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THE IMPORTANCE OF FLORAL DAMAGE FOR POLLINATOR VISITATION IN *ALSTROEMERIA LIGTU* L.[1]

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ABSTRACT

The effect of artificial damage on flowers of *Alstroemeria ligtu* L. on the rate of visitation by pollinators was studied. Floral damage (10 and 20% of red petals removed, leaving a symmetrical or asymmetrical flower) had no significant effect on pollinator visits. Removal of yellow petals with putative nectar-guides had an important impact on pollinator service: no pollinators were observed to visit these damaged flowers.
Key words: floral damage, floral symmetry, nectar guides, *Alstroemeria ligtu*, plant-insect interactions, pollinator visitation rates.

RESUMEN

Se estudió el efecto del daño floral en *Alstroemeria ligtu* L. sobre la tasa de visita de polinizadores. El daño floral (10 y 20% de los pétalos rojos removidos, dejando la flor simétrica o asimétrica) no afectó la tasa de visita de polinizadores. La remoción de los pétalos amarillos, que contienen guías de néctar putativas, tuvo un efecto importante sobre los polinizadores: las flores dañadas no fueron visitadas en absoluto.
Palabras claves: daño floral, simetría floral, guías de néctar, *Alstroemeria ligtu*, interacciones insecto-planta, tasa de visita de polinizadores.

INTRODUCTION

Flower-eating insects may reduce the reproductive success of plant species (Krupnick *et al.*, 1999). This reduction in plant fitness may be due to direct loss of reproductive structures (Krupnick & Weis, 1999), and/or to indirect effect by reducing the rate of visits by pollinators (Krupnick *et al.*, 1999). A reduction in pollinator service after flowers have been damaged may be due to a degraded floral appearance, loss of symmetry, reduced quantity and/or quality of nectar (Aizen & Raffaele, 1996; Krupnick *et al.*, 1999), or decrease in size of the floral display (Krupnick & Weis, 1999). Several studies have shown that pollinators respond to variation in flower attributes, such as flower size, color (Waser & Price, 1981), scent (Galen, 1985), as well as nectar and pollen rewards (Krupnick *et al.*, 1999).

In this study, floral damaging experiments were conducted to examine the effects of different levels of floral loss, floral asymmetry, and removal of petals with putative nectar-guides, on the rate of pollinator visitations in *Alstroemeria ligtu* L. (Alstroemeriaceae). The following hypotheses were tested: (i) floral damage decreases the visitation rate by pollinators, (ii) visitation rate decreases with increasing levels of floral damage, (iii) floral asymmetry produced by partial or total petal removal has a negative impact on pollinator visits, and (iv) floral damage on petals with putative nectar-

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guides has a larger impact on pollinator service than the same type of damage on other petals.

MATERIALS AND METHODS

Alstroemeria ligtu is a perennial herb native to Chile. In the Río Clarillo National Reserve (33° 51´S, 70° 29´W, 45 km southeast of Santiago, Chile), this herb grows mainly associated to road sides or underneath sclerophyllous vegetation. Flowering shoots are 25-60 cm height, and flowers are zygomorphic and arranged in umbels of 3 to 15 raddii with 1 to 4 flowers each. Flowers of this species present four red petals (two lateral, one top, one bottom; Figure 1) and two distinctive yellow petals streaked with brownish lines, probably nectar guides. The area of each of the four red petals correspond to roughly 20% of the total floral area. The remaining 20% is shared between the two yellowish petals.

Eight study sites with large patches of *A. ligtu* flowers with similar biotic and abiotic characteristics were choosen. All flowers in the inflorescences studied were at the same reproductive stage. In addition to the focal flower (treated or control), a total of four neighboring flowers were kept in each inflorescence.

One-hundred-and-eighty focal flowers were randomly marked and observed. They randomly received one out of six treatments, each one with 30 replicates. Treatment 1 (T1) and treatment 2 (T2) were included to assess the importance of floral asymmetry (T1 had asymmetrical damage, and T2 symmetrical damage), both treatments presenting 10% of total floral damage in the lateral petals. Treatment 3 (T3) and treatment 4 (T4) were designed to assess the effect of floral asymmetry (T3 had symmetrical damage, and T4 asymmetrical damage), and to evaluate the importance of different levels of damage in the lateral petals when comparing them with T2 and T1, respectively (T3 and T4 had 20% total floral damage). Damage to flowers in treatments T1 to T4 involved the red lateral petals. Treatment 5 (T5) involved the complete removal of the two yellow petals with putative nectar-guides. The control treatment consisted of an undamaged focal flower.

Pollinator activity on each focal flower was observed during 30 minutes. Visitor species and its contact time with the focal flower were recorded. To determine pollen export of *A. ligtu* by the visiting insects, four species of potential pollinators were collected and examined for pollen grains under a microscope. These pollen samples were compared with *A. ligtu* pollen grains isolated from anthers of freshly collected flowers.

The importance of floral symmetry and floral damage was evaluated with a two-way ANOVA with floral damage (two levels, 10% and 20%) and floral symmetry (two levels) as factors. The response variable studied was the rate of pollinator visits. For the analysis, the response variable was normalized using square root transformation. The effect of yellow petal removal (T5) on rate of visits by pollinators was independently compared to the control and T3 using the Wilcoxon rank-sum test.

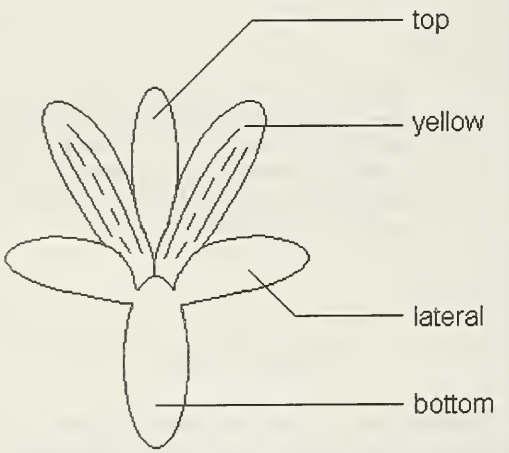

Figure 1. Schematic disposition of petals in a flower of *Alstroemeria ligtu.*

RESULTS

Four potential pollinators were included in this study: one morphospecies from the family Nemestrinidae (NEM), *Lasia corvina* (Acroceridae) (LA), and two morphospecies from the superfamily Apoidea (APO 1 and APO 2) (Daly *et al.*,1978; Peña, 1998; Richards & Davies, 1983; Sáiz *et al.*, 1989), all of which were shown to carry pollen of *Alstroemeria ligtu.*

A total of 54 out of 180 flowers observed (treated and control) were visited at least once by these pollinators. A total of 81visits were made by the

potential pollinators included in the analysis. APO 1, APO 2, and NEM were the morphospecies most frequently observed (35, 29, and 16 visits, respectively). LA was observed only once. The average time spent by these potential pollinators in contact with focal flowers differed. Nemestrinidae showed the longest mean visit time (10.25 s). APO 1, APO 2, and LA spent less than half of the time in contact with the focal flower when compared to NEM (4.61 s, 2.19 s, and 2.19 s, respectively).

Rate of visits for each treatment with their standard deviations are shown in Fig. 2. A two-way ANOVA showed no effect of levels of floral damage (F1), floral asymmetry (F2) nor interactive effects between these two factors (F3), on the rate of visits by pollinators ($F1 = 0.592$, $P > 0.1$; $F2 = 0.985$, $P > 0.1$; $F3 = 0.415$, $P > 0.1$).

Total removal of petals with nectar-guides (T5) had a statistically significant effect on the rate of visitation by pollinators when compared to control flowers (Wilcoxon test: $z = -3.8121$, $P = 0.0001$). In addition, the average numbers of pollinator visits in flowers belonging to T5 and T3 showed statistically significant differences (Wilcoxon test: $Z = 2.7726$, $P < 0.01$)

DISCUSSION

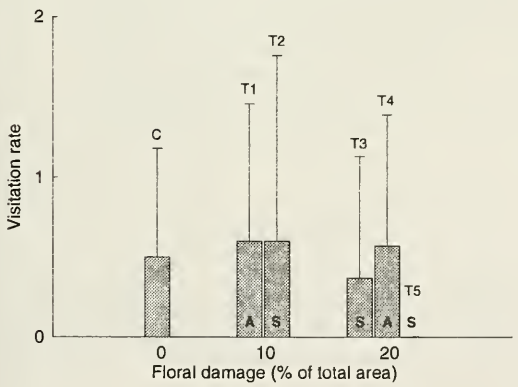

Figure 2. Effect of treatments (see Materials and Methods for detailed descriptions) on the rate of visits by pollinators. C corresponds to control flowers. Flowers with T5 were not visited at all.

Removal of yellow petals (T5) had an important effect on the rate of visitation by pollinators. The number of visits to flowers lacking the two yellow petals was zero. At least two hypotheses can explain these findings. Firstly, the two yellow petals have several brownish lines which might play a role in floral species recognition by potential pollinators. Flowers without these two petals become completely red-coloured, possibly acquiring the appearance of a different flower species. This new floral display might not be included in the search image pollinators have according to their instinctive foraging behavior and/or learning foraging experience. Secondly, the brownish lines might also be important as nectar-guides, highlighting the form and architecture of the flower as the visitor approaches (Proctor *et al.*, 1996). Hence, flowers lacking these two yellow petals could be of no interest to insects because the lack of an easy and direct way to nectar.

Different levels of floral damage and floral asymmetry on the red lateral petals had no significant effect on the rate of pollinator visits. Krupnick *et al.* (1999) reported that pollinators visited damaged flowers of *Isomeris arborea* at a lower rate than undamaged ones. These two systems may differ in relevant flower traits such as quantity and quality of nectar, and/or in the intrinsic behavior of associated pollinators.

Floral damage affecting distinctive flower petals, such as petals with nectar guides, reduces pollinator service and would indirectly reduce reproductive success in plants. Further work is needed to assess the importance of other petals for pollinator service. In addition, different levels of floral damage and asymmetry on distinctive petals might show an effect on visiting rates by potential pollinators.

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