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Pollen morphology and study of the visitors (Hymenoptera, Apidae) of *Solanum stramoniifolium* Jacq. (Solanaceae) in Central Amazon

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RESUMO – (Morfologia polínica e estudo dos visitantes (Hymenoptera, Apidae) de *Solanum stramoniifolium* Jacq. (Solanaceae) na Amazônia Central). A família Solanaceae tem ampla distribuição, principalmente nas áreas tropicais e subtropicais da América do Sul. *Solanum* L. é um dos mais importantes gêneros desta família com aproximadamente 1.200 espécies. O objetivo deste trabalho foi o de estudar a biologia floral com enfoque na morfologia polínica e no registro de algumas abelhas visitantes de *S. stramoniifolium*. Dados preliminares indicam a presença de uma espécie de abelha com ferrão e quatro espécies sem ferrão como visitantes de *S. stramoniifolium.* O pólen de *S. stramoniifolium* é tricolporado e psilado, ou seja, sem ornamentação. Conclui-se, após o estudo da biologia floral, que *S. stramoniifolium* constitui fonte potencial de pólen para diferentes espécies de abelhas com e sem ferrão, representando interessante campo para estudos de germinação, interações inseto-planta e biologia floral.

Palavras-chave: *Solanum stramoniifolium*, abelhas, pólen, polinização, acetólise

ABSTRACT – (Pollen morphology and study of the visitors (Hymenoptera, Apidae) of *Solanum stramoniifolium* Jacq. (Solanaceae) in Central Amazon). The Solanaceae family has a wide distribution, mainly in the tropical and subtropical areas of South America. *Solanum* L. is one of the most important genera of the family with approximately 1,200 species. The objective of this work was to study the floral biology, pollen morphology as well as to investigate the bee visitors of *S. stramoniifolium*. Preliminary data indicate the presence of one species of stinging bee and four species of stingless bees as visitors to *S. stramoniifolium.* The pollen of *S. stramoniifolium* is tricolporate and psilate or without ornamentation. In a word, *S. stramoniifolium* constitutes a potential source of pollen for different species of bees with and without sting, providing an interesting field for germination studies, insect-plant interactions and floral biology that are already under way.

Key words: *Solanum stramoniifolium*, bees, pollen, pollination, acetolysis

Introduction

The Solanaceae family comprises about 90 genera and 3,000 species with a wide distribution, mainly in the tropical and subtropical regions of South America. It constitutes one of the most important families of shrubs and secondary growth vegetation in Brazil. Many domesticated species have economic importance, such as tomato (*Lycopersicum esculentum* Mill.), potato (*Solanum tuberosum* L.), "jiló" (*S. aethiopicum* L.), "cubiu" (*S. sessiliflorum* Dunal), egg-plant (*S. melongena* L.). and tobacco (*Nicotiana tabacum* L.). *Solanum* L. is one of the most important genera of this family, being among the world's most numerous in species (with up to 1,200).

There are many articles about the *Solanum* genus pollen morphology, including the following: Salgado-Labouriau *et al*. 1969; Sharma 1974; Anderson & Gensel 1976; Symon 1981; Edmond 1984; Roubik & Moreno 1991. These articles suggest a homogeneous morphological pattern to the pollen grains of this genus. Edmond (1984) emphasizes that there are not significant morphological variations in the pollen grains of *Solanum* species, though he admits to the existence of those variations. This autor also considers the pollen morphology of the *Solanum nigrum* to be the morphological pattern of this genus.

The aim of this work is to focus on the morphological description of the pollen of *S. stramoniifolium*, by starting its floral biology study as well as recording its different visitors. *S. stramoniifolium* characterizes itself by its bushy shape, being from 1 to 2m high, usually armed with spines from 4 to 12mm long; the stem is tomentose,

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with star-shaped, almost sessile hairs. The inflorescence of *S. stramoniifolium* is extra-axillar, simple, with 12 to 30 flowers (Ribeiro *et al.* 1999). The calyx is campanulate, more or less truncate, with hidden lobes; the corolla is white, usually with external purple hairs, lobulated near the base, and the lobes are ovolanceolate; anthers more or less conniving and slightly curved on the apex (Ribeiro *et al.* 1999). This species is heliophyte and in environments with diffuse light it is estiolate and with less branch development, in addition to a lower yield of flowers and fruits.

Material and methods

In the first phase, some samples of *Solanum stramoniifolium* Jacq. were collected for incorporation into INPA's Herbarium, Manaus – AM (Kinupp, V.F. & Coletto-Silva, A. – collector n. 1831, voucher n. 208742). In the second phase, we carried out a palynological study of *S. stramoniifolium* with documentation and description of the pollen. The methodology used for recording the species of bees was by visitor count, photographic records and specimens collection with entomological nets. The observation of the visitors was carried out in the area of INPA's Campus in Manaus (Amazonas State), Comunidade Menino Deus do Curaçá in Boa Vista do Ramos (Amazonas State), Manacapuru and Itacoatiara (Amazonas State). These observations were made from October 2000 to April 2001. The averages of both maximum and minimum annual temperature in Manaus were 32.0-22.2ºC and 31.9-23.4ºC, in 2000 and 2001, respectively. The annual average rainfall was 2599.6mm in 2000, and 2016.8mm in 2001.

The pollen of *S. stramoniifolium* was collected from flower buds (fresh material) in INPA's Campus (Manaus) and treated by the standard method of acetolysis, following Erdtman (1960). From the acetolysed material slides were made for observation and documentation by light microscopy. For the measurement of the pollen grains as well as their morphological characterization, 25 randomly chosen grains from 5 different slides were measured. Arithmetic average and standard deviation were estimated for the morphometric data. The terminology adopted was based on Punt (1994).

Results and discussion

Observations of Visitors - Preliminary data (Fig. 1-3) show the presence of *Melipona nebulosa* (Camargo 1988), *Trigona pallens* (Fabricius 1793), *Melipona seminigra merrillae* (Cockerell 1920), *Melipona compressipes manaosensis* (Schwarz 1932) and one species of *Eulaema* (*Apeulaema*) *cingulata* (Fabricius 1804) collecting pollen from *S. stramoniifolium*. All the visitors, with the exception of the species *Trigona pallens* used the strategy of "buzz pollination" during the foraging behaviour. Published studies report that "buzz pollination syndrome" requires bees with a specific behaviour for pollen removal (Forni-Martins *et al*. 1998). Other studies provide evidences of the collection of pollen from *Solanum* species by bees, thus demonstrating the importance of this genus for the improvement of apiculture management (Absy *et al*. 1980; 1984).

Absy & Kerr (1977) studying *Melipona seminigra merrillae*, and Marques-Souza *et al*. (1995) working with *Melipona rufiventris paraensis* (Ducke 1916) verified the collection of pollen by stingless bees in some species of the genus *Solanum*. Kerr *et al*. (1986; 1987) also verified pollen of *S. annuum* (L) Morton, *S. macrocarpon* L. and *S. melongena* being collected by *Melipona compressipes fasciculata*

Figures 1-3. Some bees visiting *Solanum stramoniifolium* to collect pollen. 1. A stinging bee *Eulaema* (Apeulaema) *cingulata*. 2-3. Two species of stingless bees, *Melipona seminigra merrillae* and *Melipona compressipes manaosensis*, respectively. Scale bars = 2cm (1), 1cm (2-3).

(popular name: "tíuba do Maranhão"). Marques-Souza *et al*. (1993) verified the collection of pollen from two species of the genus *Solanum* (*Solanum myrianthum* Britton ex Rusby and *Solanum* sp.) by *Apis mellifera* in the municipality of Ji-Paraná, RO, Brazil.

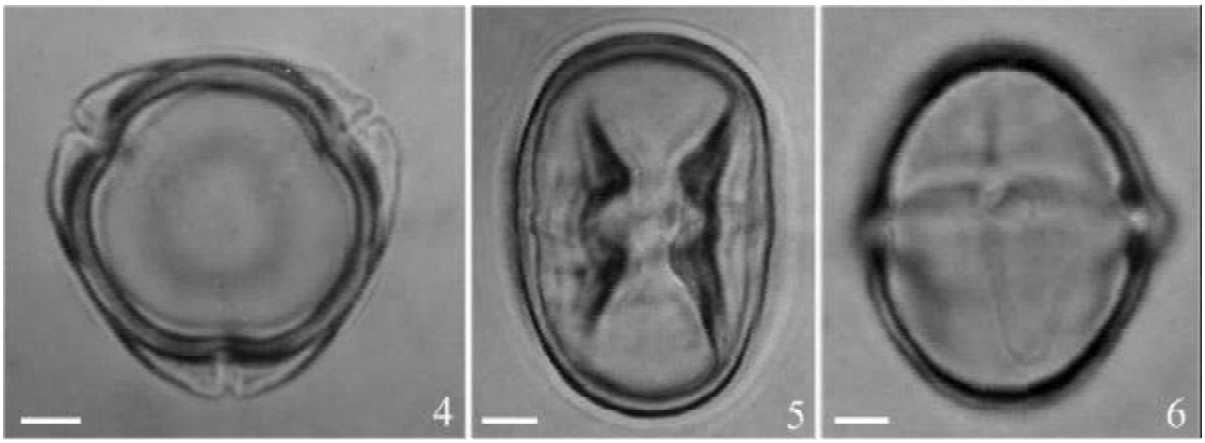
Palynological Data - The pollen of *S. stramoniifolium* (Fig. 4-6) is shown in the polar and equatorial positions. The morphometric data of the pollen grains referring to the values of the arithmetic averages of polar (P) and equatorial (E) axis were: 34.8 ± 1.6 (27.5-42.5)µm and 29.0 ± 0.5 (25-35)µm, respectively, being that the P/E ratio was 1.22. The morphological characteristics of the pollen grain of *S. stramoniifolium* are the following: small grain, subprolate shape, amb. circular, isopolar, monad; tricolporate; ectoaperture long (19.3µm) and narrow (1.3µm), endoaperture lalongate (width = 15.7µm and height = 3.7µm), wide with round edges and fastigiate; the exine sculpture is psilate with sexine less thick than the exine and non evident columellae.

Edmond (1984) emphasizes that the pollen grains of the *Solanum* did no represent significant morphological variations, but admits the possibility of these variations among species of this genus. According to this author, the *Solanum* genus pollen grain morphological variations refer only to the opening type and exine ornamentation level. In the case of the last characteristic, it varies from little to completely not ornamented grains. The variations presented by Edmond (1984) are due to many factors, such as the homogeneity of the morphological characteristics, which reflects strong philogenetic relationships in the *Solanum* section, isolation mechanisms and speciation, and genomic intermediary combinations that can, on the whole, explain the similarities found in the morphological variations of the *Solanum* genus.

Roubik & Moreno (1991) verified through of pollen morphological analyses of 11 species of *Solanum* from Barro Colorado Island (Panama Canal) that the pollen grains of the species are tricolporate and psilate. Other research that deals with the pollen morphology of the *Solanum* described it as having the psilate surface which was established through analyses of exine with optical microscopy in the studies of *S. stramoniifolium.*

Symon (1981) relates the small size of the pollen grain and the occurrence of the little complex ornamentation or lack of ornamentation in species of *Solanum*, with the expulsion process of these grains inside of the poricidal anthers. This process, according to the author, is generally executed through vibrations or "buzz pollination" by solitary bees. The same author also suggests that the large pollen grains with complex ornamentation could form deposits and block the anthers orifices in *Solanum* species. This way, a close relationship between the pollen morphology confirmed by acetolysis treatments and the pollination syndrome by "buzz pollination" presented in this research, reinforce the observations and the hypothesis of Symon (1981). Due to the fact that the pollen grains of *S. stramoniifolium* are small and with no ornamentation (psilate exine), it is probable that the grain will be expelled more easily from the poricidal anthers during the vibration of the bees.

Besides this, some authors (Erickson 1975; Thorp 1979; Corbert *et al*. 1982; Erickson & Buchmann 1983) found that the presence of electrostatic forces, at the moment of pollination by vibration, could demonstrate an advantage promoting the attachment of the pollen



Figures 4-6. Pollen grains of *Solanum stramoniifolium* (Solanaceae). 4. Polar view. 5. Equatorial view showing two of the three colpi. 6. Equatorial view showing the surface of the exine. Scale bars = 5µm.

to the body of the insect, which facilitates its transference to the stigma.

An important fact that should be reinforced is that there is a cost-benefit relationship involved in the pollination syndrome by vibrations of the bees. The bees exert a large amount of energy to move their flight muscles and to complete the vibration process. Also, there is a certain degree of waste of pollen grains in this process, and only pollen with a high protein level could justify this plant-insect relationship. This high protein level was encountered in the research of Buchmann (1986).

Carvalho *et al*. (2001) observed 14 species of bees of the Andrenidae, Apidae and Halictidae families which were visiting the inflorescence of *Solanum palinacanthum* Dunal, in Cruz das Almas, Bahia. These authors considered *Bombus* (Fervidobombus) *atratus* Franklin, *Bombus* (Fervidobombus) *morio* Swederus and *Eulaema nigrita* Lepeletier as the principal pollinators based on the pollen load and visiting time per flower. The bee's collection activity peak was observed to be between 9:00 a.m. and 3:00 p.m. It was also observed that the bees utilized the same time period for collecting pollen in *S. stramoniifolium.*

In conclusion we have found that *S. stramoniifolium* may be used as an apiculture resource for different stinging and stingless bee species providing pollen as a reward throughout the year; *Eulaema* (Apeulaema) *cingulata*, *Melipona nebulosa*, *Trigona pallens*, *Melipona seminigra merrillae* and *Melipona compressipes manaosensis* visit *S. stramoniifolim* to collect pollen; the *S. stramoniifolium* pollen morphology seems to resemble the *Solanum* genus morphological pattern studied by some authors. The reduced size of the grain and the psilated aspect of the exine justifies the type of pollinization syndrome by vibration found in the majority of the observed bees; "buzz pollination" is not the only foraging strategy observed for *S. stramoniifolium*, since "pillage" of the anthers is a behavioral form, which allows grain access by small bees as observed with *Trigona pallens*; complementary studies on the floral biology of *S. stramoniifolium* should be intensified in the Amazon region for a better understanding of the existing relationships between the pollinators and this species.

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