

# Asymmetric interactions in *Trichocereus bridgesii* (Cactaceae): nectar concentration and production patterns<sup>1</sup>

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## Introduction

Most flowering plants depend on animals for their reproductive success. Based on the dependence grade it is possible to categorize two types of interactions: symmetric and asymmetric interactions<sup>1</sup>. Symmetric interactions are composed by generalist plants that are pollinated by a wide variety of generalist pollinators, or specialist plants are pollinated by one or a few specialist pollinators (Fig. 1a and b). In contrast, asymmetric interactions consist on generalist plants that can be pollinated by different generalist species and one or a few specialist pollinators, or specialist plants that are pollinated by one or a few generalist pollinators (Fig. 1c and d).

It have been demonstrated that habitat fragmentation could cause the disruption of the interaction networks. For instance, habitat fragmentation causes the loss of specialist pollinators of both symmetric and asymmetric interactions<sup>1,2</sup>. This process produces a negative effect on pollinator fauna, decreasing the likelihood of pollen dispersal, leading to a detriment on reproduction.

The continuous population growth and consequently, urban expansion caused the fragmentation of native vegetation around La Paz city (Bolivia). Habitats remnants suggests that the native vegetation was a spiny shrubland with several species of cacti. One of the most common species of cacti is *Trichocereus bridgesii*, a columnar cactus endemic to the dry valleys of La Paz (Fig. 2a). There is no information about the reproductive biology of this species neither how habitat fragmentation affected the reproductive success.

The aim of this study was analyze the consequences that habitat fragmentation and loss of pollinators has on both nectar concentration and nectar production in *T. bridgesii*.



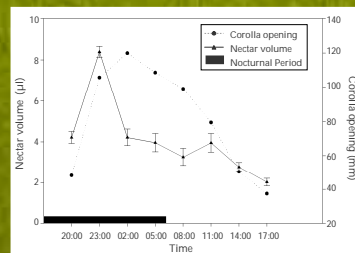
**Figure 2.** *Trichocereus bridgesii* Britton & Rose. (a) Old individual with a floral display at blooming season. (b) Ananta dry valley at La Paz city area. (c) Flower aspect an early hours after corolla opening start, and (d) Individual with a bagged buds.

## Methods

- The study was carried out during the bloom season of *T. bridgesii*. The study site was at an altitude of 3,200 m, in the driest area of La Paz city (Bolivia). Ananta Valley is the last remnant of native vegetation around the city (Fig. 2b).
- Randomly I selected five individuals with several floral buds. I bagged each bud, a few days before floral opening to prevent pollinator access (Fig. 2c).
- To analyze the corolla opening and closing, I identified and marked the two most external opposite petals<sup>3,4</sup>.
- During the floral lifetime of *T. bridgesii* (24 hours) I took measurements of nectar production and nectar concentration every three hours during five continuous days. In total, I obtained eight measurements (nectar concentration and production) per flower per day.
- To analyze nectar characteristics, I obtained nectar samples with calibrated microcapillaries. The sample was used to estimate nectar production ( $\mu\text{l}$ ) and nectar concentration was estimated using a hand refractometer (% Brix)<sup>3,4</sup>.

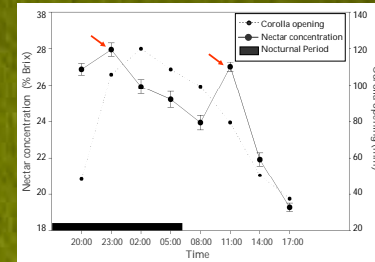
## Results

Flowers of *T. bridgesii* display a chiropterophilic syndrome: white and large flowers that start their opening the last hours of the afternoon and remain open approximately 24 hours (Fig. 2d). Corolla starts opening at 5:00 pm, with a maximum corolla aperture at 02:00 am, and closes progressively until afternoon next day.



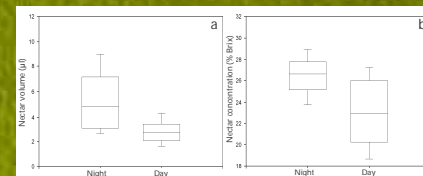
**Figure 3.** Relationship between nectar production pattern and corolla opening along *T. bridgesii* flower lifetime ( $n = 18$ ). The errors Bars represent SD.

Nectar production has an important peak, before floral anthesis, at 11:00 am. Following this peak, the production decrease as well as corolla starts to close (Fig. 3). The peak value of nectar production was 8.38  $\mu\text{l}$  before midnight.



**Figure 4.** Relationship between nectar concentration pattern and corolla opening along *T. bridgesii* flower lifetime ( $n = 18$ ). The errors Bars represent SD.

Nectar concentration has two important values, the first at 11:00 pm with a maximum value of 27.95 % Brix, and a second at 11:00 am the next day with a value of 27.07 % Brix (red arrows, Fig. 4).



**Figure 5.** *T. bridgesii* nectar variations. (a) Nectar production contrast between night and day periods (Wilcoxon test,  $Z = 5.93$ ;  $P < 0.01$ ;  $n = 18$ ) and (b) Nectar concentration between night and day periods ( $Z = 6.89$ ;  $P < 0.01$ ;  $n = 18$ ).

The variation of nectar production during the night period fluctuated between 3.96  $\mu\text{l}$  ( $\pm 0.44 \mu\text{l}$ ) and 8.38  $\mu\text{l}$  ( $\pm 0.27 \mu\text{l}$ ), meanwhile during the day period was 2.02  $\pm 0.19 \mu\text{l}$  to 3.95  $\pm 0.45 \mu\text{l}$ . Nectar production is higher at night than at day ( $Z = 5.93$ ;  $P < 0.01$ ;  $n = 18$ ) (Fig. 5 a).

Nectar concentration showed variation between day and night periods, as well as during each period. Nectar concentration values were higher at night than during the day ( $Z = 6.89$ ;  $P < 0.01$ ;  $n = 18$ ). During the night nectar concentration values ranges between 25.19  $\pm 0.44$  % Brix and 27.95  $\pm 0.36$  % Brix; nectar variation during the day was between 19.28  $\pm 0.23$  % Brix and 27.01  $\pm 0.26$  % Brix (Fig. 5b).

## Conclusions

- Besides *T. bridgesii* chiropterophilic characteristics (e.i. white and large flowers, opening start at the end of afternoon), others characteristics as floral lifetime suggest that this species is a specialist plant that should be pollinated by nocturnal generalist pollinators. However, due habitat fragmentation nocturnal pollinators have been lost.
- There for, the low floral activity during the day represents the most important phase because now *T. bridgesii* depends on diurnal pollinators for reproductive success.
- The fact that nectar characteristics have higher values at night than during the day suggests that might be an adaptation to original restricted nocturnal pollination.
- The study area is an isolated remnant but also is the lowest altitudinal distribution of *T. bridgesii* (3,200 m). In this location, nocturnal pollinators are less abundant due habitat fragmentation, caused mainly by the expansion of urban areas (Fig. 1c and d).
- Other small populations of *T. bridgesii* have reported the occurrence of nectarivorous bats and moths, although there is no information about the pollination success.

## Literature cited

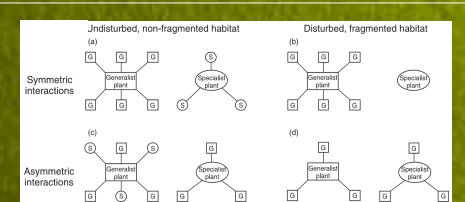
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## For further information

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**Figure 1.** Representation of specialization in plant-pollinator interactions. In symmetric specialization (a), generalist plants are pollinated by different generalist pollinators (G) while specialist plants by one or few specialist pollinators (S), so habitat fragmentation (b) will more strongly negatively affect specialist plants compared to generalist plants. In asymmetric specialization (c), generalist plants are pollinated by many specialist and generalist pollinators, whereas specialists are pollinated mostly by one or a few generalist pollinators so is similar reproductive susceptibility to habitat fragmentation for specialist and generalist plants (d).  
Extract from Ashworth et al. 2004