FLOURISHING FLOWERS AND PICKY POLLINATORS IN THE GAPS OF A CLOUD FOREST AT MONTEVERDE, COSTA RICA

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Abstract: Resources for plant reproduction may be severely limiting in the forest understory. We hypothesized that there would be more flowers in gaps than under the canopy. We counted the number of flowers in paired gap and non-gap areas and divided morphospecies into 3 morphological syndromes (cupped, spike, and tubular). We found more flowers in gaps than in non-gaps, possibly due to increased light and nutrient availability in gaps. Cupped flowers had greater, and tubular flowers lower, relative abundance in gaps compared to non-gaps.

Keywords: forest gap, morphological syndrome, flower abundance, pollinator, Monteverde

INTRODUCTION

Limited resource availability in the understory may restrict forest plants' capacity to reproduce. Large tree falls create gaps, increasing temperature, light and possibly nutrient availability at the forest floor. Unlike canopy species, understory plants generally do not need to reach the canopy to mature, so they can use the energy and nutrient resources available in gaps to reproduce.

We compared flower counts in gap and non-gap areas, to assess the importance of gaps for reproduction in non-canopy woody species. We hypothesized that there would be more flowers in gaps than in nearby non-gap areas.

Morphology of flowers can often be used to predict pollinator type (Nadkarni and Wheelwright 2000). Tubular flowers are usually pollinated by hummingbirds, which can trapline for long distances through the understory, and thus provide effective pollen dispersal even when flowers are sparse. Cupped flowers and spike inflorescences are usually pollinated by insects, which typically do not travel large distances. Therefore, it may be advantageous for plants with cupped flowers and spike inflorescences to forgo reproduction when resource availability is low, and wait to flower until a gap opens. Thus, we hypothesized that the relative abundance of cupped flowers and spike inflorescences would be greater in gaps, while that of tubular flowers would be greater in non-gaps.

METHODS

On 24 and 25 Jan 2008, we sampled 7 paired gap and non-gap areas in the high elevation cloud forest at Monteverde, Costa Rica. We found gaps of similar ages (old enough to have enhanced understory growth and young enough to still be open) along the established trails, Sendero Principal and Sendero Mirador. We ran 2 m-wide belt transects through the longest axes of the gaps. Transects ranged from 10 to 20 m in length. For each gap transect, we ran a paired transect of the same length in closed-canopy forest ("non-gap") ca. 10m away. We paired the transects to reduce the effects of potentially confounding variables, such as slope, aspect, local site characteristics, and elevation.

In each belt, we counted flowering plants, the number of flowers on each plant, and the number of flowers in each morphological syndrome: cupped, tubular, and spikes. Spike inflorescences were counted as single flowers, and we did not count flower buds or fruits.

We square-root transformed the flower counts to meet the normal distribution assumption of paired-t tests. We excluded data from one high-elevation pair because reduced forest stature at high elevation strongly affected canopy cover, which increased similarity between the gap and non-gap areas.

RESULTS

Flowers were significantly more numerous in gaps than in non-gaps (paired-t = -3.28, df = 5, P = 0.022). Relative abundance of morphological syndromes differed between gaps and non-gaps: while spike inflorescences dominated both habitats, proportionally more cupped than tubular flowers were in gaps, and proportionally more tubular flowers were in non-gaps (Figure 1. Pearson $\chi^2 = 52.31$, df = 2, P < 0.001).

Flower assemblages differed between gaps and non-gaps. Within each morphological syndrome, there was minimal overlap between the morphospecies flowering in the two habitats (Figure 2).

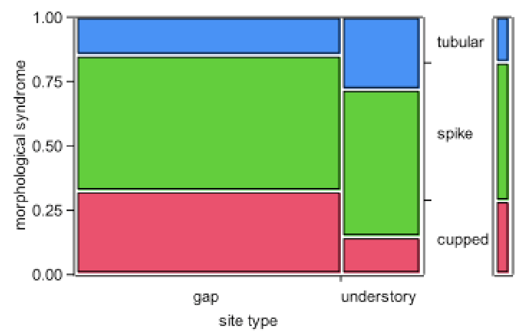

FIGURE 1. Relative abundances of morphological syndromes in gap and non-gap areas in a montane cloud forest at Monteverde, Costa Rica. Pearson $\chi^2 = 52.31$, df = 2, P < 0.001.

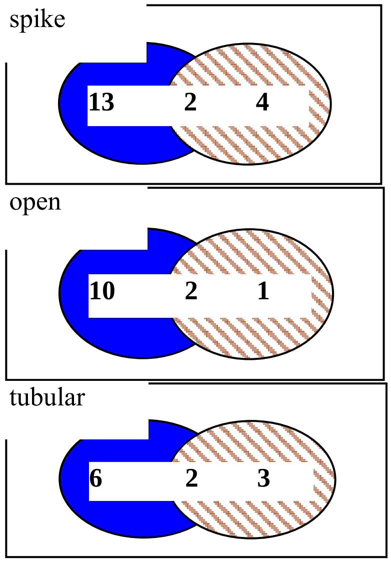

FIGURE 2. Number of flower species in gaps (solid) and non-gaps (striped), showing overlap of morphotypes between site types for open, spike and tubular syndromes.

DISCUSSION

The greater abundance of flowers in gaps supported our hypothesis that resource availability in gaps aids understory plant reproduction.

The limited overlap of morphotypes between gaps and non-gaps (Figure 2) suggests that the greater abundance of flowers in gaps is not simply due to plants' opportunistic utilization of resources. Rather, species may be specialized for the two different habitat types. If so, certain understory species might require gap conditions to flower, while others can reproduce in shade.

Increased abundance of cupped flowers in gaps would probably attract more insect pollinators. Higher temperatures in gaps also increase insect activity levels, which may translate into more flower visits per insect. In addition, there were more white and yellow flowers in gaps than in non-gaps (personal observation). These flowers should support more insects in gaps.

Hummingbirds are also likely to be attracted to gaps, where tubular flowers are more numerous than in non-gaps. However, we predict that more birds than insects would forage in non-gaps, given the higher ratio of tubular to open flowers in non-gaps.

Gaps benefit more than just canopy species, which invest available resources in growth toward the canopy. Gap conditions may also be essential for the flowering of many species that can persist, but not flower, in the shade. Thus, gaps also affect assemblages of pollinators that thrive on the resources offered by flowering plants.

LITERATURE CITED

Nadkarni, N.M. and N.T. Wheelwright. Monteverde: Ecology and Conservation of a Tropical Cloud Forest. Oxford University Press, Oxford, UK, 2000.