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# THE REPRODUCTIVE COST TO THE YUCCA PLANT (*YUCCA FILAMENTOSA* L.) IN ITS MUTUALISTIC RELATIONSHIP WITH THE YUCCA MOTH (*TEGETICULA YUCCASELLA* RILEY)

RICHARD JOHNSON
*Middle Tennessee State University*
*Murfreesboro, Tennessee 37130*

## ABSTRACT

The mutualistic relationship between the Yucca plant (*Yucca filamentosa* L.) and the Yucca moth (*Tegeticula yuccasella* Riley) was examined. Data were collected and the following variables were calculated: average number of seeds per capsule, average number of larvae per capsule, average percent of seeds eaten per larva and total cost in reproductive material per plant. The value for average percent of seeds eaten per larva was 8.37%. The value given in the literature is 20% for plants found in Missouri. Climatic differences may account for the lower value found in Tennessee plants.

Most of the variables were found to be significantly different from site to site. The variation found is most likely due to random differences in the sites such as moth density and soil conditions. Total cost was not found to be significantly different from site to site. This is surprising in as much as the other variables influence total cost. More work needs to be done to determine the forces that limit the collective larvae to eating only 50% of the plant's reproductive material.

## INTRODUCTION

In the late 1800's Riley first described an unique relationship between a member of the plant kingdom and a member of the animal kingdom (Rau 1945). This relationship between a moth and a plant serves as a prime illustration of two well recognized biological phenomena, i.e., mutualism and co–evolution. The Yucca plant (*Yucca filamentosa* L.) and the Yucca moth (*Tegeticula yuccasella* Riley) have a reproductive strategy that is as fascinating as it is unique.

Neither the Yucca moth nor the Yucca plant can reproduce without the aid of its mutualistic partner. The moth gathers pollen from the anthers of a Yucca flower. The pollen is compacted into a ball that is carried to another flower under the "chin" of the moth. Upon reaching a new flower the moth ovideposits one to several eggs in the ovary of the new flower. The moth then packs some of the pollen from the first flower onto the end of the stigma of the new flower. The moth then flies off to another flower to repeat the process. The placement of the pollen on the stigma paves the way for fertilization. It also insures, for the developing larvae, an ample food supply in the form of the developing seeds. The unique aspect of this arrangement is that each larva eats only a fixed percentage of the seeds in each capsule. The fully developed larvae eat through the walls of the capsules, lower themselves to the ground and burrow into the soil to pupate (Riley 1892).

One objective of this research was to determine the percentage of seeds eaten per larva in plants found in the Rutherford County area of Tennessee and compare this value to the 20% value found in the literature (Raven, et al. 1986). In addition I wanted to calculate the cost to the Yucca plant, in lost reproductive material, in maintaining its mutualistic relationship with the Yucca moth.

## MATERIALS AND METHODS

Six sites were identified in eastern Rutherford County, Tennessee. Sites one and three were rocky roadside areas. Sites two and six were rock gardens in the front of residences. Sites four and five were in the lawns of residences. No attempt was made to determine if the plants were naturally occurring or planted. The sites were examined intermittently in late July to determine if the larvae had emerged from the capsules. On 26 July, 1986, after the larvae had emerged from the capsules, the capsules were removed from the plants and stored in separate bags in a freezer. There were three plants at site one with flower stalks. These contained a total of 69 capsules. Site two had two plants with flower stalks. They bore a total of 18 capsules. Site three had one plant with a total of five capsules. Site four had one plant with 18 capsules. Sites five and six each had one plant with 20 and 24 capsules respectively.

Individual capsules from each plant wereexamined both by naked eye and under a dissecting microscope at 10×. The total number of whole seeds in each capsule was counted and recorded. In most cases the centers of the seeds were eaten, thus forming a tunnel through the ranks of seeds. Usually castings and webbing were left behind by the larvae and these served to bind the remains of the

Table 1. Values for Variables by Site.

| Variable | Site | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | Mean |
| Average number seeds per capsule | 308.22<br>*69<br>**d | 275.29<br>127<br>b | 245.6<br>5<br>a | 286.83<br>18<br>bc | 343.05<br>20<br>a | 334.71<br>24<br>e | 295.63<br>153 |
| Average number larvae per capsule | 5.06<br>69<br>c | 6.41<br>17<br>c | 3.00<br>5<br>b | 5.11<br>18<br>bc | 3.80<br>20<br>b | 3.50<br>24<br>ab | 4.74<br>153 |
| Average percent seeds eaten per larva | 7.20<br>63<br>a | 8.30<br>17<br>b | 12.63<br>5<br>e | 9.99<br>18<br>d | 9.78<br>12<br>cd | 8.82<br>21<br>bc | 8.37 |
| Total cost per plant in % | 36.11 | 58.77 | 38.11 | 51.77 | 36.78 | 30.00 | 42.50 |

*Number of observations
**Values with the same letter on the same line are not significantly different.

eaten seeds into a single unit. Any seed that showed signs of having been eaten upon was counted as eaten, even if only a minute section was missing. A count of larval exit holes was made for each capsule and was compared with the apparent number of larval excavations among the seeds. A reconciliation of these two numbers (if necessary) was used as the total number of larvae per capsule. From these data was calculated the values for the following variables at each site: the average number of seeds per capsule; the average number of larvae per capsule; the average percent of seeds eaten per larva and the total cost in reproductive material per plant. Total cost was calculated as: (total seeds eaten per plant)/(total seeds per plant) × 100.

## Results and Discussion

The number of larvae per capsule ranged from 0 to 13, with a mean of 4.74 larvae per capsule. These values are in agreement with those of 0 to 12 larvae per capsule found by other investigators (Rau 1945). The values for average number of seeds per capsule ranged from 243.05 at site five to 334.71 at site six. The mean for all sites was 295.63 seeds per capsule. Regression analysis indicates a random relationship between total number of seeds per capsule and number of larvae per capsule, $R^2$=.003. A greater load of larvae does not elicit greater seed production in the plant. The values for percent seeds eaten per larva ranged from 7.20% at site one to 12.63% at site three. The mean for all sites was 8.37%. This is less than half the value of 20% found in the literature (Raven, et al. 1986) (Table 1).

As determined by ANOVA, the values for total number of seeds per capsule, number of larvae per capsule and percent seeds eaten per larva are significantly different when analysed by site. Analysis by Duncan's New Multiple Range Test indicates that the values for the above variables do not fall into any set pattern at the sites. Their variation is most likely due to random differences at the sites in such variables as moth density and soil conditions.

The values for total reproductive cost (Table 1) represent the average total loss of reproductive material per plant at each site. ANOVA for this variable shows no significant differences between sites. These results are very surprising in that the other variables, total number of seeds per capsule, number of larvae per capsule and percent seeds eaten per larvae, all of which would influence total cost show much random variation from site to site. The lack of significant variation in total cost would suggest that some force or combination of forces is acting to limit the collective larvae to eating roughly 50% of the plant's reproductive material. More work needs to be done to elucidate the driving forces behind this unique and interesting mutualistic relationship.

## Literature Cited

Rau, P. 1945. The Yucca plant, *Yucca filamentosa* L., and the Yucca moth, *Tegeticula* (Pronuba) *yuccasella* Riley: an ecologico–behavior study. *Annals of the Missouri Botanical Garden*; 32:373–394.

Raven, P.H., R.F.Evert and S.E.Eichhorn editors. 1986. *Biology of Plants*. Worth Publishers, Inc.; New York.

Riley, C.V. 1892. The Yucca moth and Yucca pollination. Third Annual Report of the Missouri Botanical Garden: 99–159.