

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Abstract. The castor bean plant, *Ricinus communis* has EFN (extrafloral nectary) glands that attract ants which provide defense for the plant. From this, we proposed the idea that the more EFN glands a plant has, the more ants will visit the plant, and therefore provide more defense to the plant. Using the principle of allocation, we deduced that a plant using this strategy would invest less energy in reproduction than in defense, given that growth is fixed. In this experiment we examined the number of reproductive flowers that a plant produces (male and female) in relation to the number of EFN glands on the petiole. We predicted that the more EFN glands present, the fewer flowers will be found on the plant. When comparing males and females, we found that there was instead a positive correlation between female flowers and EFN glands but no correlation between male flowers and EFN glands. From our results and analysis, we concluded that even though more energy was invested in defense (total number of EFN glands) the castor bean plant still produced more female reproductive flowers. These results contradict our assumptions based on the principle of allocation and reveals possibilities of control issues and biotic versus abiotic (chemical) discretion in defense investments.

Introduction

The castor bean plant, *Ricinus communis,* originated from Asia and Africa and was introduced into North America in the beginning of the 20th century. Castor bean plants are not deosious and thus have imperfect flowers where each individual plant has both male and female flowers. Once the male pollinates the female flower, it will grow a fruit containing seedpods. These fruits eventually dry out and fall to the ground where the seeds may begin to germinate. The seeds contain about 60% oil and are thus industrially produced for lubricants, paints, plastics, and coatings worldwide. However, because the seeds of this plant contain ricin, a noxious protein, it has been banned by some U.S. states and cities because of its toxicity as a laxative and hyperallergen (Ahn et al., 2007). The castor bean is also a model plant for studying ant-plant interactions and mutualism. This interaction is through extra-floral nectaries (EFN glands) that provide a sugar energy source for the insects and the insects provide protection and seed dispersal for the plant.

Although the castor bean and its mutualism with ants remain one of the most studied interactions, it is difficult to distinguish costs from benefits (Rutter et al., 2004). It is widely accepted in ecological studies that one of the functions of

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EFN glands on plants is to maintain a mutualism with insects, such as ants who can provide protection and seed dispersal to the plant in return for a sugar energy source (nectar) that is secreted from these glands (Leal et al., 2006). In a study by Martins et al. (2009), castor bean seed dispersal by ants was compared to seed germination. They found that germination of fresh seeds was higher in situations where ants were the dispersers as opposed to wind or auto-dispersal. Our study investigated this ant-plant mutualism by comparing the total number of EFN glands on castor bean plants as an investment in defense versus the energy investment in reproduction of the castor bean plant. We hypothesize there is a relationship between the energy allocated for defense and reproduction and we predict that the castor bean plant produces fewer reproductive flora as it invests more energy in producing a greater number of EFN glands.

Materials and Methods

Observations were made the afternoon of November 17, 2009 at the Ballona Wetlands in Marina Del Rey, California, at a monitored ecological reserve near the coast in Los Angeles County. We studied 14 castor bean plants (n=14, each plant having male and female flowers) lining a street in the area of approximately a half of a mile and examined the most prominent budding stalk on each plant. On this part of the plant, we counted the number of male and female flowers in bloom as well as the total number of EFN glands at the top four petiole leaf positions. In the Ecology laboratory at Loyola Marymount University we examined the data using Spearman's Rank Correlation and used the Pearson product-moment correlation coefficient ($r_{critical}$ at 0.05) to evaluate the relationship between the total number of flowers and total EFN glands.

Results and Discussion

The total number of EFN glands was positively correlated with the total number of flowers (male and female) ($r=0.57$, $df=12$, $p<0.05$, Figure 1) on a given plant. When flower gender is considered, the total number of EFN glands was not correlated with the total number of male flowers ($r=0.467$, $df=12$, $p>0.05$), but positively correlated with the total number of female flowers ($r=0.595$, $df=12$, $p<0.05$, Figure 2).

Our results are not consistent with the assumptions of the principle of allocation. The principle of allocation asserts that each living organism has a limited amount of energy distributed among growth, defense, and reproduction toward survival. Although the relationship between the number of male flowers and number of EFN glands showed no correlation, the relationship between the number of female flowers and number of EFN glands showed a positive correlation where we expected a negative correlation.

One explanation for the presence of the positive correlation is that larger plants in general

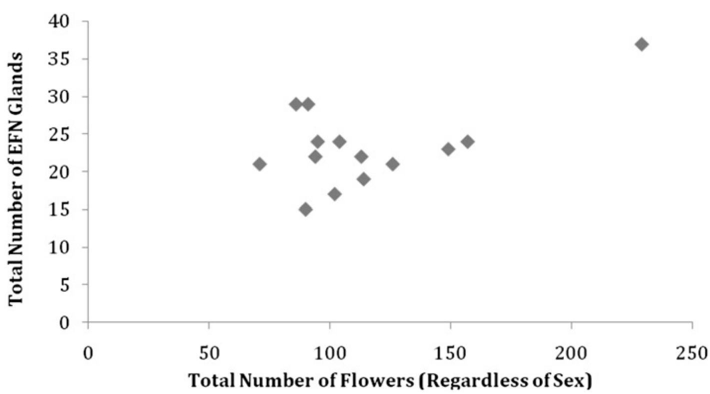

Figure 1. Total number of EFN glands in relation to the total number of flowers (reproductive structures) regardless of sex (n=14).

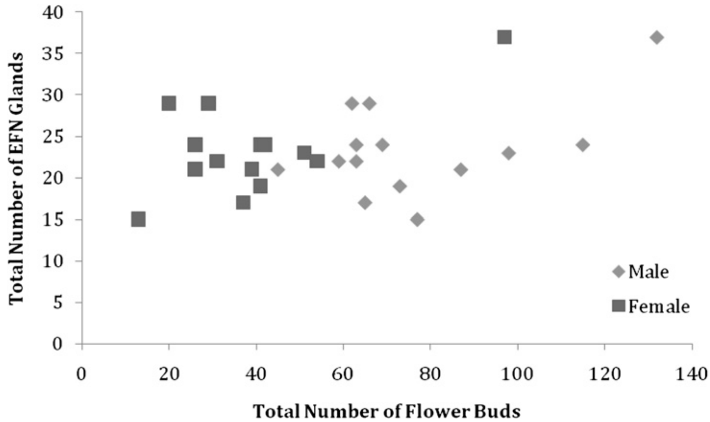

Figure 2. Total number of EFN glands in relation to total number of flower buds, with female and male results plotted separately (n=14).

produce greater number of all structures, EFN glands and flowers included. However, according to our data the same may not hold true for male flowers when the relationships are analyzed according to flower gender. One possible explanation for this discrepancy is that male flowers could have fallen off due to maturation and therefore are not all accounted for. Thus, age becomes a possible contributor. For future studies, size as well as age of the castor bean plant should be controlled.

Regardless of possible experimental design issues, our exploratory results from 14 castor bean plants remain to be explained and require further investigation. Regardless of size and age of the plants, there was a positive correlation when we were expecting to see a negative correlation. That is, we expected to see that the more energy the castor bean plant invested in defense (total number of EFN glands) the less energy the castor bean plant can invest in reproduction (total number of flowers; sex irrelevant). This leads us to question whether chemical defenses (such as production of ricin) are compromised in order to allow the positive correlation we saw in our results between biotic defenses (specifically) and production of reproductive structures. Another future study should investigate the role of chemical defenses in the castor bean plant and in the principle of allocation.

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