LITERATURE CITED

Clark, K. L., R. O. Lawton, and P. R. Butler. 2000. The physical environment in Monteverde: Ecology and conservation of a tropical cloud forest. Eds. N. M. Nadkarni and N. T. Wheelwright. Oxford University Press: New York. p. 15–34.

Gradstein, S. R. 2000. Bryophytes in Monteverde: Ecology and conservation of a tropical cloud forest. Eds. N. M. Nadkarni and N. T. Wheelwright. Oxford University Press: New York. p. 78-79.

Hansel, C., J. Z. Ruben and P. P. C. Shelby. 1996. Influence of abiotic factors on lichen and moss community structure in a high elevation tropical habitat. Dartmouth Studies in Tropical Ecology, p. 57-61.

Kricher, J. 1997. A Neotropical companion: An introduction to the animals, plants and ecosystems of the New World tropics. Princeton University Press: Princeton, New Jersey.

Proctor, M. C. F. 2000. Physiological Ecology. in Bryophyte Biology. Eds. A. J. Shaw and B. Goffinet. Cambridge University Press.

DECEITFUL POLLINATION IN *BEGONIA ESTRELENSIS*

ELVINA C. CHOW, EMILY L. SHARP AND MELISSA A. BARGER

Abstract: Begonia estrelensis is a monoecious plant that uses a deceitful pollination mechanism, in which female flowers produce no nectar or pollen reward but imitate the pollen-producing male flowers with stigmas that look and smell like anthers. There are two traits that are indicative of deceitful pollination, the ratio of male and female flowers and the difference in petal width between the sexes. Assuming that patches with more flowers have more potential pollinators, we hypothesized that number of flowers in a patch would affect sex ratio and flower petal width. We found, as predicted, a negative relationship between number of flowers and percent males, an indicator of sex ratio. However, contrary to our expectations, we found a positive relationship between number of flowers and the difference between petal widths. These relationships suggest the importance of balancing male and female fitness in order to maximize overall fitness.

Key Words: monoecious plants, sex ratio, tropical cloud forest

INTRODUCTION

The Begoniaceae family is monoecious, with male and female flowers occurring on the same plant. The female flowers produce no nectar and have no pollen reward, yet they imitate the pollen-producing male flowers with stigmas that look and smell like anthers. Thus, female flowers are deceitfully pollinated, because the pollinators are fooled into visiting both sexes (Campbell et al. 2001). This mechanism introduces a tradeoff for the overall fitness of an individual, between attracting pollinators with male flowers and successfully pollinating female flowers and producing seeds. This tradeoff is indicated by the male to female sex ratio. Another trait of deceitful pollination is petal width. Flowers with larger petals are more attrac-

tive to pollinators (Campbell et al. 2001). Because male and female flowers usually differ in size, petal width may be an important factor in deceiving pollinators.

There are two commonly occurring *Begonia* species along trails in the cloud forest at Monteverde, Costa Rica. *B. involucrata* has been extensively studied and has been shown to have a 3:1 male to female flower ratio, and a difference in petal width between the sexes, with males being larger than females (Campbell et al. 2001). These characteristics appear to maximize the deceitful pollination mechanism in this species. Little is known, however, about the other species, *B. estrelensis.* Because this species occurs in patches with more flowers than *B. involucrata*, and because large flower displays may attract more pollinators (Calvi 2005), it seemed that the deceitful pollination traits of *B. estrelensis* might differ from those of other *Begonia* species.

We proposed that *B. estrelensis* in patches with more flowers would be less likely to have a large number of male flowers to attract pollinators. Therefore, the sex ratio of flowers in large patches would be less male-biased. Similarly, female flowers in patches with more flowers would invest less in attracting pollinators, and, therefore, there would be little or no sexual dimorphism in flower size. Specifically, we predicted that patches of *B. estrelensis* with more flowers would have decreased male to female ratio and decreased difference in male and female petal widths, compared to patches with fewer flowers.

METHODS

We sampled 12 *B. estrelensis* patches at similar elevations along the Sendero Principal at the Estacion Biologia Monteverde on 21-22 January 2005. At each patch, we measured number of inflorescences, number of open male flowers, number of open female flowers, petal width for five randomly selected male flowers, and petal width for five randomly selected female flowers.

We calculated the average difference in petal width between male and female flowers by subtracting average male petal width from average female petal width for each patch. Data were analyzed with linear regressions using JMP 5.0.1.

RESULTS

Patch size ranged from 5 and 149 inflorescences, containing 20 and 715 flowers. Male flowers ranged from 13 to 100% of flowers in inflorescences. As number of *B. estrelensis* flowers increased in a patch, the male to female sex ratio, as measured by the percentage of male flowers, decreased ($r^2 = 0.26$, df = 1, 79, $P < 0.0001$, Fig. 1). Usually female flowers were larger than male flowers, with female - male difference ranging from -2.3 mm to 5.2 mm. In patches with more flowers, the difference between female and male flowers was greater ($r^2 = 0.27$, df = 1, 54, $P < 0.0001$, Fig. 2).

DISCUSSION

As we predicted, the male to female flower ratio decreased with an increased number of flowers within a patch (Fig. 1). Assuming that the number of pollinators increases with number of flowers, found for another system by Calvi (2005), a patch can attract pollinators based on number of flowers and not on male pollen rewards, without decreasing male fitness. For this Begonia species, this results in a greater percentage of female flowers in the patch and increased female fitness.

The prediction that average difference in petal width between female and male flowers would decrease with patch size was refuted. Instead, we found that female flowers were larger than male flowers in larger plots. Thus, it is not clear what selective forces influence petal width in this *Begonia* species, and future research will be needed to clarify the relationships between these factors, male and female fitness, and their contributions to overall fitness.

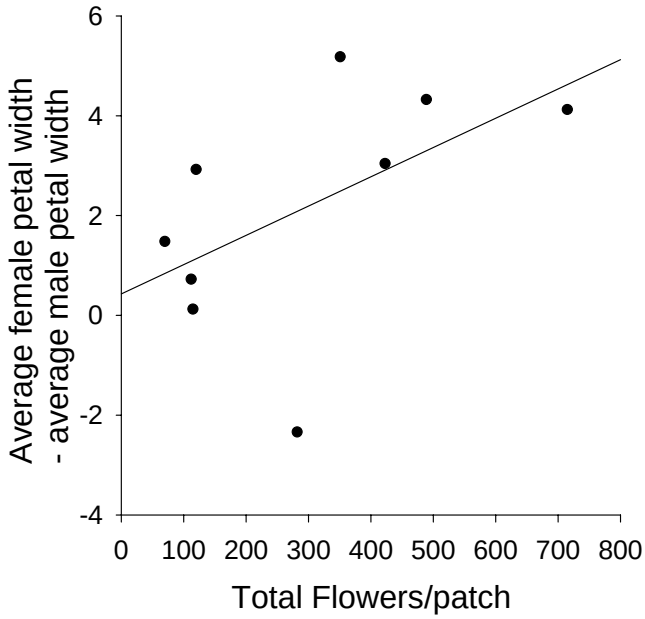

Figure 2. Effect of patch size of *B. estrelensis* on differences in petal width between female and male flowers. As patch size increased, female flowers became larger compared to male flowers.

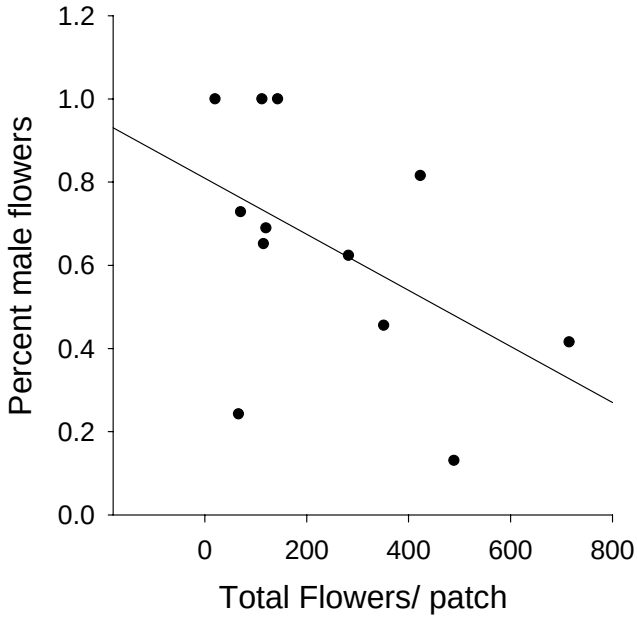

Figure 1. Effect of patch size on sex ratio of *B. estrelensis*. As number of flowers in a patch increased, the percentage of male flowers decreased.

LITERATURE CITED

Calvi, Gabriel. 2005. Does a rare species of flower receive more pollinator visits in the presence of a common flower species? Dartmouth Studies in Tropical Ecology.

Campbell, J. E., R. D. Rosengarten, and D. J. Sugar. 2001. Maintenance of a deceitful reproductive strategy in *Begonia involucrata* by a male-biased sex ratio. Dartmouth Studies in Tropical Ecology, p. 40-41.