Pollinator syndrome and reproductive effort in montane flowering plants

M. R. Babineau, D. R. Hogan, and A. M. Kim

Abstract. Hummingbird-pollinated and insect-pollinated plant species may allocate different proportions of their energy into reproductive structures. We predicted that hummingbird-pollinated plants (with larger, more showy flowers) would have a higher reproductive effort than insect-pollinated plants. For 12 species of flowering plants, we measured reproductive effort; both as flower biomass per leaf biomass and flower biomass per leaf surface area. We found weak evidence that hummingbird-pollinated plants may have higher reproductive effort than insect-pollinated plants. However, our results indicate that other life history characteristics, such as growth form, may better explain differences in reproductive effort.

Keywords: hummingbirds, life history strategies, pollinator attraction

Introduction

Certain plants have flower morphologies designed to attract a specific syndrome of pollinators (Bawa and Hadley 1990). Since birds rely on visual cues to find flowers, plants that use hummingbird pollinators often have flowers that are larger and showier than those pollinated by insects. Insect-pollinated plants may have less conspicuous flowers since insects are more often attracted by chemical cues. We predicted that plants pollinated by hummingbirds would invest a larger proportion of their biomass into reproductive structures than plants pollinated by insects. We tested this prediction by examining the ratio of flower biomass to both leaf biomass and leaf area in a tropical montane second-growth shrub community.

Methods

We measured the reproductive effort of 12 flowering plant species, representing eight plant families, around the Cuerici Biological Station, Costa Rica. Five species that displayed red flowers with long, tubular corollas were assumed to be hummingbird-pollinated; the other seven species seemed to have flower structures designed for insect pollinators (Table 1). We also recorded species growth form: self-supporting vs. non self-supporting. All species except two *Centropogon* spp. (which were sampled along trails in the forest understory) were sampled in a shrub community (<2 m canopy) about 400 m east of the station.

We estimated reproductive effort as the proportion of resources allocated to flower production versus leaf production, indexed as flower biomass/leaf biomass and flower biomass/leaf surface area. We counted the number of leaves and flowers on four individuals of each species. All flowers were counted; dead leaves were not. On two individuals of each species we measured the mass of freshly-picked leaves and flowers, as well as leaf surface area (maximum length x maximum width) for four representative leaves. We averaged these measurements and used them in all ratio calculations for that species. Stem biomass was excluded because of its dual role in leaf support and flower presentation. Individuals of a species were roughly the same height and appeared to be healthy. For larger plants, only "representative" branches were censused to estimate flower to leaf ratios.

Results

We found weak evidence for a higher flower biomass/leaf biomass ratio in hummingbird-pollinated plants (Fig. 1; Wilcoxon Ranked Test, X^2=2.38, df=1, P=0.12), but no suggestion of a difference in flower biomass/leaf area ratios (X^2=0.80, df=1, P=0.37). When the Asteraceae III sample (an insect-pollinated plant) was excluded from analysis, we found significantly higher reproductive effort in hummingbird-pollinated plants. (Wilcoxon Ranked Test, X^2=4.80, df=1, P<0.03).

Four of the five non self-supporting plants displayed classic hummingbird flowers. Non self-supporting plants had a higher flower biomass/leaf biomass ratio than self-supporting ones (Fig. 2; Wilcoxon Ranked Test, X^2=5.55, df=1, P<0.02). There was no significant difference between growth forms for flower biomass/leaf area (Wilcoxon Ranked Test, X^2=1.91, df=1, P=0.17).

Table 1. The families of insect and hummingbird-pollinated plants used in this study (* indicates non-self supporting growth form, i.e. vine-like).

Insect-pollinated Plants	Flower Characteristics
Melastomaceae (*Monochaetum* sp.)	pink, open corolla
Asteraceae I	small, white, composite (umbel-like)
Asteraceae II	small, white, composite (fuzzy flowers)
Asteraceae III*	yellow ray flowers, brown disk flowers
Scrophularecaceae (*Hemichaema* sp.)	yellow, bilabiate corolla
Hydrophyllaceae (*Wigandra* sp.)	blue, open corolla
Polygalaceae	blue-yellow, pea-like
Hummingbird-pollinated Plants	**Flower Characteristics**
Campanulaceae (*Centropogon valeri*)*	Orange tubular corolla
Campanulaceae (*C. talamancensis*)*	Purple tubular corolla
Amaryllidaceae (*Bomaria micropia*)*	Red tubular corolla (short)
Amaryllidaceae (*Bomaria acutifolia*)*	Red tubular corolla (long)
Acanthaceae (ID?)	Red tubular corolla

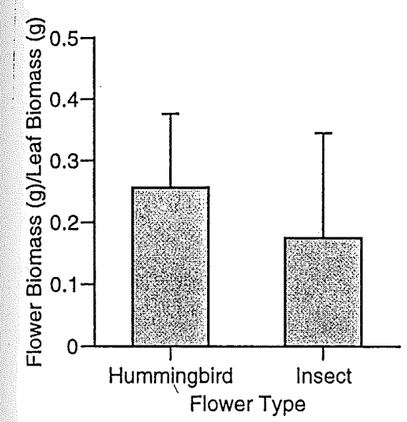

Fig. 1. Reproductive effort (mean ± 1 SE) for plant species displaying classical hummingbird vs. insect pollinated flowers at Cuerici Biological Station, Costa Rica.

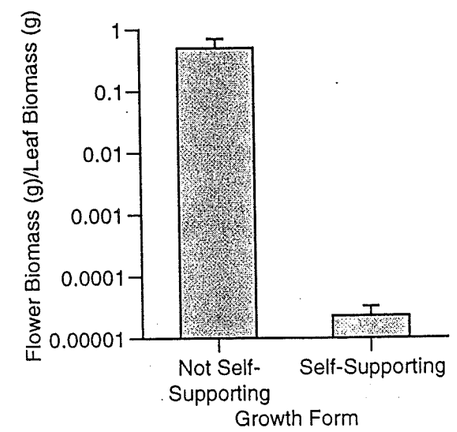

Fig. 2. Reproductive effort (log mean ± 1 SE) for plant species of two growth forms at Cuerici Biological Station, Costa Rica.

Discussion

Our data suggest that reproductive effort (measured as flower biomass to leaf biomass) may be greater for plants pollinated by hummingbirds than for those visited primarily by insects. This index of reproductive effort was probably more robust than one based on leaf surface area since light intensity in high altitude fields is strong enough to penetrate through leaves. Thus, plants there may maximize their photosynthetic potential by increasing leaf thickness rather than increasing surface area (D. R. Peart, *pers. comm.*). Future studies should also assess nectar production, since flowers pollinated by hummingbirds may expend more energy in the production and maintenance of larger nectar pools than insect-pollinated flowers.

Our results also suggest that other life history characteristics, such as mode of growth, should be considered in explaining reproductive effort. Among the species studied, we found that plants lacking woody structural support had a higher flower biomass/leaf biomass ratio than self-supporting ones and that four of the

five hummingbird-pollinated plants were non self-supporting. Although we did not address this question explicitly in our experimental design, our data suggests that selection may favor non self-supporting growth for plants with hummingbird-pollinated flowers, allowing for more energy allocation to flowers. This requires further study in a wider variety of communities.

LITERATURE CITED

Bawa, K. S. and Hadley, M., eds. 1990. Reproductive ecology of tropical forest plants. The Parthenon Publishing Group: New Jersey.