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Floral Biology of *Rhipsalis paradoxa* (Cactaceae: Cactoideae) in Semideciduous Mesophyll Forest (Atlantic Forest) at Serra do Japi, Jundia í -SP.

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Abstract

The aim of this study was to investigate the floral biology and to determine the main floral visitors and potential pollinators of *R. paradoxa* (*Cactaceae*). This study was conducted in an Environmental Protection Area in the Serra do Japi, Jundiaí-SP. The *R. paradoxa* flowering season comprehended the months of September and October of 2001. The principal floral visitors were *Apis melifera*, *B. brasiliensis*, *Melipona quadrifasciata*, *Melipona bicolor* and *Trigona* sp., all these bees belonging to Apidae family, thus this species consists in a *melittophilous cactus*. All floral visitors are potential pollinators. *B. brasiliensis* was considered the main pollinator, since it is a very common species, displays legitimate visits and promotes xenogamy when they move between distant individuals in the population. *A. mellifera*, *M. bicolor* and *M. quadrifasciata* are secondary pollinators, presenting lower visitation rates and short distance flights, promoting mainly self-pollinations and low gene flow within the population of *R. paradoxa*. *Trigona* sp. was the most common species and remained longer time in the flowers, however, this bee visited essentially flowers within the same plant favoring basically the geitonogamy, for this reason was considered only as a secondary pollinator. The conservation of the main pollinators of *R. paradoxa* is crucial for conservation of this cactus species that depend exclusively on bee pollination for its reproductive success.

Keywords: Atlantic rainforest; Bee pollination; *Cactaceae*; Floral biology; Pollination; Pollinators; *Rhipsalideae*; Semideciduous mesophytic forest

Introduction

Cactaceae has approximately 170 genera, being 100 genera belonging to the subfamily *Cactoideae*, presenting a distribution restricted to the Americas, except for some species of the genus *Rhipsalis* found in certain localities of Tropical Africa, Madagascar and Ceylon [1]. The family is subdivided into four subfamilies: *Cactoideae*, *Pereskiodeae*, *Maihuenioideae* and *Opuntioideae*. *Cactoideae* is the largest subfamily comprising seven subfamilies: *Cacteae* (25 genera), *Cereeae* (15), *Echinocereeae* (25), *Hylocereeae* (6), *Notocacteae* (7), *Rhipsalideae* (7) and *Trichocereeae* (23) [2], with *Rhipsalidae* being a monophyletic group [3]. Most of the cacti are leafless, developed, succulent plants with green stem and very varied forms, presence of thorns, isolated flowers and colorful, androceutical constituted by numerous stamens, ovary infertile, multicarpelar, unilocular and with many ovules.

In Brazil, the last estimate is that there are about 39 genera (14 endemic), totaling 261 species (76 endemic) [4]. In addition, the genus *Rhipsalis Gaertn* is composed of epiphytic species, cylindrical stem, small and branched flowers originating from areolae along the branches, seeds with mucilage cover restricted to the thread region [1] and occurs in practically all the national territory, presenting 36 species (32 Endemic). In the semi-deciduous forest of the semi-deciduous forest of the Atlantic Forest, *Rhipsalis paradoxa* (Salm-Dyck ex Pfeiff.) Salm-Dyck., An endemic species distributed from Pernambuco State to Rio Grande do Sul State [4].

Barthloot et al. [5] reviewed that the *Rhipsalideae* tribe is currently represented by four genera (*Lepismium*, *Rhipsalis*, *Hatiora* and *Schlumbergera*) and are mainly distributed in eastern South America and the highest concentration of species is found in southeastern Brazil and east of Bolivia.

A recent study pointed out that a high proportion of cacti species is threatened with extinction in the near future. Among the main causes that can lead these species to extinction are conversion of native vegetation into agriculture, pasture for livestock, destruction of habitat for housing construction and illegal collection of plants and seeds by collectors to grow them in their particular ornamental gardens. Based on the IUCN's red list of categories and criteria, approximately 31% of the planet's cacti species are threatened with extinction in the near future. In Brazil, the sites where cacti species are most threatened ("hotspots of threat") is located in western Bahia and northern Minas Gerais [6].

Despite the large number of cacti species occurring in Brazil, there are few studies on floral biology and reproduction, there being no study on pollination or floral biology for the genus *Rhipsalis* worldwide, being the first study to be published. The objective of this study was to investigate the floral biology, main floral visitors and to determine the potential pollinators of *R. paradoxa*.

Materials and Methods

Study area

This study was conducted between October 27th and 29th, 2001 in a Semideciduous Mesophyll Forest (Atlantic Forest) located in an Environmental Protection Area in the Serra do Japi, Jundiaí - SP. This region is characterized by altitudes varying between 700 m and 1300 m above sea level. The mean monthly temperatures vary between 11.8°C and 15.3°C in July, and 18.4°C and 22.2°C in January, respectively, according to higher and lower altitudes. The local vegetation is characterized as a Mesophyll Semideciduous Forest of Altitude, with a tree size of 10 m to 15 m in height, and in general, they do not present very expressive stem diameters [7]. In the Serra do Japi, *R. paradoxa* occurs mainly on rocky outcrops shaded and close to water courses, which are very humid environments (p. It was collected and deposited witness material of the species studied at UEC (State University of Campinas, SP) and fixed flowers in 70% alcohol.

Species

R. paradoxa (Salm-Dyck ex Pfeiff.): Epiphytic or rupiculous plants, crawling or hanging. Young tetragones and white-bristled, adult trines, with alternately twisted, woody edges, 12-65 cm long and 0.8-1.7 cm wide, dark green and reddish when exposed to intense sunlight. Emerald arches, glabrous, arranged at the angles of twisting, the fertile submerged, filled with white woolly garment, with two triangular basal scales of 0.4 cm long. Side blossoms, 1-2 per areola, rotated, 0.6-1 cm long And 1.2-2 cm wide; White or brownish-white perianth, sepals and petaloids white or brownish white; White or yellow fillets of pink base, white anthers; Pericarpelo turbinado, glabrous, immersed in the areola; White stiletto, stigma 5-6 lobed, white. Turbinated fruits, 0.4-0.5 cm long and 0.4-0.6 cm wide, magenta color; Scar of perianth 4 mm wide, black. Seeds 1 mm long, black [8,9].

Visitation

To describe the floral biology of *R. paradoxa*, six individuals were observed for three consecutive days. The main floral visitors were registered through direct observation of three individuals between 07:00 and 17:00 h, totaling ten hours of observation. Each subject was observed for 15 consecutive minutes, followed by a 5-minute interval between observations, in order to observe the three subjects at one hour. During these intervals, data related to floral biology were collected. The main floral visitors were also collected for identification.

Results

The flowering period of *R. paradoxa* occurred between mid-September and October of 2001. The flowers are actinomorphs with dialysépalo chalice and dialipétala corolla presenting five sepals and five petals arranged alternately between them. The gynaecine is composed of a pentacarpelar infertile ovary, the stigmatic region consisting of five stigmas. The androecium has about 95 stamens and there is a nectariferous chamber located above the ovary that can be accessed through a hole in the base of the stylet.

Floral buds in early development are targets, acquiring cream-pink color when pre-anthesis and after opening. When fully opened, the flowers showed the petals forming a 90° angle with the gynoecium. Most of the flowers opened at dawn and early in the morning, when they were already receptive. At the beginning of the anthesis, the stigmas were at the same level as the anthers, at the end of this, they are positioned about 4.0 mm above the anthers. The release of pollen occurred around 9:00 a.m. The behavior of floral visitors indicated that there is secretion of nectar. Floral visitors visited flowers on the 1st and 2nd day, however the flowers on the 2nd day were visited less frequently. The flowers of the 2nd day showed chalice, corolla and yellowish stamens, and the flower began to close. On the third day the flower was completely closed, with a wilted chalice and corolla and very yellow. The flowers at the beginning of the flowering still had stylet, stamens, sepals and petals, but well respected. None of the individuals in the study area had any fruit.

The floral visitors were *Bombus brasiliensis*, *Apis melifera*, *Trigona sp*, *Melipona quadrifasciata* and *Melipona bicolor*, all belonging to the Apidae family (Figure 1). All floral visitors touched the stigmas when they landed on the flower or when they walked on it.

The floral visitors of *R. paradoxa* exhibited different behaviors when visiting their flowers. *B. brasiliensis* landed frontally and grasped at the base of the chalice, embracing every flower, since the size of its body is approximately twice as large as that of the flower. The mean time of each visit was 5.1 s (n=10 2.6). The visitation of *A. melifera* was sporadic, visiting few flowers of the same individual. The mean time per visit was 3.8 s (n=8 2.43). In addition, *Trigona sp.* used the stigmas as a landing platform, and after landing, walked on the stamens collecting pollen from the anthers or sucking nectar present in the nectariferous chamber. This species remained approximately 1.33 s (n=20 53) in each flower and flew to flowers of the same plant and nearby plants (Figure 2).

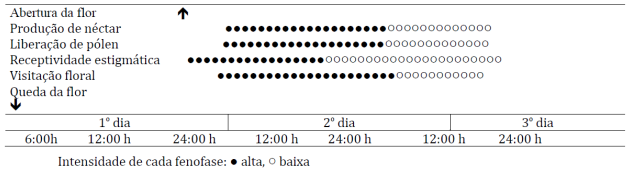

Figure 1: Fenologia floral de R. paradoxa (Cactaceae) na Serra do Japi, Floresta Mesófila Semidecídua (Mata Atlântica) em Jundiaí-SP.

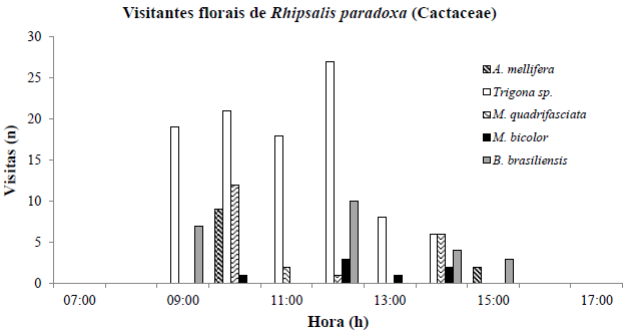

Figure 2: Floral visitors of *R. paradoxa* (Cactaceae) in Serra do Japi, Mesófila Semideciduous Forest (Atlantic Forest) in Jundiaí-SP.

Discussion

All floral visitors of *R. paradoxa* are bees belonging to the family Apidae, also consisting of the main pollinators of other cacti as well as *Echinocereus* [10], *Echinomatus* [11], *Opuntia* [12,13] and *Echinopsis* [14].

All species of floral visitors observed in flowers of *R. paradoxa* were considered potential pollinators, but they present differences in frequency of visitation, which can directly affect the pollination service. All species presented different patterns of visitation, such as behaviors while visiting the flowers, number of flowers visited, distance traveled between individuals in the area favoring more xenogamic pollinations. Among the registered floral visitors, *B. brasiliensis* was considered the main pollinator, since when landing on the flower it touched not only the stigmas as many anthers, besides being frequent throughout the day and flying to both close individuals and plants Distant, promoting more cross-pollination than the other species. Bees *A. melífera*, *M. bicolor* and *M. quadrifasciata* were considered secondary pollinators because they had a lower frequency of visits than *B. brasiliensis* and most of the time they flew to nearby plants, promoting low gene flow within the population of *R. paradoxa*.

Trigona sp. Was the most assiduous floral visitor in our study, visited more flowers, presented more time of visitation, landed directly on the stigmas and then walked on the stamens to collect pollen and/or penetrated between the stamens to access the nectariferous chamber, touching reproductive structures and making legitimate visits that most likely resulted in pollinations. However, *Trigona sp*. was not considered the main pollinating species but rather as a secondary pollinator because its visits were mostly restricted to flowers of the same individual, favoring autogamy rather than xenogamy, not favoring an increase in genetic variability in the population.

According to GOETTSCH et al. [6] the increasing fragmentation and destruction of habitats is the main threat to cacti generally not only in Brazil, but in the world as a whole. Therefore, conserving the main pollinators of endemic species such as *R. paradoxa* that depend on animal pollination is essential for the conservation of this species, allowing its reproduction and minimizing the risk of extinction.

Final Considerations

Ripsalis paradoxa is pollinated exclusively by bees belonging to the family Apidae, consisting of a species of mitochondrial cactus.

All floral visitors are able to promote the pollination of *R. paradoxa*, but they differ essentially in the frequency of visitation. *B. brasiliensis* is the main pollinator because it is a very frequent species, it performs legitimate visitation, that is, it touches both stigmas and anthers and still flies both to nearby individuals and to more distant plants, which favors the transference of Xenogeneic pollen among individuals in the population.

The bees *A. melífera*, *M. bicolor* and *M. quadrifasciata* are secondary pollinators, since they presented less frequency of visits and they were flying mainly between short distances, promoting low gene flow within the population of *R. paradoxa*.

Although *Trigona sp*. Having been the most frequent species, visiting a larger number of flowers, remaining for longer in each flower and also making legitimate visits, was considered as secondary pollinator, since their visits were restricted to flowers of the same individual, essentially favoring geitonogamy and not xenogamy.

The conservation of the main *R. paradoxa* pollinators is crucial for the conservation of this species of cactus, since its reproduction depends exclusively on the pollination service provided by the bees, which would reduce their risk of extinction.

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