THE DIVERSITY AND DENSITY OF FLOWERING PLANTS IN DIFFERENT SUCCESSIONAL STAGES OF FOREST GROWTH AT HIGH ELEVATIONS

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Abstract. Diversity of vegetation varies between the different successional stages of tropical forests following clearing. We examined diversity of flowering plants at a high-elevation site in Costa Rica where three stages of succession were evident. We found significantly more flower morphotypes/m2 and a higher number of flowering individuals/m2 in the early-successional fields than in the primary and secondary forests. We also found a trend toward a greater proportion of hummingbird pollinated flowers and a greater number of flower morphologies in the early successional forest, fewer in the secondary forest, and least in the primary forest. Hummingbird pollinated flowering plants may require more light, or perhaps these light requiring plants optimize reproduction by attracting hummingbirds to pollinate their flowers.

Key words: early successional forest, hummingbird pollinated flowers. pollination biology, primary forest, secondary forest.

INTRODUCTION

High-elevation oak forests in Costa Rica have been heavily cleared for timber and charcoal production (Janzen 1983). This is evidenced in many areas by three different successional stages of vegetation: early, mid, and late. Late successional (primary) forests are known to be high in diversity and contain large gaps after tree falls or other disturbances. Large gaps have a high community diversity as a result of the strong light intensity and the larger seed input from both outlying established species and from pioneer species (Begon et al. 1990). If cleared land acts similarly to large gaps, early successional stages would also be expected to have high diversity. Mid successional (secondary) forests, with trees not yet old enough to fall and create large gaps might be the least diverse among the different successional forest stages. We also predicted that the abundance of flowering plant and flower morphology would follow the same pattern.

We therefore hypothesized that there would be a higher density of flowering plants and a higher abundance of morphotypes in the early successional forest, the lowest numbers in the secondary forest, and an intermediate level in the primary forest. In addition, differences in forest habitat and available resources may determine the type of pollinators, which in turn might affect the reproductive success of the flowering plants in that area (Perlroth et al. 1995). Our second hypothesis was that the mean percentage of hummingbird-pollinated flowering plants and flower morphotypes would be more abundant in the early successional growth due to the easy accessibility of these flowers to the hummingbirds, which would result in higher pollination rates and consequently more flowering plants in these areas.

METHODS

On 27 January 1997, at the Cuerici Biological Station near Cerro de la Muerte, Costa Rica, we sampled three sites: one in primary forest, one in secondary forest, and one in an early successional open area for flowering plants. The early successional stage was characterized by small shrubs (<3 m) and no canopy cover. The secondary forest site was characterized by an overstory of alder trees (*Alnus sp.*) and relatively open understory. The primary forest site was in a large oak forest with a dense understory. Flowering plants were identified as shrubs, trees, vines, or understory plants that were displaying any size colored flower at that time.

We randomly selected three transect belts at each site. Transect width was 2 m x 10 m at the early successional stage site, 8 m x 40 m at the secondary forest site, and 20 m x 50 m at the primary forest site. Quadrat size changed with forest site, with larger widths for more sparsely-distributed plants in order to obtain a adequate sample size for those areas. We spent approximately 30 min counting each transect and this time limit determined the length of the transect.

Within each transect, we recorded the number of flowering plants and we counted each flower morphotype as an estimate of the number of species present.

We used one-way ANOVAs to compare the number of morphotypes per m2 and the number of individuals per m2 among the three sites, and to test for differences in the mean percentage of hummingbird-pollinated flower numbers and morphotypes/m2 among the three successional stages.

RESULTS

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DISCUSSION

We found that there were more flowering individuals and more species per unit area in the cleared forests, as we predicted. This is possibly because high light in the more open areas provide optimum conditions for reproducing flowering plants. Shrubs in these early successional sites are shorter lived than trees in the primary and secondary forest, and therefore may be adapted to produce and disperse many seeds to reach other sunnier early successional or disturbed environments. Also, the increased light availability in the more open areas could allow these plants to allocate more energy to flower production.

We did not find a significant difference in relative abundance and number of morphotypes/m2 across forest types, contrary to our prediction. However, we found a trend towards a greater mean percentage of hummingbird-pollinated flowers and a greater number of morphotypes in the early successional forest, fewer in the secondary forest, and the least in the primary forest. In higher elevations, hummingbirds and large bees were found to be the most frequent pollinators. Hummingbird pollinated flowering plants may require more light, or perhaps these light requiring plants optimize reproduction by attracting hummingbirds to pollinate their flowers.

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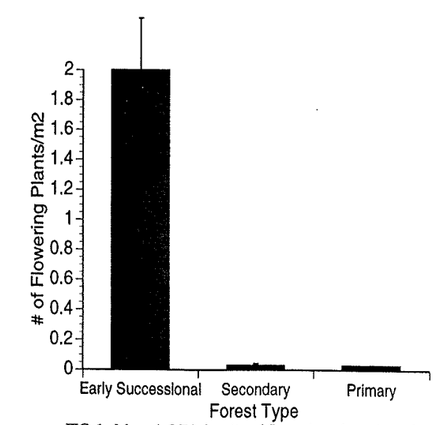

FIG. 1. Mean (±S.E.) density of flowering plants in early successional, secondary, and primary forests.

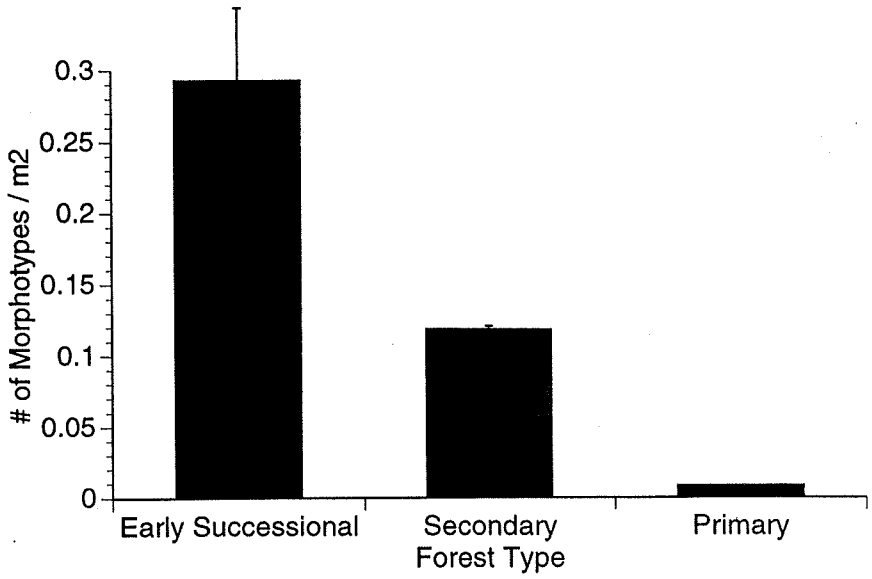

FIG. 2. Mean (±S.E.) number of flowering plant morphotypes/m^2 in early successional, secondary and primary forest types.

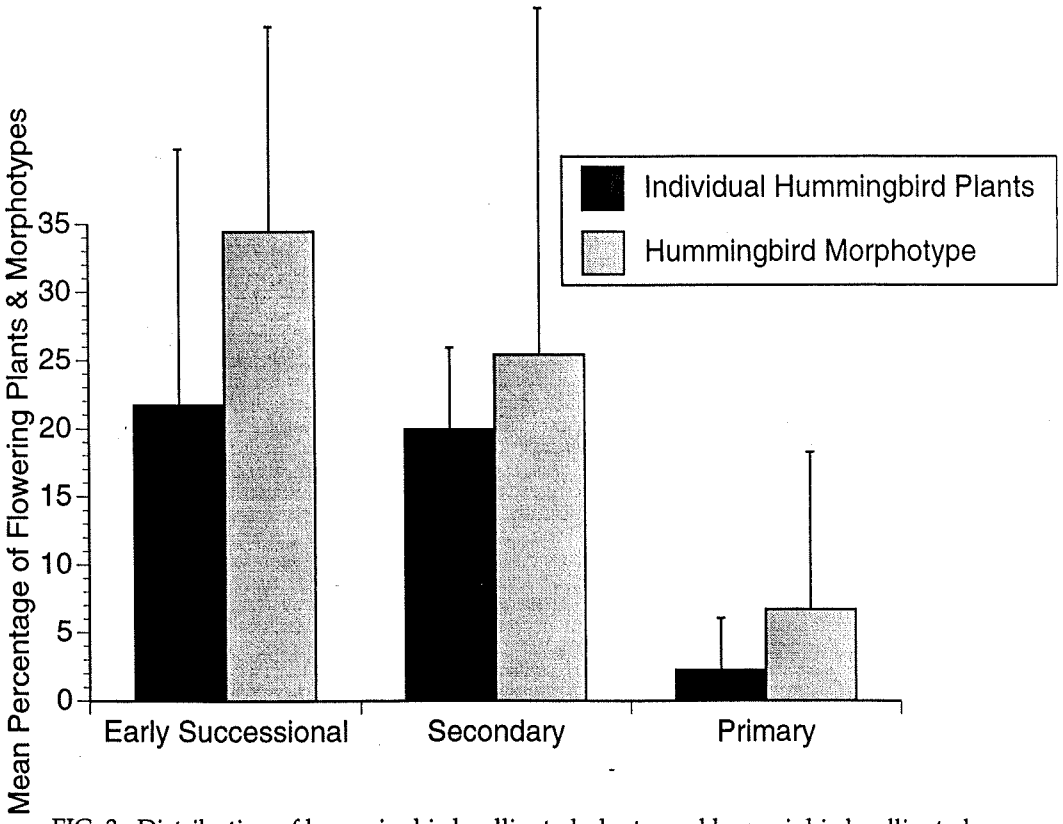

FIG. 3. Distribution of hummingbird pollinated plants and humminbird pollinated morphotypes in early successional, secondary, and primary forests. Data represent means ±S.E. percent freqency in three transects in each habitat.