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Effect of Florivory on the Donation and Deposition of Pollen in *Ipomoea imperati*

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Authors' contributions

This work was carried out in collaboration between all authors. Author JCLA performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors RMG and AEGR managed the analyses of the study. Author RMG managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The potential effect of florivory on donation and deposition of pollen in *Ipomoea imperati* was studied. Three different levels of flowering damage (0%, 25%, and 75%) were applied to emasculated and non-emasculated flowers and the number of pollen donated and deposited was measured. It was found that there are significant differences in pollen donation and reception between flowers with 75% damage compared to the control and flowers with 25% damage. It is concluded that the florivory has a negative effect on pollen transport of *Ipomoea imperat*i. This negative effect could be associated with a change in visiting patterns and behavior of the pollinators.

Keywords: Ipomoea imperati; florivory; fitness; deposition of pollen; donation of pollen.

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1. INTRODUCTION

Florivory is the process in which a predator totally or partially consumes flowers, differing from the herbivory by the specificity of the tissue removed and their consequences on the plant reproduction. Organs damaged caused by florivory include bracts, sepals, petals, stamens, and pistils, as well as gametophytes, pollen and ovules [1,2]. Herbivory, however, causes a direct reduction of photosynthetic tissue, deteriorating the competitive capacity and the fitnes of the plants and reducing the availability of resources [3]. Likewise, florivory is associated with decreasing the attractiveness to pollinators and hence their success in pollination. Moreover, many reproductive structures, including petals, sepals, anthers, and carpels, can be photosynthetically active and produce a substantial amount of photosynthate in some plant species [4,5,6].

This antagonistic interactions (florivory and herbivory) can sometimes have different effects on plant population dynamics as population growth rates can be differentially sensitive to changes at different life-history stages for example trees vs vines. The shape, odor, color, and symmetry of the flowers usually work as adaptive systems of restriction of pollinators [7] Thus, losing these attributes as a result of herbivores, can lead to loss in the capacity of pollination and transport of pollen. The florivory directly affect male and female fitness by consuming all kinds of gametes (pollen and ovules) as well as pistils and stamens [8,9].

Ipomoea imperati is a perennial creeping vine, from rhizomes. It is a species with a striking flower morphology and florivory can be easily observed. Stems prostrate, ascending to about 15 cm, rooting at the nodes, reaching up to 30 m from the original root. Leaves are alternate, petiolate, leaf blade variable, often linear, lanceolate to cordate or 3-5-lobed, 10-15 cm long, 5-7 cm wide, glaucous green, densely arranged. Flowers are white with a yellowish center, 5-7 cm across, funnel-shaped, with flat spreading petals, each with a longitudinal crease. Flowers open early in the morning and close at dusk. Fruit is a rounded capsule [10].

I. imperati is self-incompatible. The five epipetalous stamens are unequal in length and have anthers that dehisce extrorse. Self-specific incompatibility occurs due to a failure of the echinate pollen grains to germinate. If germination occurs occasionally, pollen tubes rarely grow longer than two pollen diameters [11].

The aim of this work is to determine the effects of differential levels of floral parts removal on pollen donation and deposition, which may be a good indicator of male and female adaptation of *Ipomoea imperati.* The underlying hypothesis in this study is that due to the effect of the florivory on the symmetry and appearance towards the pollinators, it is expected that the greater the floral area removed the less will be the donation and deposition of *Ipomoea imperati* pollen.

2. MATERIALS AND METHODS

The present study was developed in the biological station of the Coastal Research Center La Mancha (CICOLMA) located in the municipality of Actopan, Veracruz (190 35 '25 N, 960 22' 49 W). The climate is warm humid with summer rainfall, annual precipitation is 1200 to 1500 mm, the average temperature is 25℃ and the prevailing wind comes from the north. CICOLMA has an extension of 83.29 hectares [12] among heterogeneous landscape composed of medium deciduous forest, low deciduous forest, flooded forest, coastal dunes, mangrove associated with a coastal lagoon and pasture [13]. This work was carried out in an area of coastal dunes.

2.1 Methods

A total of 72 plants of *Ipomoea imperati* were located taking care that they were developed in an area as homogeneous as possible, to eliminate possible environmental effects. Three groups of 24 flowers were randomly selected on these plants and three flower removal treatments were applied, 25%, 75% and control (0%). To perform the damage on the flowers, a hole maker was used to produce an effect that simulates natural damage.

Half of the flowers of each treatment (12 flowers) were emasculated, for this, the flowers were visited and before they opened the anthers were cut so that the pollen grains found in the stigma were the result of deposition by pollinators. The remaining 12 flowers of each treatment were used to calculate the percentage of pollen grains donated per treatment.

An additional 10 flowers were chosen and covered with pollination bags to avoid the movement of pollen by pollinators. This sample is used to calculate the average number of pollen grains offered by the flower. With this data, the percentage of removal of pollen can be calculated by counting the grains of the non-emasculated flowers.

The analysis was performed as follows: To determine if there are differences in the percentage of pollen donation, we used data from non-emasculated flowers and compared with the flowers covered with pollination bags, using a one-way ANOVA test with data transformation with arcosene [14]. A post hoc test (Tuckey SHD) was applied to estimate the differences between the treatments. To compare pollen deposition data, the number of pollen grains per stigma of the emasculated flowers per treatment was analyzed using a one-way ANOVA with data transformation with square root plus .5 [14].

3. RESULTS

We quantified the total number of pollen grains *Ipomoea imperati* available for dispersion, and a total of 866.41 (± 253.2 n = 10) grains per flower was detected.

When we analyzed if there was a donation process and if there were differences in the processes of the differen treatments, we found that the total number of pollen grains in the three treatments without emascularity was statistically significant in the total percentage of donated pollen (F = 5.43 P = 0.009). The treatment that pollen was donated most was control with 95.9% of its total pollen. While the treatment of floral removal to 75% managed to donate 78.1% of its pollen. A posteriori test of the means (Tuckey test) showed that the treatment of 75% of floral removal differs significantly from the rest, with no difference between the remaining two (25% vs. control) (Fig. 1).

Regarding pollen deposition, the emasculated plants of the three treatments were analyzed and showed significant differences in the number of pollen grains deposited in the stigma (F = 6.81, P =0.003). The treatment that showed the highest number of pollen deposited was the control (0% florivory) with an average of 62.6 pollen grains in each stigma, while the treatment that received the least pollen was 75% of the floral area removed with an average of 24.4 grains per stigma. The posteriori test of the means showed that the flowers with the 75% florivory treatment differed significantly from the two remaining groups (Fig. 2).

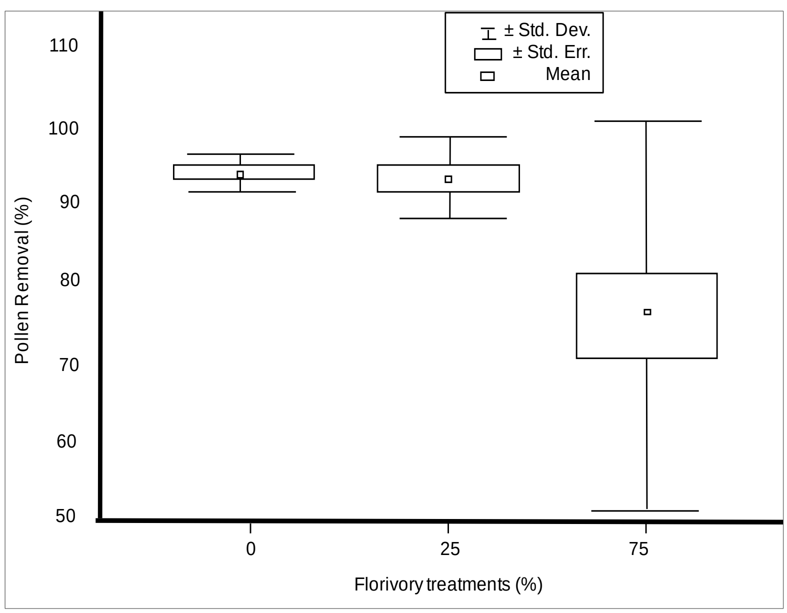

Fig. 1. Percentage of removal (donation) of pollen in florivory treatments

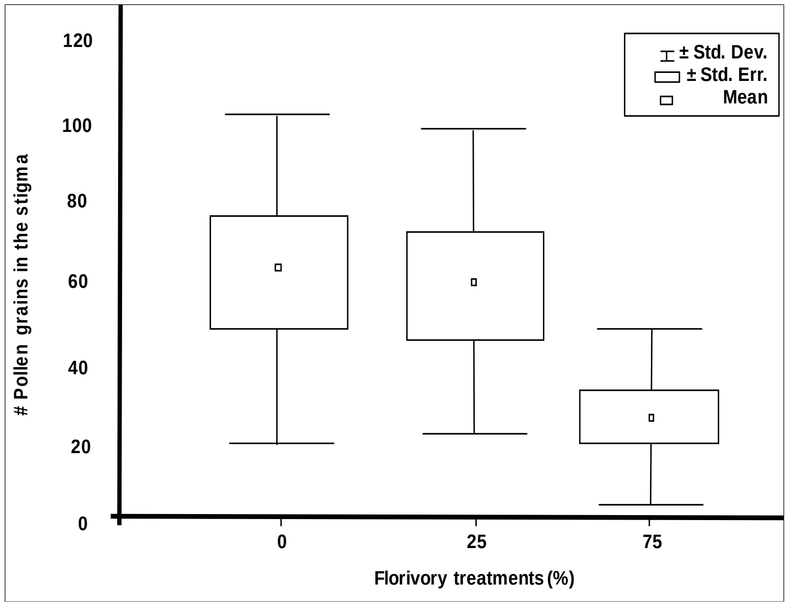

Fig. 2. Number of pollen grains per stigma in flowers subject to three levels of florivory

4. DISCUSSION

Traits such as flower color, size, number and type of reward are important for pollen dissemination and reception [15,16,17]. The results of this work suggest that there is an effect of florivory on the donation and deposition of pollen in *Ipomoea imperati*. This observation can have two connotations. The first is that florivory directly affects the ability of the plant to receive and donate pollen (i.e. it is possible that the insects may discriminate and limit the donation and deposition of pollen on heavily damaged flowers). This implication can only be proved if we analyze the real fitness (# of offspring) both male and female on damaged flowers by other way, the present study suggests that damaged flowers are poorly visited by pollinators, that is, their attractiveness is diminished, affecting not only the visiting rate of pollinators but maybe also their foraging behavior . In general, the empirical evidence shows that both natural and artificial florivory impose a negative cost to plant reproduction. In fact, the natural damage is two-fold stronger than that of artificial damage [18], suggesting that plants are under selection pressure to limit florivore feeding and/or mitigate the fitness costs associated with floral damage [2].

On the other hand, despite showing significant differences between treatments for the response variables, it is observed that for donation and deposition of pollen in the treatment of 75% of floral removal, deposition and donation values are relatively high (78.1% donation and 24 pollen grains per stigma). These could indicate that the effect of florivory might not be so severe, however, flowers with excessive damage do not close at the end of the day, therefore, reproductive structures are exposed to floral visitors who usually do not visit these flowers, and this may cause a compensation effect. In this respect, it would be interesting to explore a possible spatial and temporal segregation in the visitors of *Ipomoea imperati* with high levels of flavor and its effect on the production of fruits and seeds.

An interesting aspect is that there is a large variation in the percentage of pollen donation in the treatment of 75%. This may support the idea of the temporary segregation of visitors since it seems that the visit of pollinators to this type of flowers, should be subject to the temporary shortage of less damaged flowers.

5. CONCLUSION

From the results of the study, it can be concluded that florivory has a negative effect on pollen transport of *Ipomoea imperati*. It is proposed that this negative effect is associated with a change in visiting patterns and behavior of the pollinators. Due to the strong pressure of selection that is the florivory, it would be important to carry out similar studies with intermediate levels of floral damage. T*h*is would allow to determine the damage thresholds that show effects on pollen donation and deposition, as well as the behavior and rate of visits of pollinators to *Ipomoea imperati* or related species.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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