EFFECTS OF FLOWER DENSITY ON PATCH USE BY POTENTIAL POLLINATORS

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Abstract. We examined the effects of flower density of the composite *Veronia* sp. on patch use by foraging insects. We measured visitation rate, visit duration, and number of flowers visited by insects in low and high density patches. More insects visited high than low density patches. By developing an index of nectar loss and pollen dissemination, we inferred that high density patches lose similar amounts of nectar, but disseminate more pollen, compared to low density patches.

Key Words: patch density, Veronia sp., *foraging*

INTRODUCTION

From a plant's perspective, two factors that are important for energy efficient reproduction are maximizing pollen dissemination and limiting nectar loss. If the plant requires insects to transfer pollen, it must invest substantial energy in pollen and nectar to attract foragers. We hypothesized that a flower patch of high density would attract more insects and thus disseminate more pollen than a low density patch. We further hypothesized that there would be an energetic cost associated with increased pollinator visitation in the form of increased nectar loss for the patch as a whole.

Veronia sp. (Compositae) has small, white flowers and occurs in patches of various size and flower density along the road near the Palo Verde National Wildlife Refuge. We asked how flower density within a patch affects patch use by foraging insects. We also asked how flower density affects pollen dissemination and nectar loss. Based upon the above ideas, we predicted that rates of pollen dissemination and nectar loss would both be higher in patches of high flower density.

METHODS

We defined a study area along the main road, east of the Organization for Tropical Studies Estacion Biologica in Palo Verde, from 10am to noon, on 11 January, 1997. We selected 8 healthy *Veronia* sp. patches out of the 12 patches present in the study area. Each patch was approximately 20-30m from the nearest distinct patch. We measured the area of each bush by counting the number of 50cm x 50cm quadrats covering that bush. We estimated the overall flower density within each patch by multiplying the average number of flowers in 3 random 50cm x 50cm quadrats by the area of the patch. Of the 8 patches, 4 were randomly assigned to a low-density group; the remaining 4 patches were of high-density. Since each patch had sufficient flowers to be categorized as a high density patch, we reduced the densities in 4 patches to approximately 5 flowers per 50cm x 50cm quadrat to generate the low density group. There were approximately 8 - 10 flowers per 50cm x 50cm quadrat in each high density patch, and 5 flowers per quadrat in each low density patch. We then reduced the size of the larger patches so that all patches were about the same size, 10m2.

To evict pollinators, we shook each patch prior to the experiment. In one 10-min. trial for each patch, we counted the number of pollinators that visited the patch. For each individual, we recorded the times of arrival and departure, and its "guild" (i.e. flies, bees, butterflies and others) and, if possible, its movements. Because of the high frequency of visits, movements were recorded for only some of the insects we observed. We recorded movements on randomly chosen insects. The recorded movements were 1) the number of flowers the pollinator visited per patch, 2) the time spent per flower, and 3) how long the pollinator stayed in the patch. If the observed pollinator left the patch within 10 min, the observer would continue the observation on another newly arrived pollinator.

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

While there were no statistically significant differences in the visitation rates and movement patterns of all pollinator species combined across patches of different densities, we did observe some interesting trends for particular guilds.

Each composite head on *Veronia* has a number of individual florets, each of which may contain nectar. We did not attempt to measure the nectar available in the experimental patches. However, because high and low density treatments were randomly assigned, we assumed that there was no relationship between the nectar available per flower and the density of flowers in a plant. Thus, it is unlikely that any differences we found between low and high density patches were due to resource differences at the level of the flower on the inflorescence. The overall trends suggest that more pollinators visit high than low density patches, but that insects visit similar numbers of flowers and spend similar amounts of time in patches of high and low density. However, there was no significant difference in the total number of flower visits and the total time spent in high and low density patches. Thus, if we were to assume that each of the guilds extracts equal amounts of nectar per unit of time, then the total amount of nectar lost by high and low density patches would be similar. However, since we could not reasonably assume that the rates of nectar consumption are equal for all guilds, we decided to examine the trends separately for butterflies, bees, and flies.

For bees and butterflies, both the time spent in each patch and the number of flowers visited were not significantly different between the high and low density patches. From this we inferred that the nectar loss to bees and butterflies was similar in low and high density patches. However, our results suggest that the plants lost more nectar to flies in high than low density patches.

To assess how successful a plant is at disseminating pollen, it is useful to look at how many potential pollinators it attracts and whether those pollinators make subsequent visits to other plants of the same species. Since we were not able to document where the pollinators went after they visited the plants that we studied, we restrict our discussion to the number of pollinator visits to each patch. If we assume that all pollinators are equally effective at pollen dissemination, then high density patches disseminated more pollen than did low density patches, since more pollinators visited the high density patches.

In summary, it appears that high density patches may lose similar amounts of nectar, but disseminate more pollen than low density patches. Thus, plants that incur the costs associated with producing more flowers may indeed increase their chances for successful pollination, while at the same time reducing nectar depletion.

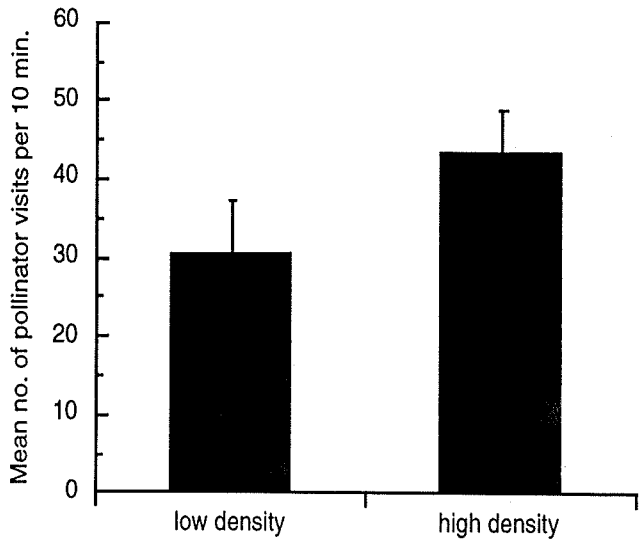

FIg. 1. Pollinator visitation in*Veronia sp.* bushes of low and high flower density in Palo Verde National Park, Costa Rica. The low density bushes (n=4) contained five flowers per 0.5 m^2; high density bushes (n=4) contained 8-10 flowers per .5 m^2. Values are means $\pm$ 1 s. e..

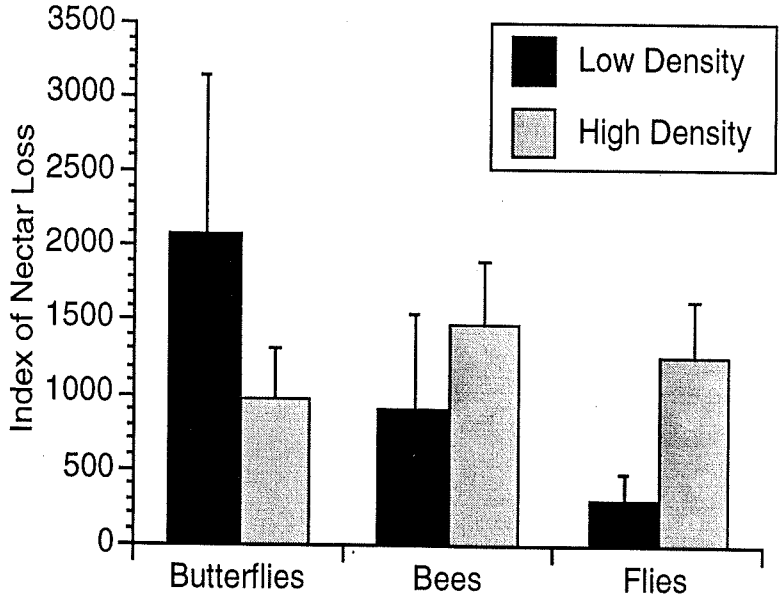

Fig. 3. Nectar loss index for *Veronia sp*. bushes at Palo Verde Nat. Park, Costa Rica. Values are mean numbers of pollinators visting patches multiplied by the mean time that each spent in a patch, n=4 patches at low density and 4 at high density.