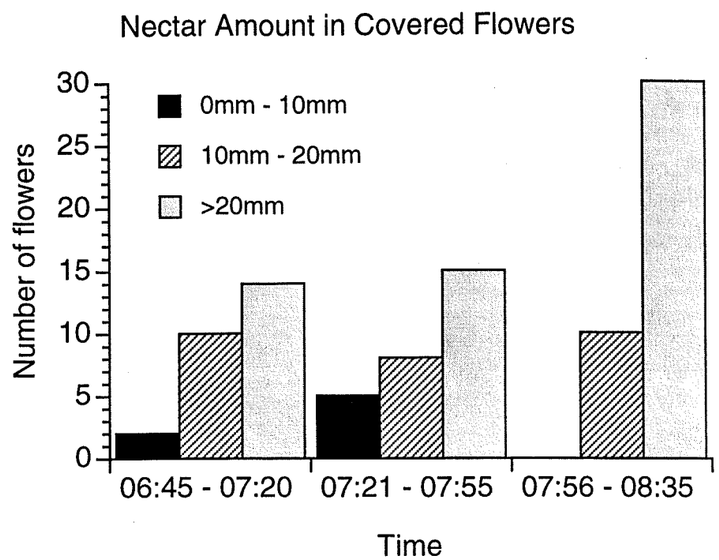

FIG. 1. Frequency of covered flowers in three nectar level catagories for three time periods. Without visitation of nectar feeders, nectar accumulates throughout the morning.

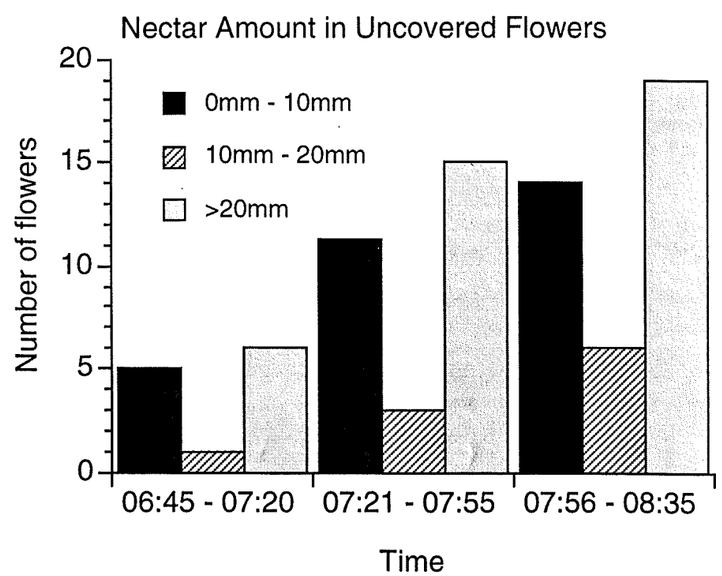

FIG. 2. Number of uncovered flowers in three nectar levels for three time periods. Throughout the morning, nectar is depleted in visited flowers.

INSECT POLLINATOR RESPONSES TO INCREASED NECTAR QUANTITY IN VERONIA *(ASTERACEAE)*

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Abstract. Pollinators are attracted to flowers because of the nectar and pollen rewards the flowers offer. To maximize rewards, pollinators should forage at flowers that contain the most nectar and pollen. We examined pollinator response to manipulated nectar rewards in flowers of a tropical shrub *Veronia sp.* (Asteraceae). Contrary to our predictions, pollinators spent more time in unmanipulated patches, as well as more time per flower in unmanipulated patches. There was no significant difference in the number of pollinators and the mean number of flowers visited by pollinators in the two patches. We suspect that the manipulation adversely affected the flowers' attractiveness to pollinators.

Key words: pollination biology, Veronia sp.

INTRODUCTION

Pollinators are attracted to flowers because of the nectar and pollen rewards that the flower offers (Howe and Westley 1988). Optimal foraging theory predicts that pollinators will spend a greater amount of time in higher reward patches than in lower reward patches. If insects are optimal foragers, they must detect flowers containing the greatest rewards either before or after they enter a patch. Fouts et. al. (1994) found that high nectar rewards did not attract a higher number of lepidopteran pollinators into a patch, but did increase their length of stay, suggesting that pollinators detect high nectar content after entering a patch. In this study, we examined the behavior of several types of pollinators on high and low nectar Veronia patches to determine if pollinators optimally forage on this flower species. We also tested whether pollinators can detect high nectar content before entering a patch. If pollinators can detect nectar content before entering a patch, we would expect more pollinators to enter a high nectar patch than a low nectar patch.

In accordance with optimal foraging theory, we hypothesized that: (1) pollinators spend more time foraging in high nectar patches than in low nectar patches; (2) pollinators spend more time per flower in high nectar patches than low nectar patches; and (3) pollinators would visit more flowers in high nectar patches than low nectar patches.

METHODS

On the evening of 11 January 1997 at the Palo Verde National Wildlife Refuge (PVNWR), Costa Rica, we haphazardly selected 20 flowering *Veronia sp.* plants along the side of the road east of the OTS field station. On each of these plants, six neighboring flowers were arbitrarily selected and covered with mesh bags to eliminate pollinators and nectivorous insects, and to increase nectar content. These manipulated patches remained bagged for 15 hours. The following morning we returned to the patches and selected nearby groups of six neighboring flowers on the same plant to act as controls. The mesh bag was then removed from the manipulated patches and pollinator behavior was observed for 10 min on both manipulated and control patches. The number of pollinators visiting the patch (if one pollinator visited the patch twice, this was counted as one individual), the duration of time spent at a flower in the patch, the number of total flowers visited (if an individual visited the same flower twice, this was counted as two flowers visited), and the total time the individual spent in the patch were recorded.

RESULTS

Pollinators such as bees, butterflies, sweatbees, flies, and beetles visited our patches of *Veronia.* Pollinators spent significantly more time in the unmanipulated control patches (61.3 + 18.2 s) than in the experimental patches (22.2 + 7.2 s; paired t-test, t=2.19, df=16, P=0.04; Fig. 1). Pollinators also spent significantly more mean time per flower in the unmanipulated control patches (27.8 +6 s) than in the experimental patches (14 +3.8 s; paired t-test, t=2.29 , df=16, P=0.04; Fig. 2). There was also no significant difference between total number of pollinators visiting the control and experimental patches (paired t-test, t=1.61, df=16, P=0.48). Finally, the average number of flowers visited per pollinator was not significantly different between control patches (1.68 +0.28) and experimental patches (1.19 + 0.17; paired t-test, t=1.56, df=16, P=0.14; Fig. 3).

Discussion

Pollinator foraging in this study, appears to have been negatively affected by our manipulations of flower patches in this study. Average times spent per flower and per patch by pollinators were actually greater for the control sites than for the manipulated sites (Figs. 1, 2), a result opposite of that predicted.

We expected the nectar levels of bagged plants to increase relative to unmanipulated plants because of their exclusion from nectar-decreasing pollination activity. But, because of the small size of *Veronia sp.*, flowers we could not quantify nectar levels. Nectar levels in the bagged group may not have been greater than in the control group. Furthermore, the bagging treatment may have damaged or altered the flowers in other ways. There was evidence of moisture from condensation in the bag, bending and weakening of stems, and heating from an increased in-bag temperature. These factors could account for the low pollinator response to bagging treatments.

We suspect that pollinators presented with a choice of high and low nectar flowers can distinguish between the two and preferentially forage on the high nectar plants. A modified experimental design is necessary to ensure that control and experimental flowers actually contain different amounts of nectar. Manual addition of nectar to the flowers, as performed by Fouts et al. (1994), might be more effective at creating nectar-enhanced patches. Until we understand the basis for pollinator flower choice, the foraging behavior of pollinators in *Veronia sp.* patches with variable nectar rewards will remain unknown.

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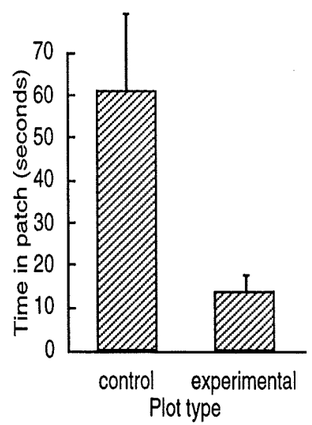

FIG. 1. Mean time spent in patches by pollinators in manipulated and control patches. Time in patch was measured over a 10 min period. Twenty manipulated patches were covered for 15 hours with bags in an attempt to increase nectar content, while 20 control patches were not covered.

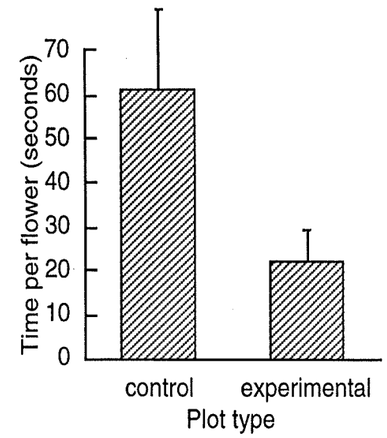

FIG. 2. Mean time spent on flowers by pollinators in manipulated and control patches. Measurement was done over a 10 min period. (See legend of Fig. 1 for more details.)

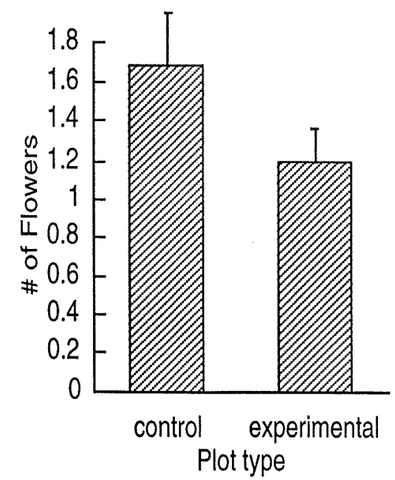

FIG. 3. Mean number of flowers visited by pollinators in manipulated and control patches. Measurement was done over a ten minute period. (See legend of Fig. 1 for more details.)