VARIABLE SEX RATIOS IN THE MONOECIOUS PERENNIAL *BEGONIA INVOLUCRATA*

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Abstract: The sex ratio of flowers in monoecious plants can influence individual reproductive success. We tested how flower sex ratios in individual *Begonia involuncrata*, a monoecious, deceit-pollinated perennial, were related to begonia size. We expected and found a male-biased sex ratio for the species, which may help maintain pollinator visits by maintaining high levels of honest rewards (male flower pollen). However, larger begonias had a higher proportion of female flowers, perhaps because they have more resources and can therefore afford to produce more costly female flowers. Conversely, increased maleness in smaller begonias may reflect the constraints of resource limitation and/or represent optimal reproductive strategies given resource limitations. Interestingly, the different sex ratios of different sized begonias, which represent individual solutions to reproductive success, may help to maintain the male-biased sex ratio within the population, which is theoretically required to maintain the deceit-pollination system.

Key Words: Begonia involucrata, *sex ratio, deceit pollination, reproductive investment*

INTRODUCTION

Plant fitness depends on maximizing reproductive success, but lack of mobility and access to resources limit plant reproductive strategies. For monoecious plants with imperfect flowers, the ratio of female to male flowers is a variable attribute that can influence reproductive success.

We studied *Begonia involuncrata*, a monoecious, perennial plant that employs deceit pollination. In the deceit pollination system, female flowers mimic male flowers, yet do not offer nectar or pollen rewards. However, maintenance of reliable visitation rates from pollinators requires that there be sufficient rewards (honest signals) to pollinators through a male-biased sex ratio. Campbell et al. (2001) estimated that there may be an evolutionarily stable equilibrium with a sex ratio of 1:3 for females:males. For begonias, producing female flowers is more costly than male flowers because female fruits require more energy and nutrients than male pollen. Thus, the effect of sex ratio on fitness in begonias could be influenced by (1) maintenance of the deceit pollination system and (2) relative costs of male and female flowers.

We tested two competing hypotheses: (1) Begonias have a genetically fixed female:male sex ratio that is just adequate to maintain deceit pollination (possibly 1:3 female:male), or (2) begonias have plasticity in their sex ratio. Under hypothesis 2, larger begonias might produce relatively more female flowers because they have more resources to invest in reproduction.

METHODS

We conducted our study on 21 January 2006 in the Monteverde Biological Station in Costa Rica. We haphazardly sampled 26 begonias along Sendero Principal: 1 to 15 individuals from each of

12 patches (with patches defined as one or more flowering ramets within a radius of 2 m). Patches were separated from the nearest other patch by 5 - 20 m. We restricted our sample to begonias in the early stage of flower development, with female buds and male buds or open flowers containing pollen, to avoid underestimating male flower abundance due to their abscission after pollen distribution.

For each begonia, we counted the number of mature green leaves, female flowers and male flowers. We measured plant height, largest width between two consecutive leaves, and width perpendicular to the first width. We estimated competition due to crowding with an ordinal score of 1-3 for each plant (1 meaning no plants within 0.5 m and 3 meaning 4 plants within 0.5 m). We estimated canopy cover with a spherical densiometer.

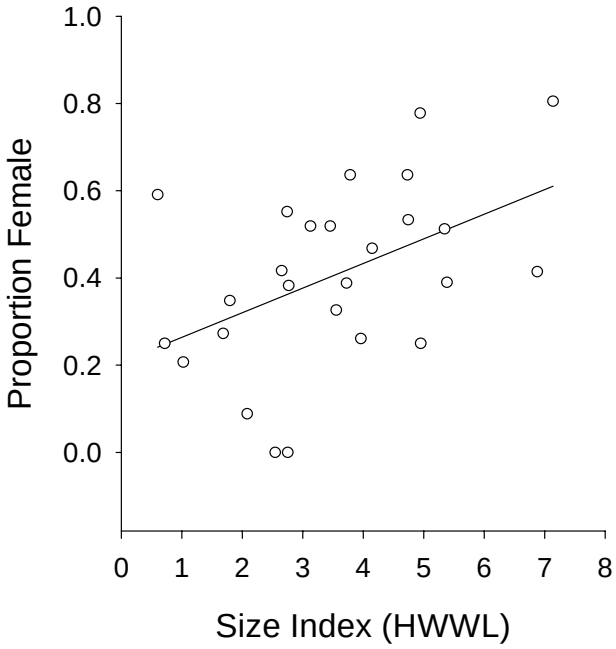

Figure 1. The proportion of female flowers in individuals of the monoecious, perennial *Begonia involucrata* increased with plant size.

We created a size index by multiplying height, both widths, and the number of leaves (HWWL index). We used linear regression to evaluate the relation between the proportion of female flowers and HWWL index, canopy cover, total number of flowers, and level of crowding (JMP v.5. 0.1).

RESULTS

The number of flowers per begonia ranged from 14 to 70 (mean ± SE = 38.3 ± 3.4). The proportion of female flowers ranged from 0 to 0.80 (mean ± SE = 0.41 ± 0.04; female:male =1:1.40). The proportion of female flowers increased significantly with begonia size (r^2=0.22, P=0.02, df=24; Fig. 1). However, proportion of female flowers was unrelated to canopy cover, total number of flowers or crowding by other plants (Fig. 2).

DISCUSSION

The ratio of female to male flowers in begonias is presumably a result of selection to maximize individual fitness but it may also have consequences for the efficacy of the deceit pollination system, which influences reproductive success of the population. For an individual, reproductive success is achieved by producing more flowers of the under-represented sex, given available resources. For the species, reproductive success requires a male-biased sex ratio that presents an honest signal to attract pollinators, but natural selection does not shape populations directly.

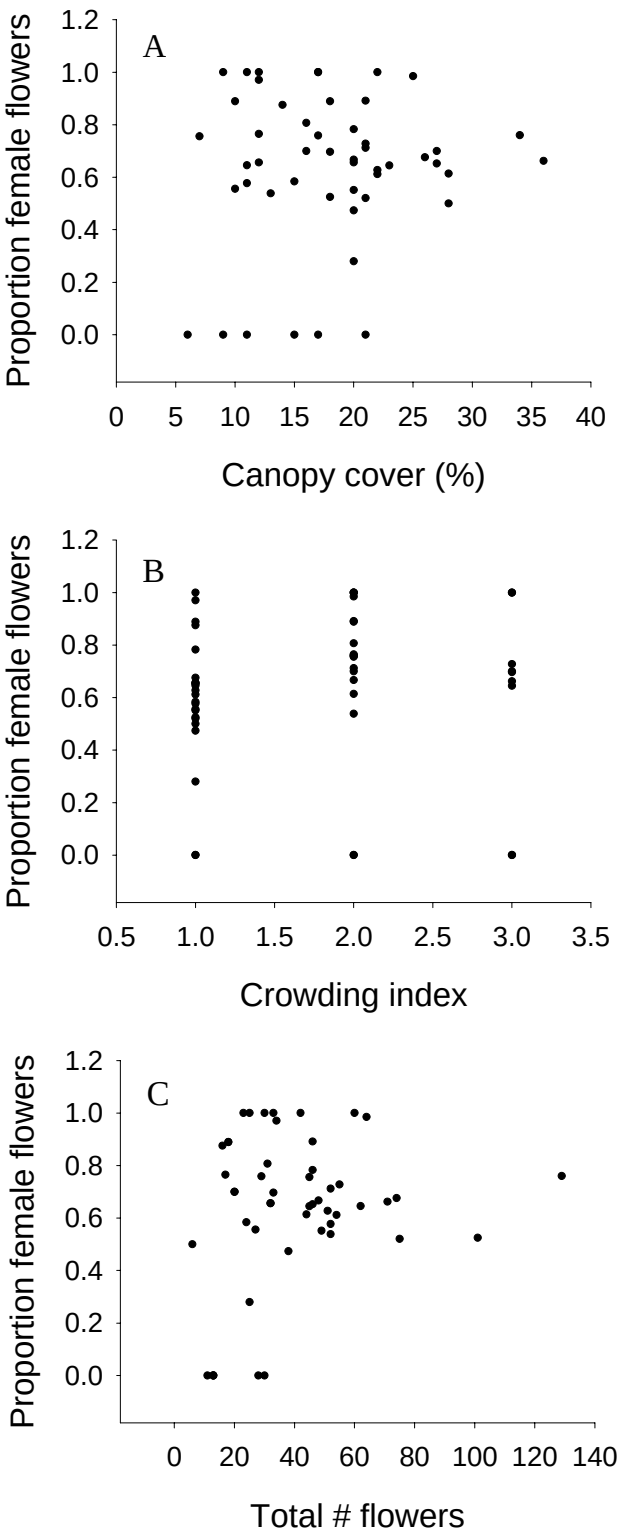

Figure 2. There was no relationship between the proportion of female flowers in begonia individuals and (a) canopy cover over the begonia ($p = 0.26$), (b) total number of flowers ($p = 0.57$), or (c) crowding by other plants ($p = 0.89$).

Bigger begonias tended to produce more female flowers, which supported the hypotheses that (1) the sex ratio of *B. involucrata* is plastic and (2) larger begonias tend to produce a larger proportion of more expensive female flowers, perhaps due to greater plant resources. We suggest that femaleness contributes more to individual fitness because having more in a male-biased system ensures that the probability of female fertilization is high. The increased maleness of smaller begonias may reflect the constraints of resource limitations and/or represent an optimal solution in the face of resource limitations. This finding raises the possibility that size constraints on sex ratios have the incidental effect of creating a male-biased sex ratio for the population as a whole, which is theoretically necessary to maintain pollinator visitation in this deceit-pollinated system.

LITERATURE CITED

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