EFFECT OF POLLINATOR TYPE ON PLANT DENSITY AND MORPHOLOGY

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Abstract: Animal pollinated plants face challenges that include attracting pollinators as well as maximizing the probability of genetic outcrossing. Plant density can affect the reproductive success of insect pollinated plants differently from that of hummingbird pollinated plants. We hypothesized that there would be a difference in the number of flowers per plant because hummingbird pollinated plants must attract pollinators from a distance, while insect pollinated plants must maximize cross-pollination. We also predicted differential success in seed set would influence the size of conspecific patches of plants. However, pollinator type was unrelated to flowers per plant or plants per patch. Instead there were strong differences among plant species within pollinator guilds.

Key words: flowers, hummingbirds, insects, pollination, pollinator guilds

INTRODUCTION

The agents of plant pollination are primarily wind or animals. Plants that exploit animal pollinators must both attract pollinators and maximize the probability of genetic outcrossing via that pollinator. These challenges have led to a variety of strategies, especially involving flower morphology and nectar reward systems. Some plants are generalists, trading off wasted nectar and pollen to take advantage of many visitors; many others have specialized on a particular pollinator species to increase cross-pollination events, although they then become dependent on the existence of that pollinator (Begon et al. 1990).

In the tropics, where a majority of flowering plants use animal pollinators, two particularly important subsets of pollinators are hummingbirds and insects. Bird and Canny (1996) showed that insect-pollinated plants in patches have a higher reproductive success than solitary individuals, but that solitary hummingbird-pollinated plants have a reproductive success that is equal to or higher than individuals in patches. They suggested that this was because an insect expends proportionally more energy to travel the same distance as a larger hummingbird. Thus, insects tend to pollinate plants that are close together, so small isolated patches of insect pollinated plants should grow smaller while high density patches grow larger (assuming that seeds frequently fall close to the parent). On the other hand, plant species that are pollinated by hummingbirds, which can easily travel longer distances, may have a higher reproductive success in isolation where their chances of self-pollination are decreased. Plants that are aggregated in a way that matches pollinator behavior might leave relatively more offspring than plants that are not.

Plant morphology also contributes to the success of a plant. Flower density on an individual plant may influence how effectively pollinators of various types are attracted. More flowers may attract visitors from a greater distance, but decrease the chance of exchanging pollen with a conspecific. The optimal number of flowers on a plant may be different for hummingbird-pollinated plants vs. insect-pollinated plants.

Because plants tend to be pollinator limited, pollination success is a strong selective pressure on flowering plants. We hypothesized that plant densities would reflect the influence that pollination success has on flowering plant distributions, predicting that insect pollinated plants would be found in greater densities than hummingbird pollinated plants. We also hypothesized that the type of pollinator would be

related to plant flower density, predicting that insect-pollinated species would have fewer flowers per individual than hummingbird-pollinated species.

METHODS

We sampled six flowering plant species (three presumed to be hummingbird pollinated and three presumed to be insect pollinated) in a 2 ha field north of the biological station in Cerro de la Cuerici on 29 - 30 January 2004. For each species, we sampled all flowering and non-flowering conspecifics within at least five patches. Patches (defined by the presence of at least one flowering individual) were haphazardly selected within the field. Patches were defined by a boundary rule; to be scored as within the patch, a plant had to be within 1 m or 5 m (insect-pollinated vs. hummingbird-pollinated) of another conspecific plant already within the patch. We then estimated the size of each patch (by measuring the area defined by the boundary), and the density within the patch of plants of that species (with "plant" defined based on the presence or absence of above-ground connections).

We determined plant density by dividing the number of plants by the patch area. We standardized for plant size differences by dividing the number of flowers per plant by plant height. We summed these flower values for all plants with at least one flower within each patch to calculate flower density. Both flower density and plant density data were log transformed to correct for non-normality. We tested for patterns in plant density with an ANOVA model that included pollinator guild and species nested within pollinator guild. We tested for patterns in flower density with an ANOVA model that included pollinator guild, species nested in this guild, and patch nested within species (with patch as a random effect); this analysis excluded plants without flowers.

RESULTS

Plant species within guilds varied strongly in plant densities ($F_{5,145} = 25.63$, $P < 0.0001$) and flower densities ($F_{5,142} = 29.31$, $P < 0.0001$; Table 1). Plant density was not related to pollinator guild ($F_{1,98} = 0.08$, $P = 0.94$), but varied among species ($F_{4,98} = 6.25$, $P = 0.0002$). Similarly, flowers per plant was not related to pollinator guild ($F_{1,117} = 1.54$, $P = 0.28$), but varied among species ($F_{4,117} = 7.27$, $P = 0.0002$). Flowers per plant did not vary among patches ($F_{25,117} = 1.15$, $P = 0.09$).

Table 1. Mean (± SE) plant density and flowers per plant for six species, studied at Cerro de la Muerte, Costa Rica.

Plant name	Pollinator guild	Plants per m^2	Mean flowers per plant
Bomeria spp.(Alstroemeriaceae)	hummingbird	23.6 ±19.3	18.2 ±5.8
Uncaria torrentosa? (Rubiaceae)*	hummingbird	0.4 ±0.2	105.2 ±36.8
Centropogon talamancensis (Lobeliaceae)	hummingbird	61.1 ±23.7	36.9 ±13.5
Monnim xalapensis (Polygalaceae)	insect	14.2 ±3.9	40.4 ±1.9
Monochaetum spp.(Melastomataceae)	insect	4.9 ±2.8	20.5 ±5.1
Dahlia spp.(Asteraceae)	insect	3.3 ±1.7	5.1 ±1.5

*known by locals as Uña de gato, but this may be incorrect identification

Discussion

Our results strongly refuted both hypotheses. Plant species, not pollinator guild, was the main determinant of plant density per patch and flowers per plant. Patches within species did not differ, reinforcing the conclusion that species identity explains most of the variation seen in local plant density and flowers per plant. Apparently factors other than pollinator type are important in determining plant density and flowers per plant.

One interpretation is that selection acts at a finer scale than the broad guilds we defined. Each species may have a different subset of insects or hummingbirds with different idiosyncratic preferences for floral patches of different sizes. Future studies could evaluate whether differences in flower morphology relate to pollinator subsets that are more specific than those recognized in this study.

Pollinators, by affecting plant reproductive success, may influence plant density by affecting how many seeds are available for dispersal in different patches. Other factors, such as interspecific competition, microhabitat quality, and dispersal limitation, may however have more influence on plant density than pollinator selection pressure. Future studies could explore the interaction of other factors that may determine flowering plant densities at a larger scale than within individual patches. The relative importance of these mechanisms could be tested by mapping flowering plant distributions and measuring distances between conspecific patches as well as soil quality and light availability for each patch. Despite the selection pressure of pollinators on pollinator-limited plants, other factors are influential and cause species specific variation in plant and flower density. Varying the scale of the study and increasing the number of species tested could help to determine which factors are most influential on these plant characteristics.

Literature Cited

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