

# Pollen morphology of ornamental plants

## *Morfologia polínica de plantas ornamentais*

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### ABSTRACT

Pollen grains are reproductive structures with an inner wall (intine) and an outer wall (exine), related to the time required for their maturation until the germination of the pollen tube. These two walls present the morphological components used in palynological characterization. There is a lack of palynological studies for ornamental plant species in Joinville (SC). Thus, ornamental plant species without pollen descriptions from Joinville were collected. Closed buds were removed, preserved in acetic acid, the pollen grains were acetolysed and light microscopy slides were prepared. SEM images were also taken. Measurements, apertures, exine ornamentation, shape, symmetry, and amb were evaluated. The pollen morphology of the species *Angelonia minor* (Plantaginaceae), *Calliandra brevipes* (Fabaceae), *Unxia kubitzkii* (Asteraceae), and *Myrceugenia campestris* (Myrtaceae) was analyzed. The pollen grains of Plantaginaceae, Asteraceae, and Myrtaceae are in monads, radially symmetrical, isopolar, while those of Fabaceae are in polyads with irregular symmetry, heteropolar. *A. minor* has small grains, 3-colporate, suboblate, circular, microverrucate/microfossulate perforated; *C. brevipes*, very large, porate, psilate/microverrucate; *U. kubitzkii*, large, 3-colporate, oblate-spheroidal, circular, echinate; *M. campestris*, small, 3-colporate, oblate, psilate.

**Keywords:** *Angelonia*, *Calliandra*, *Myrceugenia*, *Pleroma*, pollen, *Unxia*.

### RESUMO

Grãos de pólen são estruturas reprodutivas, com uma parede interna (intina) e uma parede externa (exina), relacionadas ao tempo necessário para sua maturação até a germinação do tubo polínico. Essas duas paredes apresentam os componentes morfológicos utilizados na caracterização palinológica. Há carência de estudos palinológicos para espécies de plantas ornamentais, em Joinville (SC). Assim, espécies de plantas ornamentais sem descrições polínicas, de Joinville, foram coletadas. Botões fechados foram retirados, conservados em ácido acético, os grãos de pólen foram acetolisados e confeccionaram-se lâminas de microscopia de luz. Foram também realizadas imagens em MEV. Avaliaram-se medidas, aberturas, ornamentação da exina, forma, simetria, âmbito. Analisou-se a morfologia polínica das espécies *Angelonia minor* (Plantaginaceae), *Calliandra brevipes* (Fabaceae), *Unxia kubitzkii* (Asteraceae) e *Myrceugenia campestris* (Myrtaceae). Os grãos de pólen de Plantaginaceae, Asteraceae e Myrtaceae são em mônadas, radialmente simétricos, isopolares; os de Fabaceae, em poliade com simetria irregular, heteropolares. *A. minor* tem grãos pequenos, 3-colporados, suboblato, circulares, microverrucados/microfossulados perfurados; *C. brevipes*, muito grandes, porados, psilados/microverrucados; *U. kubitzkii*, grandes, 3-colporados, oblato-esferoidais, circulares, equinados; *M. campestris*, pequenos, 3-colporados, oblato, psilados.

**Palavras-chave:** *Angelonia*, *Calliandra*, *Myrceugenia*, *Pleroma*, pólen, *Unxia*.

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## INTRODUCTION

Pollen grains are fundamental reproductive structures in angiosperms, composed of an inner wall called the intine and an outer wall known as the exine. These structures play a crucial role in the reproductive success of plants, being remarkably resistant, which is directly related to the time required for their maturation until the germination of the pollen tube (HESSE, 2000). The exine, mainly composed of sporopollenin, is the outermost layer and the first to be formed (SANTOS, 2003). The intine is extensible and of a cellulosic nature, thin, hyaline and rich in pectin, being of paramount importance for the reproductive success of angiosperms and the outer layer is composed of microfibrils and embedded amorphous materials, which are crucial for retaining pollen moisture in the stigma, facilitating the growth of the pollen tube due to the increase in volume (JOHNSON & STEINER, 2000). These two walls present the main morphological components used in palynological characterization, which can be classified in terms of amb, polarity, symmetry, shape, size, and ornamentation. Pollen grains can vary from smooth granules to highly decorated structures and may have apertures that facilitate the exit of the pollen tube. Identification generally occurs at the genus or family level and may even reach the species level (EDLUND *et al.*, 2004).

Palynology is the field of study dedicated to the analysis of live pollen, fossil pollen, and plant spores. Both pollen grains and live spores are used to study plant relationships and evolution, while fossil pollen grains and spores are important tools for investigating paleoenvironments, stratigraphy, historical geology, and paleontology (RUDALL, 2007).

The cultivation of ornamental plants is a practice that dates to antiquity, as ancient civilizations already recognized plants with distinct characteristics and cultivated them for aesthetic pleasure. The use of ornamental plants is closely linked to environmental and socioeconomic issues. Species of this type are cultivated globally, and, in non-native regions, their cultivation can have negative impacts on both the natural environment and agriculture. Non-native (exotic) species are often used to standardize landscapes, while native plants play a crucial role in preserving local flora (McNEELY *et al.*, 2001).

There is a lack of palynological studies for species from ornamental plant families in the municipality of Joinville (SC). In this context, ornamental plant species were analyzed in relation to their pollen morphology.

## MATERIAL AND METHODS

The following species were studied: *Angelonia minor* (Plantaginaceae), *Calliandra brevipes* (Fabaceae), *Unxia kubitzkii* (Asteraceae), *Myrceugenia campestris* (Myrtaceae) (figure 1).

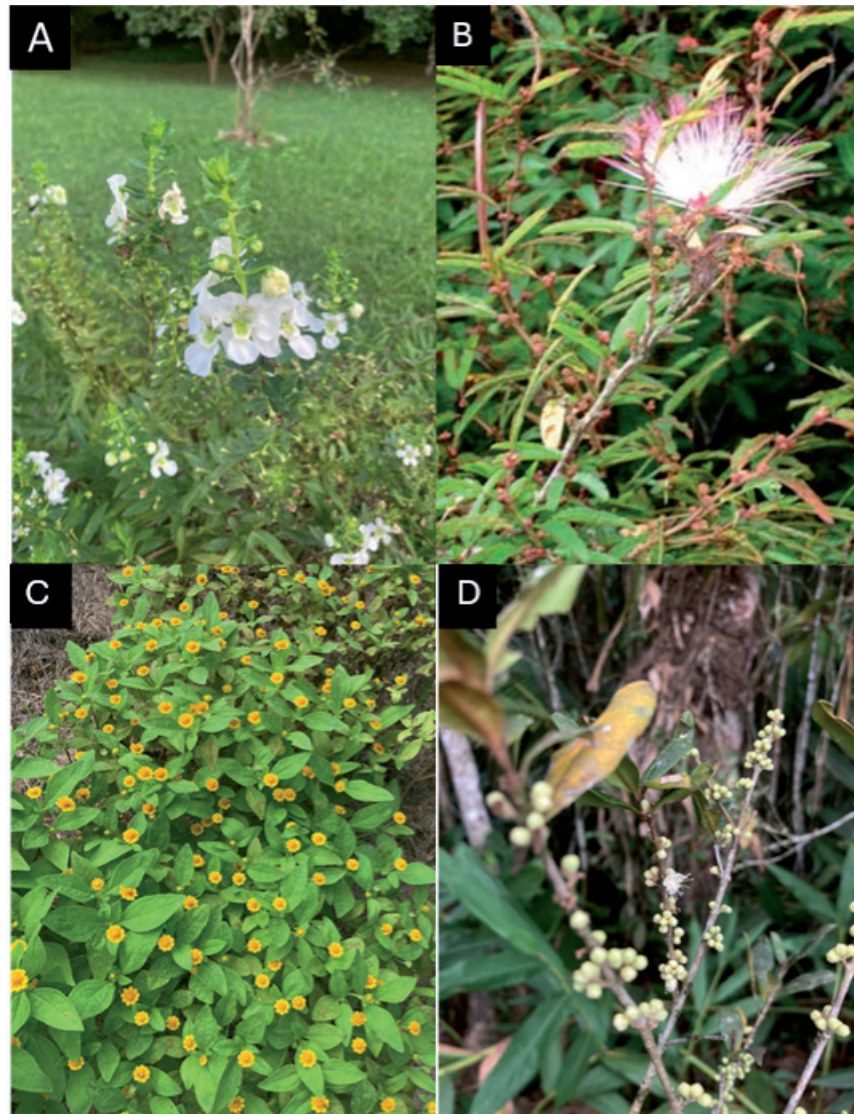
Closed buds were removed and preserved in acetic acid until the acetolysis process (ERDTMANN, 1960). Shortly before acetolysis, the buds were opened, the anthers removed and macerated, followed by the acetolysis process (the anthers were placed in acidic solutions, specific substances, and subjected to centrifugation) (ERDTMANN & SORSA, 1952). The acetolyzed pollen grains were mounted in glycerol gelatin on optical microscope slides (five slides for each species) (BARTH & MELHEM, 1988).

All slides were kept in the palynological collection of the Bee Laboratory (Label) at Univille. The slides were observed under a light microscope (400x), with the aid of the "Dino-Eye Capture 2.0" software.

Pollen grains on the slides were photographed, with 25 repetitions performed for each type of view (equatorial and polar), measuring in micrometers ( $\mu\text{m}$ ) the following parameters: equatorial diameter and polar axis (for dicotyledonous grains), as well as exine thickness (SALGADO-LABOURIAU, 2006). The grains were classified based on characteristics such as pollen unit, size, amb, symmetry, polarity, shape, apertures, and ornamentation (PUNT *et al.*, 2007).

The data were compiled into tables (Microsoft Excel), with the respective measurements of pollen grains in polar and equatorial views, exine thickness measurement showing the size range (Xmin-Xmax), the arithmetic mean and standard deviation, in addition to the other characteristics (pollen unit, size, amb, symmetry, polarity, shape, apertures, ornamentation).

Additionally, some samples were analyzed using Scanning Electron Microscopy (SEM) at the State University of Santa Catarina (Udesc). For this, the anthers of buds preserved in acetic acid were removed and macerated on coverslips to mechanically release the grains, using tweezers and a drop of acetic acid. The grains were subsequently stained with gold-palladium, analyzed, and registered.



**Figure 1** – Images of the studied species: A) *Angelonia minor* flower; B) *Calliandra brevipes* flower; C) *Unxia kubitzkii* flower; D) *Myrceugenia campestris* flower. Source: primary.

## RESULTS

Results are presented on tables 1 and 2 and on figures 2 to 6. The pollen grains of families Plantaginaceae, Asteraceae, and Myrtaceae show grains in monads, with radial symmetry, isopolar. The family Fabaceae presents grains in polyads, with irregular symmetry, and heteropolar.

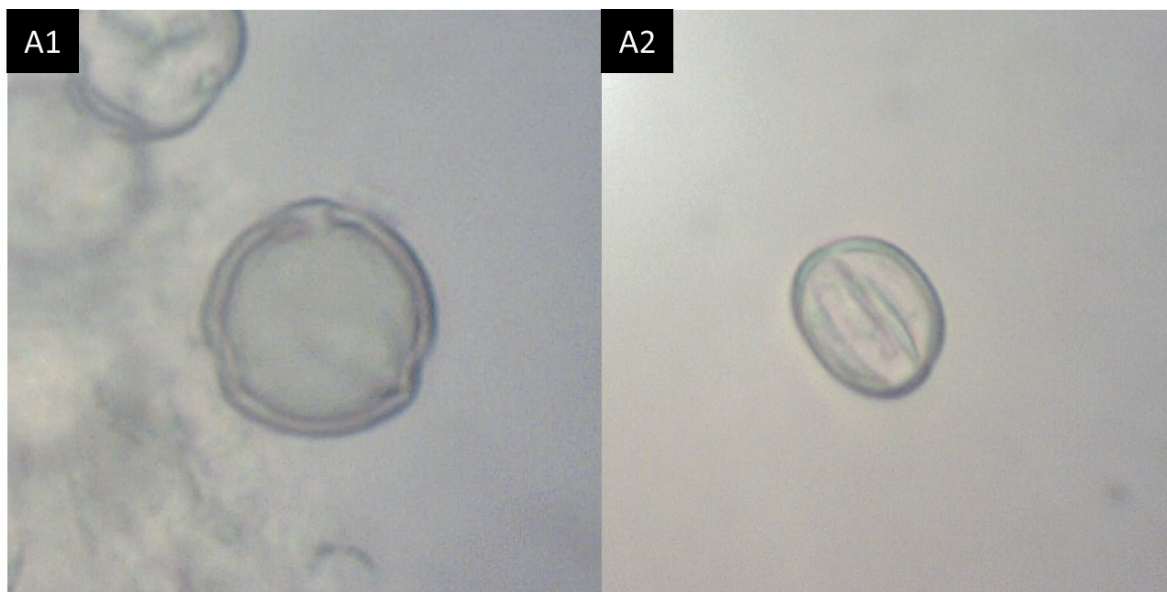
**Table 1** – Morphometric data of the pollen grains of the analyzed species. Values are in micrometers.

Species	P/E	Shape	Exine	Apertures
<i>Angelonia minor</i>	0,85	Sub oblate	1,26	Tricolporate
<i>Calliandra brevipes</i>	1,74	–	1,41	Porate
<i>Unxia kubitzkii</i>	0,93	Oblate spheroidal	1,9	Tricolporate
<i>Myrceugenia campestris</i>	0,72	Oblate	1,34	Tricolporate/angle aperturated/syncolpate

**Table 2** – Morphometric data of the pollen grains of the analyzed species. Values are in micrometers.

Species	Ornamentation	Âmb	Polar average	Equatorial average	Size
<i>Angelonia minor</i>	Microverrucate-microfossulate	Circular	13,82	16,73	Small
<i>Calliandra brevipes</i>	Psilate-microverrucate	–	113,94	65,25	Very great
<i>Unxia kubitzkii</i>	Echinate	Circular	18,85	20,16	Small
<i>Myrceugenia campestris</i>	Perforated	Triangular	14,21	19,70	Small

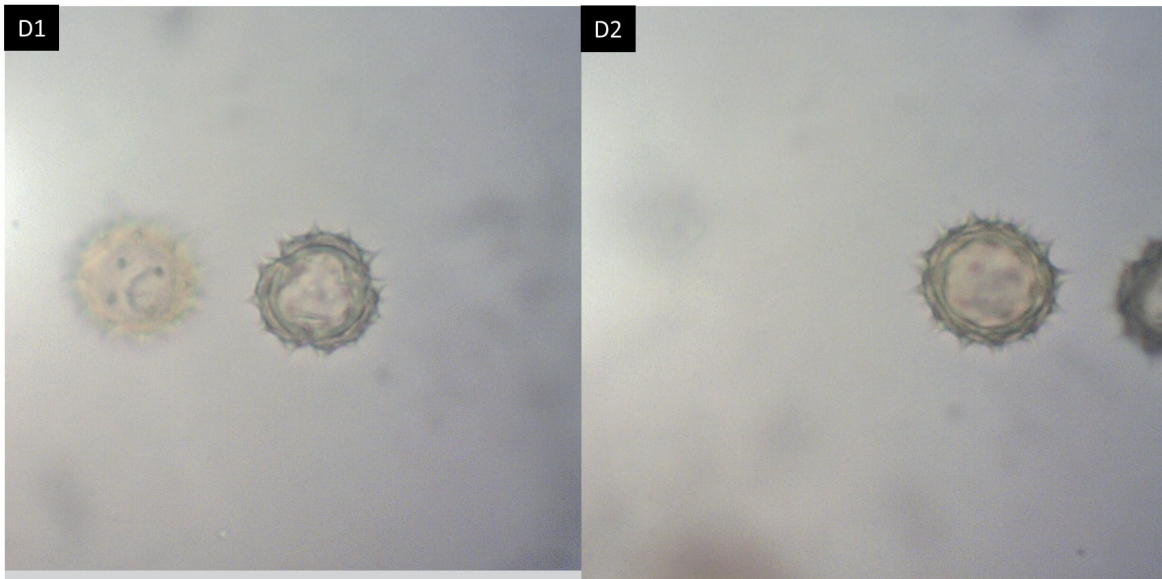
The images of the pollen grains of the studied species under light microscope are in the figures 2 to 5.



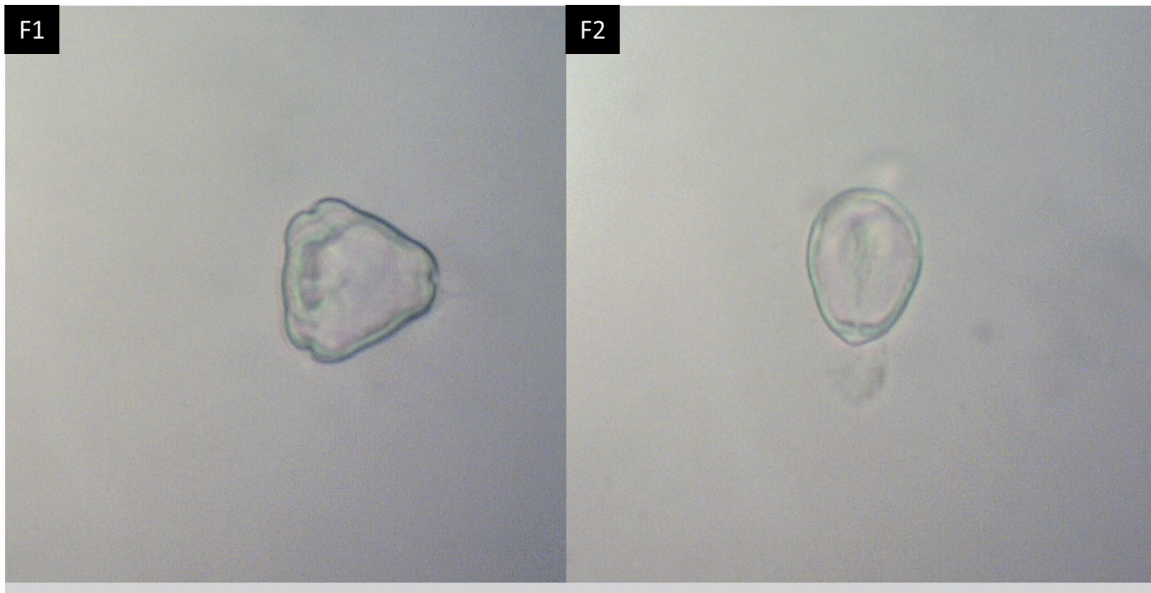
**Figure 2** – *Angelonia minor*: A1) polar axis; A2) equatorial diameter. Source: primary.



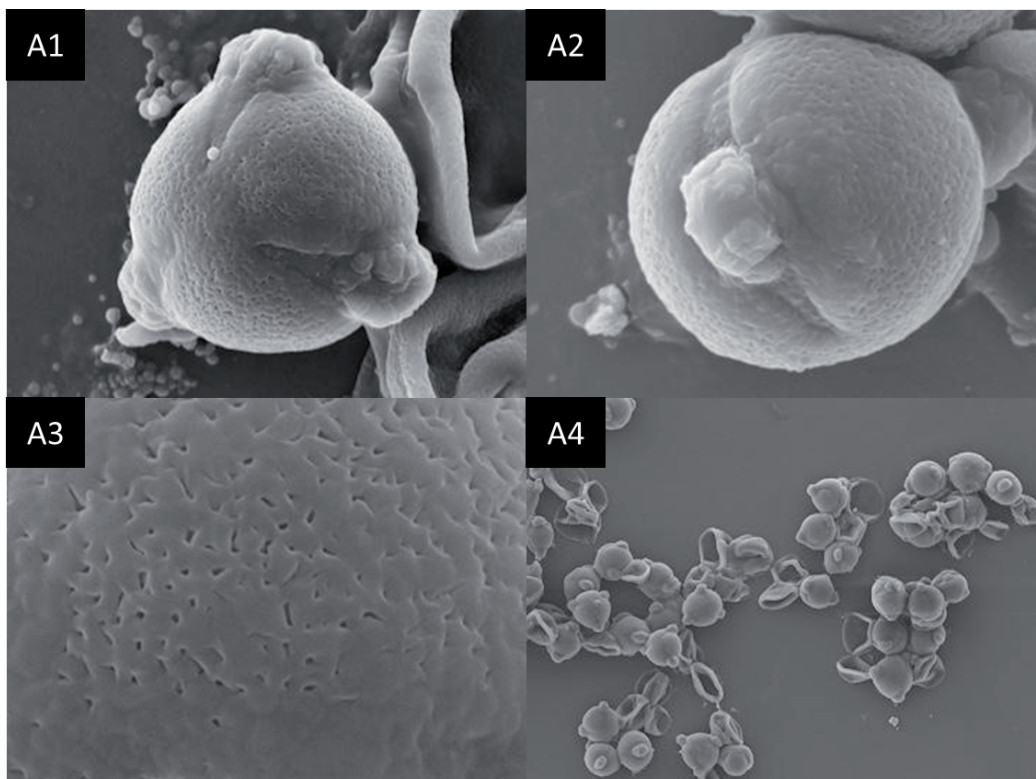
**Figure 3** – *Calliandra brevipes*. Source: primary.



**Figure 4** – *Unxia kubitzkii*: D1) polar axis; D2) equatorial diameter. Source: primary.

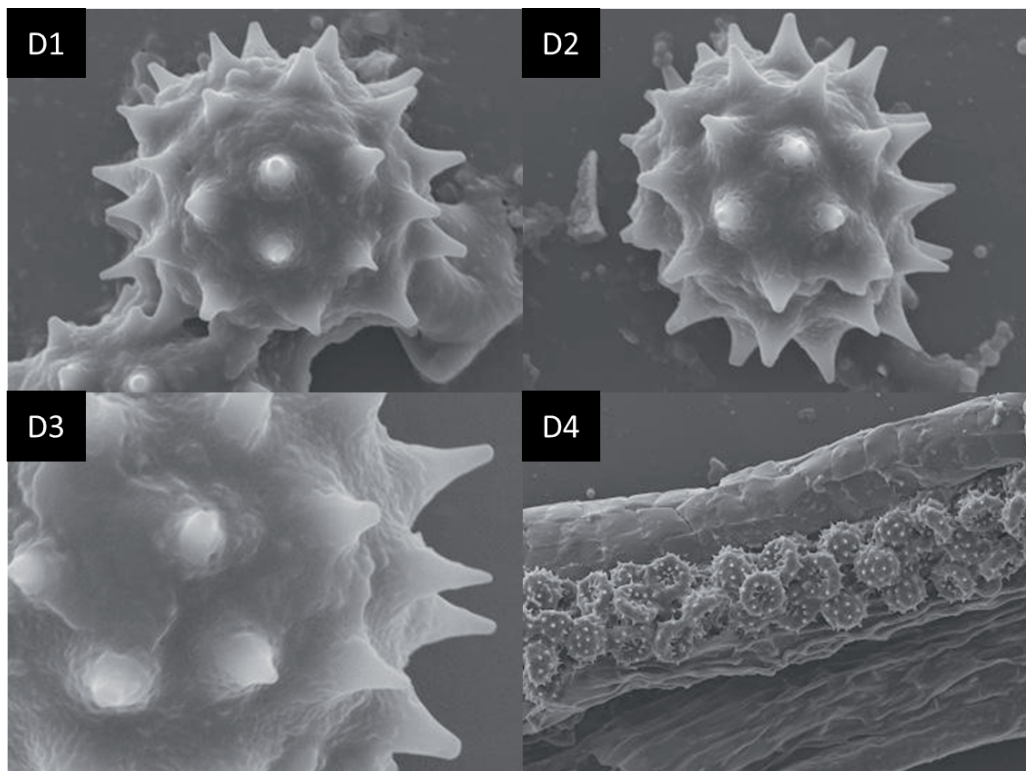


**Figure 5** – *Myrceugenia campestris*: F1) polar axis; F2) equatorial diameter. Source: primary.



**Figure 6** – Images of the pollen grains of the species *Angelonia minor* seen under SEM: A1) polar axis (Ubisch bodies can be seen in the background); A2) equatorial diameter; A3) polar axis (exine); A4) grains in polar axis and equatorial diameter. Source: primary.

The pollen grains of the analyzed species were submitted to scanning electronic microscopy at the Udesc. The resulting images are in figure 7.



**Figure 7** – Images of the pollen grains of the species *Unxia kubitzkii* seen under SEM: D1) polar axis; D2) equatorial diameter; D3) polar axis (exine); D4) grains in polar axis and equatorial diameter. Source: primary.

## DISCUSSION

### PLANTAGINACEAE

#### *Angelonia*

The Plantaginaceae family was established after the disintegration of Scrophulariaceae, with taxonomists accepting the circumscription of Plantaginaceae in a broad sense, with approximately 108 genera (APG III, 2009). Thus, Plantaginaceae are quite morphologically variable, reflecting a recent evolutionary diversification in the type of pollination (SOUZA & LORENZI, 2012).

In Brazil, 16 native genera are reported for the Plantaginaceae family, and among them, the genus *Angelonia* is the most common, with approximately 50 species currently described for the genus, thus being the largest genus of the neotropical tribe Angeloniae of Plantaginaceae (MISSOURI BOTANICAL GARDEN, 2017). This genus has a distribution restricted to the neotropical region, being exclusively found in the Americas, extending from central Mexico to the extreme south of South America (BOFF *et al.*, 2015). *Angelonia*, in Brazil, occurs predominantly in rocky fields and in the Caatinga, with 15 species endemic to Brazil, but none endemic to the Southern region (SOUZA & Hassemer 2017).

On the other hand, the Neotropical group called the *Angelonia* clade comprises about 40 species of the genera *Angelonia*, *Basistemon*, *Monttea*, *Monopera*, and the oil-free genus *Melosperma*, with the phylogenetic position of *Monopera* within the *Angelonia* clade (ALBACH *et al.*, 2005) inferred from morphological similarities with *Angelonia* (BARRINGER, 1983). Although records of the environments in which the two genera occur are incomplete, it is known that *Angelonia* species are herbs or shrubs that live in moist or waterlogged soil near rivers, while *Monopera* contains only two herbaceous species, *M. perennis*, occurring in Brazil (Mato Grosso do Sul) and Paraguay, and *M. micrantha*, occurring in seasonally dry tropical forest in northeastern Brazil (SOUZA & GIULIETTI, 2009). According

to Scatina & Souza (2021), *Angelonia* and *Monopera* are closely related genera, and *Angelonia* may be paraphyletic, due to the nesting of *Monopera* within *Angelonia*. Thus, knowledge of the pollen variability of these taxa can contribute to a more accurate taxonomic placement.

Some *Angelonia* species are used as ornamental plants, such as *A. angustifolia* and *A. salicariifolia* (SOUZA & LORENZI, 2012). *Angelonia angustifolia* Benth. is a heterotypic synonym of *A. minor* Fisch & C.A. Mey (REFLORA, 2024).

Plants of the *Angelonia* clade depend on oil-collecting bees of the tribes Centridini and Tapinotaspidini for successful pollination, with the interaction between both partners being a special case of bee/flower adaptation in the Neotropical region, with pollinating bees exploiting oil glands located in sacs in the flower, using specialized hairs on their front legs (MARTINS & ALVES-DOS-SANTOS, 2013).

The species *Angelonia minor* studied here presented characteristics similar to those described by Halbritter & Weis (2016) for *A. goyazensis*, with the exception that these authors mention spheroidal pollen (here sub oblate) and micro reticulate exine (here microfossulated). Stebler (2024a) also mentions spheroidal pollen and reticulate exine for *A. gardneri*. No palynological descriptions were found for *Monopera*.

## FABACEAE

### *Calliandra*

The genera of Mimosoideae have pollen grains that are generally released as polyads or tetrads, while monads are rare as pollen units (BARNEBY, 1998). The genus *Calliandra* Benth. includes ca. 132 species and is restricted to the Americas, with three centers of species diversity: Mexico, eastern Brazil (mainly the Espinhaço range) and the Andes (MacQUEEN & HERNÁNDEZ, 1997).

The dispersal units of *Calliandra* are of one of two types: polyads and bitetrads (VAN CAMPO & GUINET, 1961). Guinet & Hernández (1989) state that, although *Calliandra* species consistently have 8-grain polyads, tetrads occasionally occur in some species (e.g., *C. spinosa* Ducke). Thus, *Calliandra* polyads have 8 grains, strongly bisymmetrical in wide view, with the individual grains in a monoplanar arrangement, with a margin comprising six peripheral pollen grains surrounding the two remaining central grains (GUINET, 1965). Hernandez & Sousa (1988) described isolated pollen grains from *Calliandra* polyads as pyramid-shaped, with 6-8 circular pores and a reticulate exine. Individual grains from the same polyad show strong heteromorphy, with the central grains differing from the peripheral grains in size, shape, and, less obviously, ornamentation (GUINET, 1981).

Bauermann *et al.* (2009) studied *C. selloi* and report a very large polyad, with eight cells in a bitetrad, elongated shape, one end rounded and the other conical with a terminal pore, acalymmate (a dispersal unit of two or more monads enclosed by an exine, which is discontinuous at the junctions between the monads), with a rugulate exine. However, Halbritter (2016) reports *Calliandra emarginata* polyads with pores at the junctions of the monads. On the other hand, Stebler (2024b) reports for *Calliandra tweedii* a polyad with a verrucate coating and a pollen tube that generally appears to grow at the tip (suggesting that the polyad is monoporate). The species studied here, *Calliandra brevipes*, has a psilate-micro verrucate exine, the pores were not observable, and it is acalymmate, the remaining characteristics being as described for the genus, although a pollen tube is also observed at the narrower end of the polyad. According to Santos & Romão (2008), the tube seen at the top of the polyad, termed “viscine bodies” by Greissl (2006), is actually the sticky liquid at the apex of the polyad that solidifies upon contact with air, and not a structure *sensu* sporopollenin viscin threads. These and other inconsistencies regarding the terminology related to mimosoid polyads led Teppner (2007) to clarify and propose the adoption of a terminology to be used specifically for Mimosoideae polyads and, more specifically, for *Calliandra*. *Calliandra* possesses a wide range of potentially useful morphological characteristics, which are of great value in establishing affinities between the groups of species included in this genus (PRENNER, 2004).

## ASTERACEAE

*Unxia*

The genus *Unxia* belongs to the tribe Millerieae Lindl. The tribe Millerieae was re-established by Panero & Funk (2002) based on phylogenetic analyses using chloroplast molecular data. The new circumscription accommodated in the tribe the genera that belonged to the subtribes Desmanthodiinae, Espeletiinae, Galinsogiinae, Guardioliinae, Melampodiinae, and Milleriinae of Heliantheae *sensu* Robinson (1981). Millerieae currently has 34 genera and about 400 species found mainly in central Mexico and the northern Andes, with some species in tropical regions of the Old World, especially in Africa (PANERO, 2007). The tribe Millerieae Lindl. includes, in Brazil, 11 genera and 38 species, among which is *Unxia* (REFLORA, 2024). Panero (2007) states that Millerieae does not possess any morphological characteristic that defines it, but that, nevertheless, most species tend to have opposite leaves, scarious receptacle paleae, subcylindrical cypselae, and a paleaceous or bristly pappus, when present.

The genus *Unxia* is distinguished by having a characteristic combination of the aforementioned attributes. In Brazil, it is native, but not endemic, its natural occurrence being in northern Brazil (Acre, Amazonas, Amapá, Pará, Rondônia, Roraima States), in the Amazon phytogeographic domain, in the vegetation types of Terra Firme Forest and Várzea Forest, and it is also considered an ornamental plant (REFLORA, 2024).

Da Silva *et al.* (2020) cite for *Unxia camphorata* a medium-sized, radially symmetrical, isopolar grain, subtriangular amb, oblate-spheroidal to prolate-spheroidal shape, tricolporate, with a long *colpus*, lalongate endoaperture, echinate exine ( $2.31 \pm 0.39 \mu\text{m}$  (1.81-3.05)). The pollen grain of the species studied here, *Unxia kubitzkii*, is small, radially symmetrical, isopolar, with subtriangular amb, oblate-spheroidal shape, tricolporate, with short and not so visible *colpi*, echinate exine ( $1.9 \mu\text{m}$  thickness).

## MYRTACEAE

*Myrceugenia*

Myrtaceae is represented by approximately 1,000 species worldwide, being one of the most important families in Brazil (more than a hundred species) and the infra-family classification proposed by Wilson *et al.* (2005) recognizes two subfamilies, Myrtoideae and Psiloxylodeae, and 17 tribes. Myrtoideae includes several tribes, with Myrtaceae concentrated in a single tribe, Myrteae, and three subtribes: Myrciinae, Eugeniinae, and Myrtinae, all Brazilian Myrtaceae being included in the Tribe Myrteae (WILSON *et al.*, 2001). *Myrceugenia* is a genus of woody, flowering, perennial trees and shrubs of the family Myrtaceae, native to South America (from central Brazil to southern Chile), which includes about 46 species native to South America and is closely related to the genus *Luma* (which does not occur in Brazil), some botanists including *Myrceugenia* in *Luma* (GOVAERTS *et al.*, 2008).

Da Silva *et al.* (2020) describe the grains of *Myrceugenia euosma* as being in monads, small to medium, radial, isopolar, triangular in shape, peroblate to oblate, tricolporate, with long *colpus*, parasyncolporate, with circular endoaperture, *fastigium*, microreticulate exine ( $2.38 \pm 0.32 \mu\text{m}$  (1.65-2.89)). In the present study, with *M. campestris*, small pollen was observed, with radial symmetry, isopolar, triangular amb, oblate, tricolporate, angleaperturated, syncolpate and with psilate exine ( $1.34 \mu\text{m}$  thickness).

## CONCLUSION

The pollen grains of the species under study exhibit only minor variations from the patterns reported for their respective clades. These subtle differences help to better understand the species' diversity by highlighting the uniqueness of the pollen characteristics.

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