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EEB 381: Bach

Final Paper

EFFECT OF FLOWER DENSITY ON FORAGING OF *LYCAENA DORCAS*

ABSTRACT

The purpose of this study was to examine if individual *Lycaena dorcas* were flower constant and to determine if floral density and display had an affect on *L. dorcas* foraging. Data was collected at a beach near Waugoshance Point in Northern Lower Michigan. Several *L. dorcas* individuals were followed to determine their preferred flower, and then plots were made that contained low density and high density of the preferred flower along with some mixed plots of the preferred flower and one other species. *L. dorcas* was found to only visit *Potentilla fruticosa* flowers, thus constancy of individuals could not be tested. We found that plot density has a significant positive effect on number of butterfly visitors to the plot; we found marginally significant positive effects of density on total time spent by butterflies in the plot and the visitation rate. Overall, more butterflies were found in high density plots of *P. fruticosa* and *L. dorcas* spent more time in higher density plots than in low density plots; mixed plots were visited the least. These results are consistent with optimal foraging theory because the butterflies visited plots that had high densities of their preferred flower

much more and spent more time in high density plots, minimizing their searching efforts for the greatest net energy intake.

INTRODUCTION

Flower constancy occurs when pollinators show a preference for a species of flower they have previously visited and ignores other flower species. Constancy affects both the animal foraging and as a result, plant pollination (Goulson 1994). Several hypotheses have been proposed to explain why flower constancy occurs. Goulson et al. (1997) proposed that Darwin's Interference Hypothesis, the idea that learning the handling skills for a new flower interferes with an insect's ability to remember the handling skills of previously learned flowers, is a viable explanation for flower constancy.

Kandori and Ohsaki (1996) suggested that butterflies create a search image that decreases searching time and use previously learned handling techniques on new flowers they encounter. This result is consistent with optimal foraging theory, which states that organisms will exhibit foraging behavior that provides the greatest net energy intake (Goulson 1994), because butterflies in the study were decreasing their handling times, thus increasing their foraging efficiency.

Hill et al. (2001) performed a study with bees investigating their willingness to travel further as a function of net reward (amount of pollen in a flower) and found that many bees will take smaller net rewards if it requires less travel. Goulson (1994) found that if a scarce flower offers a substantially higher net reward, bees that show flower constancy with a more abundant flower species in the same area would be coaxed to the scarce flowers, even though the handling time may be higher. Goulson and Cory (1993) showed that butterflies are flower constant because they avoided flower species that their experience proved were poor sources of nectar.

Foraging of pollinators also has a strong affect on floral reproduction. It has been hypothesized that flowers have a better chance of being pollinated when they are in an area where there is a variety of other flower species than if they are in an area alone (Ghazoul 2006). This occurs due to the increased floral variety attracting more pollinators. Ghazoul (2006) conducted a study with *Raphanus raphanistrum* to test this assumption and found that pollinator visits to *R. raphanistrum* flowers increased when they occurred with other flower species, either one or a combination of two or three different species. Due to this increased visitation in mixed plots, *R. raphanistrum* had increased seed production. However, Ghazoul (2006) also found that the facilitative effects that other species had on the pollination of *R. raphanistrum* depended on the density and evenness of the mixed plots; he found that the relative abundance of *R. raphanistrum* declined in a two-species mixture due to competition.

The purpose of this study was to determine if individual *Lycaena* *dorcas* (Dorcas Copper) exhibit flower constancy, then to investigate if *L. dorcas* are more drawn to an area with various species of flowers or an area with a high or low density of their preferred flower species. We hypothesized that individuals would exhibit flower constancy and that butterflies would prefer an area with a high density of their preferred flower species, according to optimal foraging theory. We also hypothesized that the butterflies would be more attracted to a mixed plot of flowers versus a low density plot because the variety of flowers in a plot usually makes it more attractive to pollinators (Ghazoul 2006).

METHODS

Data was collected at Wilderness State Park on a beach near Waugoshance Point where the *Lycaena dorcas* was found to be the dominant butterfly species. The dominant flower species were *Centaurea maculosa* (Spotted Knapweed) and *Potentilla fruticosa* (Shrubby Cinquefoil). Our study field was sandy with both species of flowers on either side of a rocky path.

First, we followed six *L. dorcas* for 10 to 20 minutes each, noting the transitions they made from flower to flower and how many seconds they spent on each one. After following these six butterflies, we determined that *P. fruticosa* was the preferred flower of *L. dorcas*. Using this information, we set up nine plots: three low density plots of *P. fruticosa* flowers, three high density of *P. fruticosa* flowers, and three mixed plots of *P. fruticosa* and *C.*

maculosa. For each plot we recorded the approximate number of *P. fruticosa* flowers and *C. maculosa* flowers (Table 1). We then observed each of these plots for 15 minutes each, noting each butterfly visitor and how many seconds it spent in the plot.

RESULTS

From following individual butterflies, we found that *L. dorcas* only visited *P. fruticosa* flowers, thus constancy of individual butterflies could not be tested.

We found that number of butterfly visitors differed significantly by density (F=5.610, df=3, P=.036). There was a positive correlation between the number of *P. fruticosa* flowers in a plot and the number of butterfly visitors to that plot (Figure 1). We also found that the mean number of butterfly visitors increased from mixed plots to low density plots to high density plots, respectively (Figure 2).

Total time spent in each plot by all its butterfly visitors also differed with density, although it was found to be only a marginally significant result (F=4.681, df=3, P=.052). There was a positive correlation between the number of *P. fruticosa* flowers in a plot and the amount of total time spent in that plot (Figure 3). We also found that the mean number of total time spent increased from mixed plots to low density plots to high density plots, respectively (Figure 4).

The visitation rate (number of *P. fruticosa* flowers/number of total butterfly visitors) to each plot showed a marginal significance ($F=4.234$, $df=3$, $P=.063$). However, there was a positive correlation between the number of *P. fruticosa* flowers in a plot and the visitation rate to that plot (Figure 5). We also found that the mean visitation rate increased from mixed plots to low density plots to high density plots, respectively (Figure 6).

DISCUSSION

Several studies have been conducted on the factors that influence butterfly foraging. Jennerson (1984) examined pollination systems and found that visitation rates are not always a good measure of foraging behavior because the butterfly or other insect can visit certain flowers without pollinating them. Our study also takes into account number of butterfly visitors and time spent on each flower, which increases the validity of our results on foraging behavior.

Andersson and Dobson (2003) found that newly emerged butterflies had innate response to floral scent, but then determined that with experience, butterflies tend to use visual floral traits to select which flowers to feed on, indicating butterflies had modified behaviors that increased foraging efficiency. Our study found that butterflies do respond to floral displays by visiting high density plots of their preferred flower more frequently; staying in that area longer increased their net energy intake by reducing searching time.

Neumayer and Spaethe (2007) conducted research on butterflies during different seasons to determine if butterflies searched randomly for flowers or seeked out the most rewarding flowers; they hypothesized that red flowers, the easiest color for butterflies to see, would be visited much more than other flowers. They found, however, that butterflies frequented other color flowers because they offered the most nectar. This examination of butterfly foraging behavior relates to our study by showing that the color of flowers does not necessarily attract more butterflies; therefore, the purple flowers of *C. maculosa* were most likely not visited because they were a poor nectar source, not because *L. dorcas* preferred the brighter yellow flowers of *P. fruticosa*.

In pollination systems of the Venezuelan Central Plain, Ramirez (2004) observed that the time of pollination activity was influenced by community structure and plant species richness. He found that these factors may change from season to season, affecting pollinator's behaviors. This is consistent with our findings because the species richness was lacking in our study field, causing low visitation rates to mixed plots.

Our study had a few limitations; results that should have been very significant were only marginally so because of the lack of data points. The study should have been expanded to include more plots of each type of density to show a better trend. However, our results agreed with several other studies and proved to be marginally significant with only nine plots, thus our findings were not inconsequential. Ghazoul's (2006) study showed that when one flower species is only with one other flower species the visitation rate decreases, which agrees with our findings. Perhaps had there been a third plant species in the area, our mixed plot would have had a higher visitation rate, as shown in Grahzoul's (2006) research on *Raphanus raphanistrum*.

The results of our study were consistent with the aforementioned studies on butterfly foraging, and also agreed with our original hypothesis that we based on optimal foraging theory—the butterflies preferred areas with a high density of their preferred flowers because it increasing their foraging efficiency by reducing searching time and flight time. Although individual flower constancy could not be tested, the fact that *L. dorcas* only preferred *P. fruticosa* also was consistent with optimal foraging theory—by specializing on one type of flower, *L. dorcas* decreased its handling time.

FIGURES AND TABLES

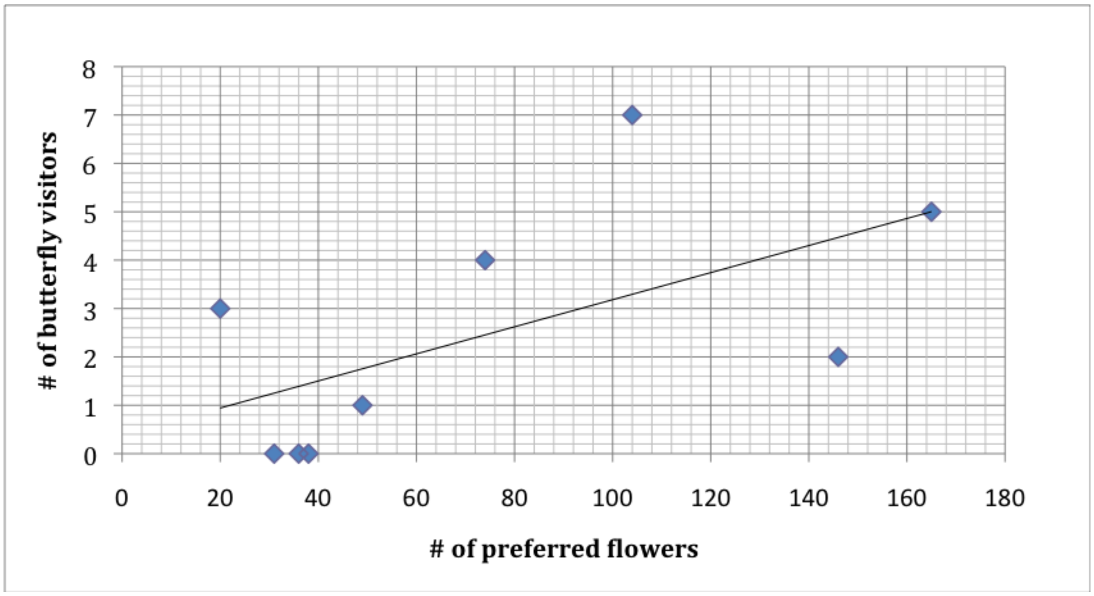

Figure 1: Number of butterfly visitors to preferred flower. A line of best fit shows a positive relationship between the two variables.

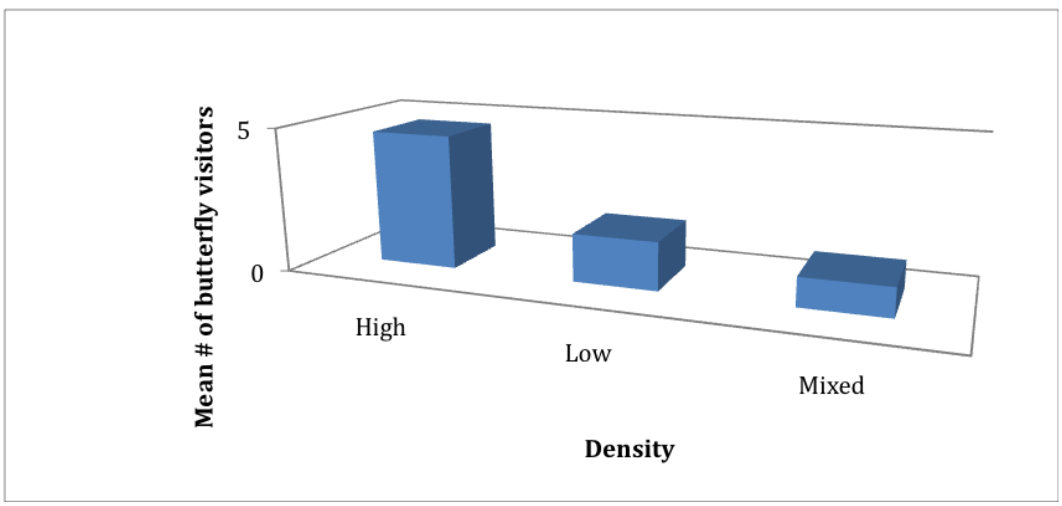

Figure 2: Butterfly visitors by density of plots.

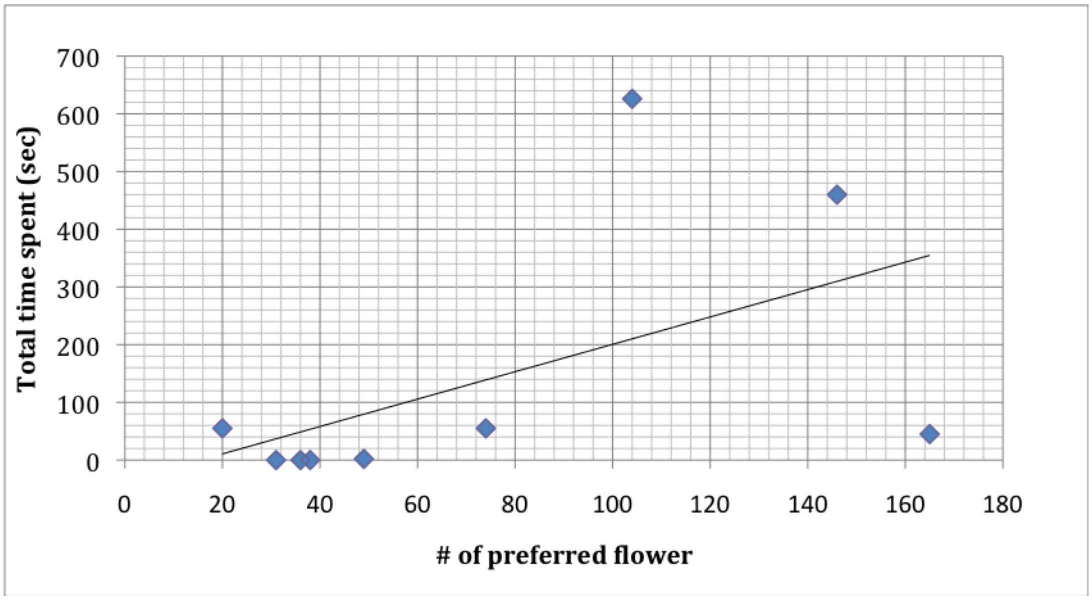

Figure 3: Total time spent on preferred flower. A line of best fit shows a positive relationship between the two variables.

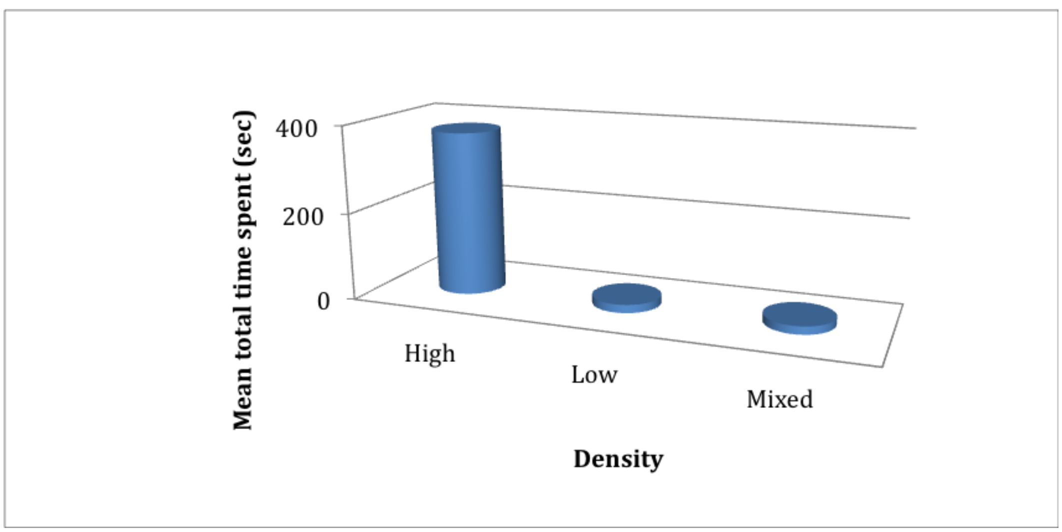

Figure 4: Time spent in plot by density.

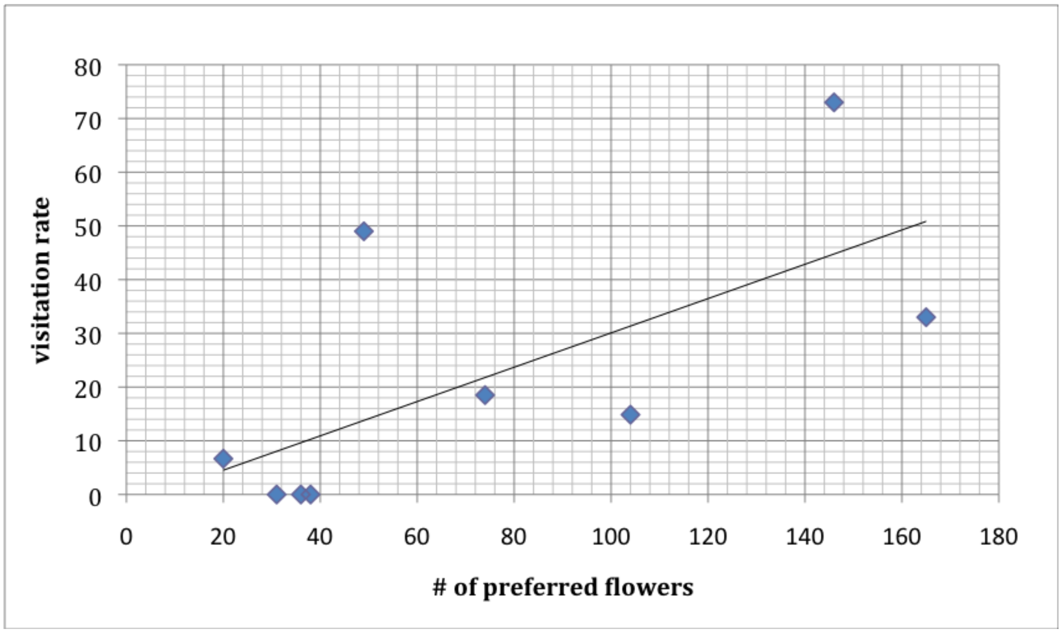

Figure 5: Visitation rate to preferred flower. Visitation rate is # of *P. fruticosa* flower/# of butterfly visitors. A line of best fit shows a positive relationship between the two variables.

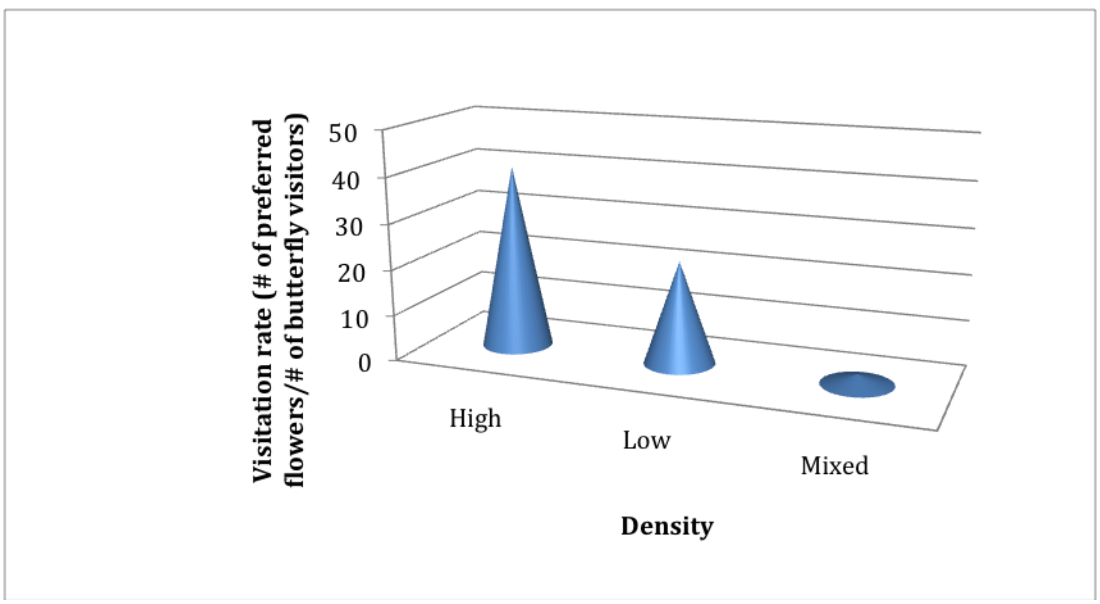

Figure 6: The Affect of Plot Density on Visitation Rate.

Table 1: Plot data from the field. Low density plots were defined as having under 100 *P. fruticosa* flowers and high density plots had more than 100.

Density	# P. fruticosa flowers	# C. maculosa flowers
Mixed	31	30
Mixed	20	25
Mixed	36	32
Low	38	0
Low	74	0
Low	49	0
High	104	0
High	146	0
High	165	32

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