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Pollen types of Sapindaceae from Brazilian forest fragments: apertural variation

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ABSTRACT

Morphological variations in angiosperm pollen grains may aid in the differentiation of families, genera and species. Sapindaceae pollen morphology holds promise for the recognition of taxa of this cosmopolitan family, which is well distributed in tropical regions and possesses great morphological diversity. This study presents the pollen morphology of 23 native Brazilian species of Sapindaceae from forest fragments in the state of São Paulo, Brazil. The aim was to identify pollen types in order to expand the morphological knowledge of the analyzed species and contribute to the taxonomy and conservation of the family. Pollen grains were acetolysed, measured and photographed using light and scanning electron microscopy. Qualitative data were described for three pollen types, while quantitative data were analyzed by descriptive and multivariate statistics. The pollen grains are monads, isopolar or heteropolar, small to medium in size, peroblate to oblate-spheroidal and with a subcircular to quadrangular amb. Variation in the type of the apertures [3-porate, 3-(4)-colporate, 3-syncolporate or 3-parasyncolporate] allowed the analyzed genera to be separated into three pollen types. Furthermore, differences in ornamentation (psilate, rugulate, striate, microreticulate, reticulate) delimit species within the established pollen types.

Keywords: Brazil, eurypalynous, palynotaxonomy, pollen grains, pollen morphology

Introduction

Human activities often result in the fragmentation of forest habitats, particularly in tropical regions. Due to this fragmentation, the knowledge of biodiversity in these areas favors preservation, avoiding large losses (Kronka *et al.* 2005). The Brazilian forest fragments are composed of seasonal semideciduous forest in Cerrado areas, comprising examples of plant formations that have resisted fragmentation processes in the Northwest of the State of São Paulo, being Sapindaceae one of the most representative families in this area (Ranga *et al.* 2012).

Sapindaceae is the largest and most important family of Sapindales (APG IV 2016) and comprises about 140 genera and 1,900 species, distributed mainly in tropical regions (Acevedo-Rodríguez *et al.* 2011). In Brazil, the family is represented by 28 genera and 417 species, of which 190 species are endemic (BFG 2015). The greatest diversity within the group occurs in the areas of Atlantic and Amazonian forests (Acevedo-Rodriguez 1993), biomes known for high species richness and high rates of endemism of angiosperms (Daly & Mitchell 2000).

Some floristic surveys point out the richness of Sapindaceae species in forest fragments in Brazil (among them Santos & Kinoshita 2003; Durigan *et al.* 2008; Cielo-

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Filho *et al.* 2009; Costa *et al.* 2011; Rosado *et al.* 2014). These studies emphasize that the richness of climbing plants in these environments is usually concentrated in a few families, among them Sapindaceae (Stranghetti & Ranga 1998; Rezende & Ranga 2005; Rezende *et al.* 2007; Santos *et al.* 2009).

Currently, several authors describe for Sapindaceae *sensu lato* four subfamilies: Dodonaeoideae, Hippocastanoideae, Sapindoideae and Xanthoceroideae (Harrington *et al.* 2005; Thorne & Reveal 2007; Buerki *et al.* 2009; 2010a). Buerki *et al.* (2010b) reviewed the circumscription of Sapindaceae using molecular, morphological and biogeographic data, and they included in this analysis several important genera that had not been discussed in taxonomic studies. These authors indicated two approaches to treat the genera of Sapindaceae: the classification proposed by APG IV (2016) where the family has a broad definition in Sapindaceae *sensu lato*, or the choice to consider Aceraceae, Hippocastanaceae and Sapindaceae as distinct families and to exclude *Xanthoceras* Bunge, considering this genus as the monotypic family Xanthoceraceae (Buerki *et al.* 2010b).

Studies on Sapindaceae pollen morphology have been conducted by Erdtman (1952), Merville (1965), Barros (1969), Campos & Melhem (1969), Salgado-Labouriau (1973), Carreira (1976), Muller & Leenhouts (1976), Markgraf & D'Antoni (1978), Cruz & Melhem (1984), Roubik & Moreno (1991), Ferrucci & Anzotegui (1993), Ham & Tmolik (1994), Pire *et al.* (1998), Luz & Barth (1999), Perveen (2000), Melhem *et al.* (2003), Marinho (2017) and Siahkolaee *et al.* (2017). These studies present the morphological description of the pollen grains of some species and genera of the family. Other species had their pollen grains described in some taxonomic studies, such as Somner & Ferrucci (2009), Somner *et al.* (2013) and Acevedo-Rodriguez *et al.* (2011).

Sapindaceae pollen presents variations in the polarity, shape, amb, size and mainly regarding the type and number of apertures and the ornamentation of the exine. However, morphological studies rarely describe the pollen types for the family, which could help in the morphological grouping of genera and species. Thus, the aim of this work was to identify pollen types in Sapindaceae and to expand the morphological knowledge of the analyzed species from Brazilian forest fragments, increasing the studies on pollen conducted for the area (Souza & Gasparino 2014; Belonsi & Gasparino 2015; Dutra & Gasparino 2018; Landi & Gasparino 2018 and Souza *et al.* 2019).

Materials and methods

We studied the pollen grains of Sapindaceae species (Tab. 1) native of the remnant forest fragments of the northwest area of the State of São Paulo. These species occur throughout the Brazilian territory (Fig. 1, Specieslink 2019). Ranga *et al.* (2012) and Sprengel-Lima & Rezende (2013) describe 23 Sapindaceae species in the northwest area of the State of São Paulo (area used as the basis for this study); nonetheless, *Allophylus sericeus* Cambess., *Paullinia rhomboidea* Radlk., *Serjania glutinosa* Radlk., *S. marginata* Casar. and *Thinouia mucronata* Radlk. were not analyzed due to a lack of pollen material. The species *Allophylus racemosus* Sw., *Paullinia spicata* Benth, *P. stipularis* Benth, *Urvillea rufescens* Cambess, and *U. uniloba* Radlk. have also been described for the Brazilian forest fragments and were included in the analysis. Pollen grains of 35 specimens were studied by light microscopy (LM) and scanning electron microscopy (SEM). The materials were obtained from dried herbarium specimens supplied from INPA, SJRP and SP herbaria (acronyms according to Thiers 2016). The pollen samples were acetolyzed according to the method described by Erdtman (1960), with the modifications cited by Melhem *et al.* (2003). Pollen grain diameters (n = 25), aperture and exine thickness (n = 10) were measured within seven days of preparation. For SEM, acetolyzed and non-acetolyzed pollen grains were used, following Melhem *et al.* (2003). Permanent slides of light microscopy are deposited in the pollen reference collection of the Departamento de Biologia Aplicada à Agropecuária, Jaboticabal, SP, Brazil.

Statistical analysis was conducted to obtain the means (x), standard deviation (s_x), standard error (s), 95 % confidence intervals (CI), coefficient of variability (V), and range (R) following Vieira (2011) and Zar (2010). To compare the values of the pollen grain diameters, the graphs of the software MINITAB10.3 for Windows were employed, which represent the mean and the confidence interval values. To determine whether the pollen data

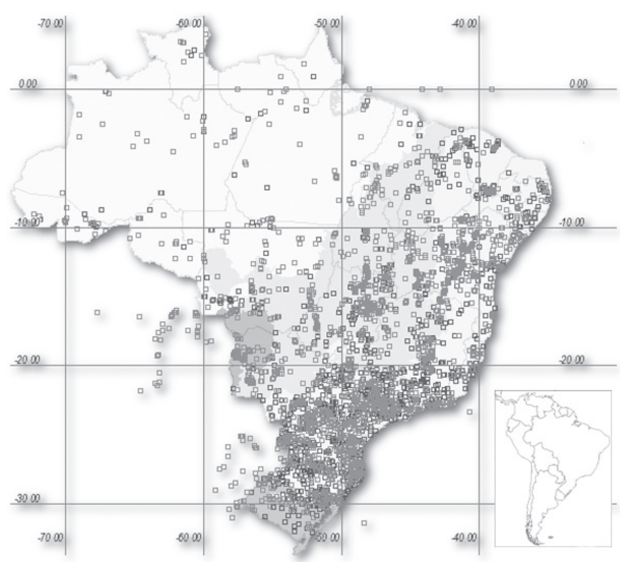

Figure 1. Occurrence map of the analyzed Sapindaceae species in Brazil. The filled squares correspond to the geographical coordinates and the empty squares, to the localities of collections available in the Specieslink database (http://splink.cria.org.br/).

permitted the grouping of species, a principal component analysis (PCA) was performed using the programs FITOPAC 1 (Shepherd 1996) and PC-ORD version 5.15 (McCune & Mefford 2011). Seven metric variables were used for the PCA: PDEV (polar diameter equatorial view), EDEV (equatorial diameter in equatorial view), WAPE (width aperture), EXIN (exine thickness), SEXI (sexine thickness), NEXI (nexine thickness) and SHAP (shape).

Furthermore, to determine whether the pollen characteristics provided additional discrimination among the genera and species analyzed, the data obtained for the pollen grains were compared by a cluster analysis (UPGMA and Euclidean distance) also using the software PC-ORD (McCune & Mefford 2011).

The pollen terminologies follow Punt *et al.* (2007) and Hesse *et al.* (2009). We adopted Faegri & Iversen (1966) and Gasparino *et al.* (2013) for the polar area index and the width index of colpi, respectively. The pollen description is presented in the following order: pollen unit, polarity, size (P x E means), amb, polar area details, shape, apertures (number, type, length and width), details of ectoapertures, details of endoapertures, pollen wall stratification, ornamentation, sexine and nexine thickness. This sequence is a model for the detailed presentation of qualitative data on the pollen grains. Photomicrographs were performed with a light microscope Leica IM50, for LM photos, and the electromicrographs with a JEOL, JSM5410 scanning electron microscope for the SEM images.

Results

General description

The pollen grains of the studied Sapindaceae species are monads; isopolar or heteropolar; small to medium; with subcircular, subtriangular, triangular or quadrangular amb in polar view; peroblate, oblate, suboblate to oblate-spheroidal; 3-porate, 3-(4)-colporate or 3-colporate with long and narrow ectoapertures (3-syncolporate or 3-parasyncolporate); circular, lalongate or lolongate endoaperture. The exine is tectate with striate or rugulate

Table 1. Voucher specimens of Sapindaceae from Brazilian forest fragments. SJRP = UNESP, Campus São José Rio Preto; Location: Brazil. São Paulo. São José do Rio Preto. INPA = Instituto Nacional de Pesquisas Amazônicas; Location: Brazil. Amazonas. Manaus.

Taxon	Locality
Allophylus racemosus Sw.	BRAZIL. Paraná: Piraquara, 15-XII-1995, *J. M. Silva* 1583 (SJRP 17486).
Cardiospermum grandiflorum Sw.	BRAZIL. São Paulo: Paulo de Faria, 27-V-1993, *V. Stranghetti* 107 (SJRP 10113); Paulo de Faria, 22-VII-1994, *V. Stranghetti* 350 (SJRP 10200).
Cupania vernalis Cambess.	BRAZIL. Paraná: Londrina, 08-V-1992, *V. C. M. Delgado* 09 (SJRP 19377); São Paulo: Paulo de Faria, 04-IV-2002, *F. Tomasetto* 282 (SJRP 26593).
Diatenopteryx sorbifolia Radlk.	BRAZIL. São Paulo: Paulo de Faria, 14-IX-2001, *A. A. Rezende* 757 (SJRP 29576); Paulo de Faria, 18-IX-2001, *F. Tomasetto* 283 (SJRP 26592).
Dilodendron bipinnatum Radlk.	BRAZIL. São Paulo: Paulo de Faria, 08-VI-2001, *F. Tomasetto* 153 (SJRP 26594).
Magonia pubescens A. St.-Hil.	BRAZIL. Mato Grosso: Chapada dos Guimarães, 01-X-1990, I. *Wrindisch 5782* (SJRP).
Matayba elaeagnoides Radlk.	BRAZIL. Mato Grosso do Sul: Nova Andradina, 24-XIII-2012, *A. A. Rezende & N. T. Ranga* 1338 (SJRP 31179).
Paullinia elegans Cambess.	BRAZIL. Paraná: Três Barras do Paraná, 25-II-1993, *R. M. Britez* n/n (SJRP 08535).
Paullinia spicata Benth.	BRAZIL. São Paulo: São José do Rio Preto, 26-X-1995, *A. A. Rezende* 219 (SJRP 13544).
Paullinia stipularis Benth.	BRAZIL. Amazonas: Alvarães, 31-I-2000, *M. A. D. Souza* 838 (INPA 203244).
Serjania caracasana (Jacq.) Willd.	BRAZIL. São Paulo: São José do Rio Preto, 06-XII-1995, *A. A. Rezende* 281 (SJRP).
Serjania fuscifolia Radlk.	BRAZIL. São Paulo: Birigui, 03-V-1999, *E. Montilha et al.* 05 (SJRP 19923).
Serjania hebecarpa Benth.	BRAZIL. São Paulo: São José do Rio Preto, 30-V-1996, *A. A. Rezende* 457 (SJRP 13552); São José do Rio Preto, 16-VIII-1996, *K. G. Melzi n/n* (SJRP 14931).
Serjania laruotteana Cambess.	BRAZIL. São Paulo: Campinas, 24-IX-1996, *K. Santos n/n* (SJRP 30321); Birigui, 11-XIII-1999, *E. Montilha et al. n/n* (SJRP);
Serjania lethalis A. St. Hil.	BRAZIL. São Paulo: Vinhedo, 17-VIII-2002, *J. R. Guillaumon* n/n (SJRP 28821); Barretos, 27-V-2010, *O. Augusto* n/n (SJRP 31031).
Serjania meridionalis Cambess.	BRAZIL. São Paulo: Campinas, 27-II-2006, *K. Santos & A. A. Rezende* n/n (SJRP 30318), Vinhedo, 14-II-2004, *J.R. Guillaumon* n/n (SJRP 28792).
Serjania orbicularis Radlk.	BRAZIL. São Paulo: Onda Verde, 06-III-1998, *N. T. Ranga & A. A. Rezende* n/n (SJRP).
Serjania pinnatifolia Radlk.	BRAZIL. São Paulo: Paulo de Faria, 19-IV-1994, *V. Stranghetti* 307 (SJRP 10124).
Serjania tristis Radlk.	BRAZIL. São Paulo: São José do Rio Preto, 28-II-1996, *A. A. Rezende 332* (SJRP); Onda Verde, 11-IV-1996, *N. T. Ranga & A. A. Rezende* 362 (SJRP).
Urvillea laevis Radlk.	BRAZIL. São Paulo: Campinas, 27-II-2006, *K. Santos & A. A. Rezende n/n* (SJRP 30326); Paulo de Faria, 19-IV-2001, *A. A. Rezende* 669 (SJRP).
Urvillea rufescens Cambess.	BRAZIL. Rio de Janeiro: Araruama, 26-VIII-1965, *W. Hoehne* 6095 (INPA 141300).
Urvillea ulmacea Kunth	BRAZIL São Paulo: São José do Rio Preto, 03-IV-1978, *M. Coleman* 295 (SJRP 00705); Vinhedo, 13-VIII-2002, *J. R. Guillaumon n/n* (SJRP 28815).
Urvillea uniloba Radlk.	BRAZIL. São Paulo: Paulo de Faria, 20-V-1994, *V. Stranghetti* 328 (SJRP 10640).

ornamentation, or semitectate, microreticulate or reticulate. The sexine is thicker than the nexine (Figs. 2-7).

Type I. 3-porate (Figs. 2A, 3, Fig. 7A-B; Tabs. 2-4)

Pollen grains heteropolar, small to medium 19.90-25.62 μm x 29.95-40.62 μm (Tabs. 2-3); triangular or subtriangular amb (*A. racemosus*, Fig. 3A and *P. stipularis*, Fig. 3J); oblate (P/E = 0.56-0.66, Tab. 2); 3-porate (1.29-5.65 μm - Fig. 2A, Tab. 4); the exine is tectate rugulate (*P. spicata*, Fig. 7A-B), semitectate, microreticulate (*P. elegans*, Fig. 3E-F) or semitectate, reticulate homobrochate (*A. racemosus*, Fig. 3C-C' and *P. stipularis*, Fig. 3L); exine (2.16-2.96 μm), sexine (1.41-1.95 μm) and nexine (0.55-0.62 μm - Tab. 4).

Comments: The largest pollen grains were observed in *Paullinia spicata* and the smallest pollen grains, in *Allophylus racemosus* (Tab. 3). The thickest exine was observed in *P. spicata* and the pollen grains with thinnest exine are those of *P. elegans* (Tab. 4).

Species included: *Allophylus racemosus*, *Paullinia elegans*, *P. spicata* and *P. stipularis*.

Type II. 3-(4)-colporate (Figs. 2B, 4, 7C-E; Tabs. 2-4)

Pollen grains isopolar, small to medium 19.49-27.08 μm x 21.13-31.49 μm (Tabs. 2-3); subcircular or quadrangular amb (Fig. 4H); suboblate or oblate-spheroidal (*Diatenopteryx sorbifolia*) (Tab. 2); 3-colporate (Fig. 2B), long and narrow ectoapertures, without anastomose in the polar area (Tab. 4), lalongate (*D. sorbifolia*, Fig. 4C) or lolongate endoapertures (Tab. 4); the exine is tectate striate (*Dilodendron bipinnatum*, Figs. 4E, 7C-D) or semitectate microreticulate homobrochate (*D. sorbifolia,* Fig. 4C and *Magonia pubescens*, Fig. 7E); exine (2.29-2.91 μm), sexine (1.57-1.92 μm) and nexine (0.58-0.69 μm - Tab. 4).

Comments: *Magonia pubescens* presents pollen grains and exine thickness greater than the other species (Tabs. 3-4). In this species, 4-colporate and quadrangular amb pollen grains were also observed (Figs. 2B, 4H).

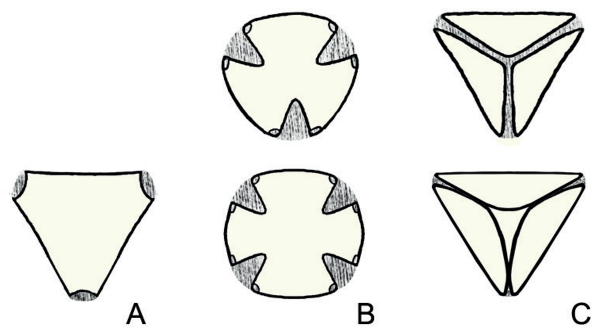

Figure 2. Illustrative scheme of Sapindaceae pollen grains. **A.** Pollen Type I -3-porate. **B.** Pollen Type II - 3-(4)-colporate. **C.** Pollen Type III - 3-syncolporate or 3-parasyncolporate.

Table 2. Morphological characterization of Sapindaceae pollen grains. P/E = Ratio between polar and equatorial diameter; PT = Pollen type; Endo = Endoaperture; EO = Exine ornamentation; S = Small; M = Medium; O = Oblate; P = Peroblate; OE = Oblate-spheroidal; SO = Suboblate; I = 3-porate; II = 3-(4)-colporate; III = 3-syncolporate or 3-parasyncolporate; LO = Lolongate; LA = Lalongate; CIR = Circular; RT = Reticulate; RU = Rugulate; MR = Microreticulate; ST = Striate; PS = Psilate.

Species	Size	P/E	Shape	PT	Endo	EO
Allophylus racemosus	S-M	0.66	O	I	-	RT
Cardiospermum grandiflorum	S-M	0.53	O	III	LO	RT
Cupania vernalis	S-M	0.48	P	III	LO	RG
Diatenopteryx sorbifolia	S	0.92	OE	II	LA	MR
Dilodendron bipinnatum	S	0.85	SO	II	LO	ES
Magonia pubescens	M	0.86	SO	II	LO	MR
Matayba elaeagnoides	S	0.64	O	III	CIR	PS
Paullinia elegans	S-M	0.56	O	I	-	MR
Paullinia spicata	S-M	0.64	O	I	-	RG
Paullinia stipularis	S-M	0.64	O	I	-	RT
Serjania caracasana	S-M	0.61	O	III	LO	MR
Serjania fuscifolias	S-M	0.58	O	III	LO	MR
Serjania hebecarpa	M	0.58	O	III	LO	MR
Serjania laruotteana	M	0.60	O	III	LO	MR
Serjania lethalis	S-M	0.61	O	III	CIR	RT
Serjania meridionalis	S-M	0.60	O	III	CIR	MR
Serjania orbicularis	M	0.57	O	III	LO	MR
Serjania pinnatifolia	M	0.59	O	III	LO	RT
Serjania tristis	S-M	0.52	O	III	LO	RT
Urvillea laevis	S-M	0.52	O	III	CIR	MR
Urvillea rufescens	S-M	0.58	O	III	CIR	MR
Urvillea ulmacea	S-M	0.59	O	III	CIR	RT
Urvillea uniloba	S-M	0.63	O	III	CIR	RT

Species included: *Diatenopteryx sorbifolia*, *Dilodendron bipinnatum* and *Magonia pubescens*.

Type III. 3-syncolporate or 3-parasyncolporate (Figs. 2C, 5-6, 7F-N; Tabs. 2-4)

Subtype a. Syncolporate (Figs. 5, 7F-M)

Pollen grains isopolar (*Urvillea rufescens*, Fig. 5Q) or heteropolar, small to medium 16.51-22.87 µm x 30.90-37.23 µm or medium 25.70-28.21 µm x 43.70-46.97 µm (*S. hebecarpa*, *S. laruotteana*, *S. orbicularis* and *S. pinnatifolia*) (Tabs. 2-3); subtriangular (*U. ulmacea*, Fig. 5R) or triangular amb; oblate (P/E = 0.53-0.63, Tab. 3); 3-syncolporate (Fig. 2C), very long and narrow ectoapertures, anastomose in the polar area, lolongate (*Cardiospermum grandiflorum*, *S. caracasana*, *S. hebecarpa*, *S. laruotteana*, *S. meridionalis*, *S. orbicularis*, *S. pinnatifolia* and *S. tristis*) or circular (*S. lethalis*, *U. laevis*, *U. rufescens*,

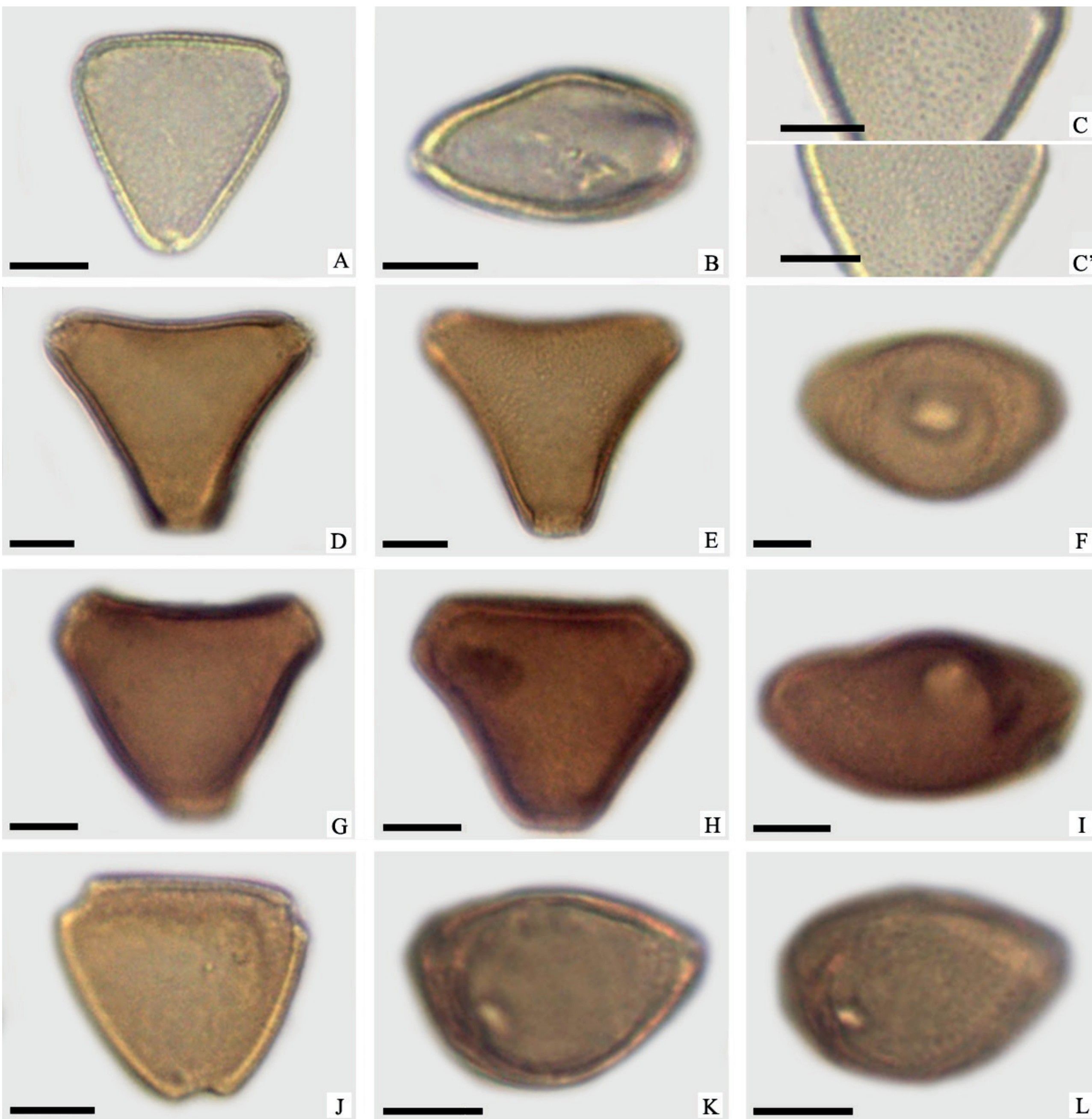

Figure 3. Photomicrographs of the Sapindaceae pollen grains. Type I. **A-C**. *Allophylus racemosus* Sw. **A.** General aspect, polar view; **B.** General aspect, equatorial view; **C.** Optical section, ornamentation. **D-F.** *Paullinia elegans* Cambess. **D.** General aspect, polar view; **E.** Polar view, ornamentation; **F.** General aspect, equatorial view and porate aperture. **G-I.** *Paullinia spicata* Benth. **G.** Polar view, porate aperture; **H.** General aspect, optical section; **I.** Equatorial view, porate aperture. **J-L.** *Paullinia stipularis* Benth. **J.** General aspect, polar view; **K.** General aspect, equatorial view; **L.** Equatorial view, ornamentation. Scale bars: **C-C'** = 5 µm; **A-B**, **D-L** = 10 µm.

U. ulmacea and *U. uniloba*, Tabs. 2-4) endoapertures; the exine is semitectate microreticulate homobrochate (*C. grandiflorum*. Figs. 5A-B, 7F, *S. caracasana,* Fig. 5D, and *S. meridionalis*) or heterobrochate (*S. hebecarpa, S. laruotteana,* Fig. 5G-H, *U. laevis*, Fig. 7K-L and *U. rufescens*, Fig. 5P-Q), sometimes not evident (*S. orbicularis*); reticulate heterobrochate (*S. lethalis,* Fig 7H, *S. pinnatifolia,* Figs. 5L-7J, *S. tristis*, Fig. 5O, *U. ulmacea,* Figs. 5R-7M, and *U. uniloba*); exine (2.15-3.00) µm, sexine (1.44-2.01 µm) and nexine (0.46-0.60 µm - Tab. 4).

Comments: The largest pollen grains were observed in *Serjania laruotteana*, *S. orbicularis* and *S. hebecarpa* (Tab. 3). The species with the greatest thickness of the exine pollen is *S. meridionalis* (Tab. 4).

Species included: *Cardiospermum grandiflorum*, *Serjania caracasana*, *S. hebecarpa*, *S. laruotteana*, *S. lethalis*, *S. meridionalis*, *S. orbicularis*, *S. pinnatifolia*, *S. tristis*, *Urvillea laevis, U. rufescens*, *U. ulmacea* and *U. uniloba*.

Subtype b. Parasyncolporate (Figs. 2C, 6, 7N; Tabs. 2-4)

Pollen grains isopolar (*Cupania vernalis,* Fig. 6C and *Matayba elaeagnoides*, Fig. 6F) or heteropolar (*Serjania fuscifolia*, Fig. 6I), small 14.26 µm x 29.85 µm (*C. vernalis*) or small to medium 16.62-22.46 µm x 25.90-38.56 µm (Tabs. 2-3); triangular amb (Figs. 6B, E, G-H); peroblate (*C. vernalis*) or oblate (*M. elaeagnoides* and *S. fuscifolia*, Tab. 2); 3-parasyncolporate (Figs. 2C, 6A-B, D-E, H, 7N), very long and narrow ectoapertures with the apices divided into two branches and anastomose in the polar area, lolongate (*C. vernalis* and *S. fuscifolia*) or circular (*M. elaeagnoides*, Tabs. 2-4) endoapertures; the exine is tectate psilate (*M. elaeagnoides*, Fig. 6D-F), rugulate (*C. vernalis*, Fig. 6B-C), or semitectate microreticulate homobrochate (*S. fuscifolia*, Fig. 6H-I); exine (1.94-2.11 µm), sexine (1.36-1.46 µm) and nexine (0.44-0.51 µm - Tab. 4).

Comments: *Cupania vernalis* and *Matayba elaegnoides* have small pollen grains (Tab. 3); and all Type III (subtype b) species present similar values of exine in their pollen grains (Tab. 4).

Species included: *Cupania vernalis*, *Matayba elaeagnoides* and *Serjania fuscifolia*.

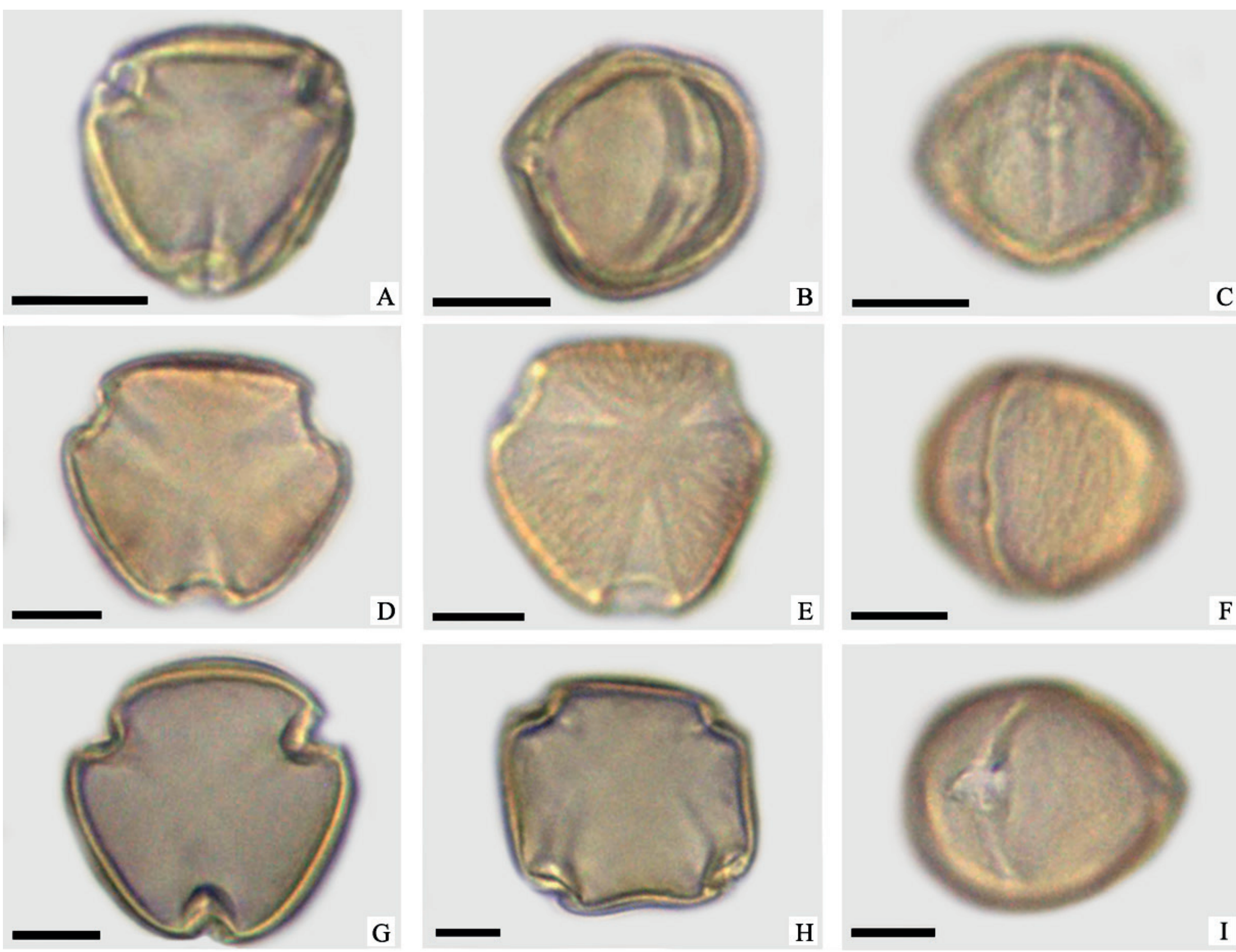

Figure 4. Photomicrographs of the Sapindaceae pollen grains. Type II. **A-C.** *Diatenopteryx sorbifolia* Radlk. **A.** General aspect, polar view; **B.** General aspect, equatorial view; **C.** Equatorial view, colporate aperture**. D-F.** *Dilodendron bipinnatum* Radlk.; **D.** General aspect, polar view; **E.** Polar view, ornamentation; **F.** Equatorial view, aperture. **G-I.** *Magonia pubescens* A. St-Hil. **G.** Polar view, optical section; **H.** Polar view, 4-colporate pollen grain; **I.** Equatorial view, aperture. Scale bars: 10 µm.

Key to the pollen types and taxa studied

1. Pollen grains with simple apertures (porate).. Type I (3-porate, Fig. 2A)
1'. Pollen grains with compound apertures (colporate)..2
2. Ectoapertures not anastomosed in the polar area..Type II (3-(4)-colporate, Fig. 2B)
2'. Ectoapertures (or their apices) anastomosed in the polar area....... Type III (3-syncolporate or 3-parasyncolporate, Fig. 2C)

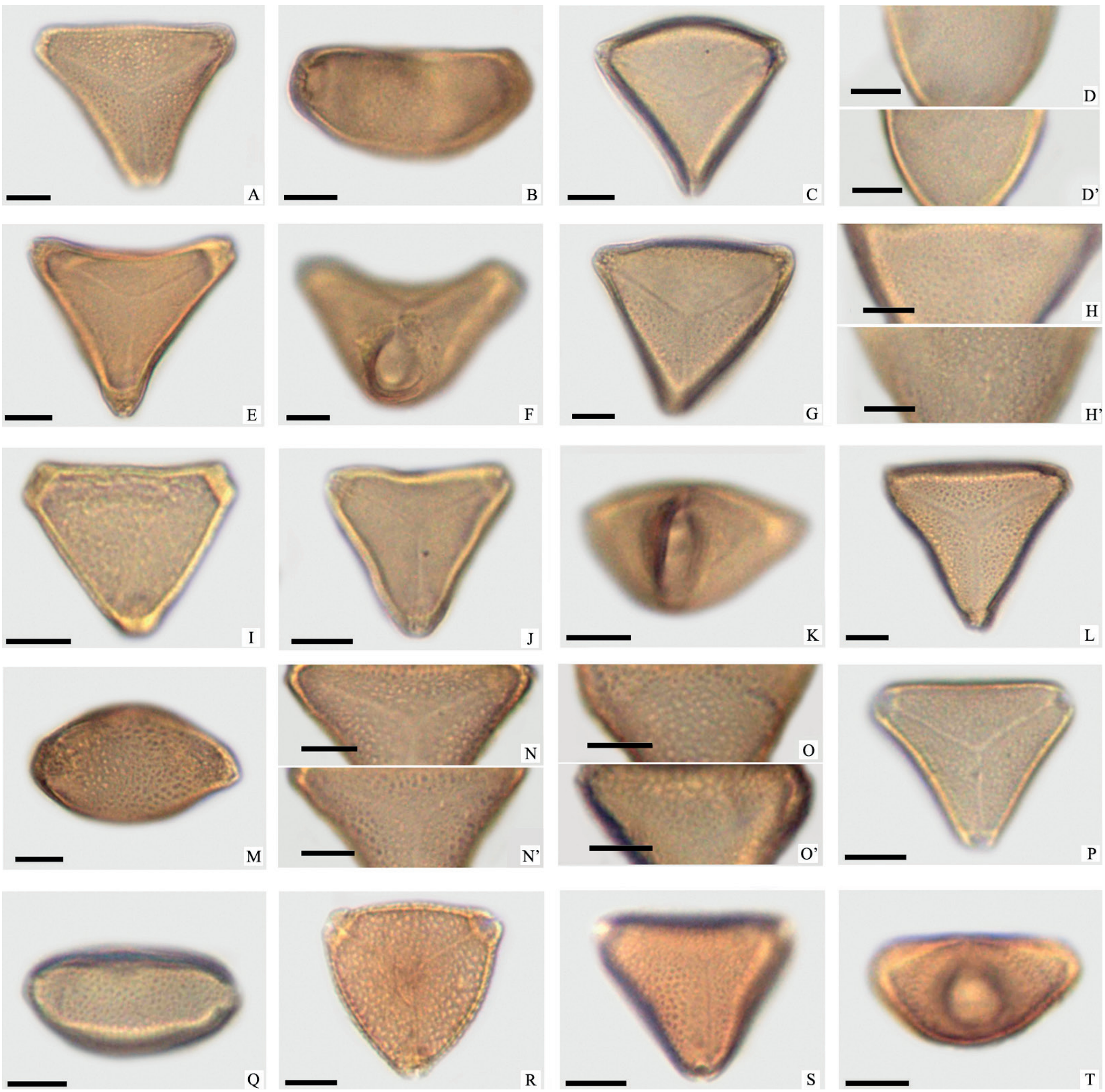

Figure 5. Photomicrographs of the Sapindaceae pollen grains. Type IIIa. **A-B.** *Cardiospermum grandiflorum* Sw. **A.** Polar view, ornamentation and syncolporate aperture; **B.** General aspect, equatorial view. **C-D** *Serjania caracasana* (Jacq.) Wild. **C.** General aspect, polar view; **D.** Optical section, ornamentation. **E-F.** *Serjania hebecarpa* Benth. **E.** General aspect, polar view; **F.** Equatorial view, aperture. **G-H.** *Serjania laruotteana* Cambess. **G.** Polar view, aperture and ornamentation; **H.** Optical section, ornamentation; **I.** *Serjania lethalis* A. St. Hil., polar view. **J-K.** *Serjania meridionalis* Cambess. **J.** General aspect, polar view and syncolporate aperture; **K.** Equatorial view, aperture. **L-N.** *Serjania pinnatifolia* Radlk. **L.** Polar view, aperture and ornamentation; **M.** Equatorial view, ornamentation; **N.** Optical section, ornamentation. **O.** *Serjania tristis* Radlk., ornamentation. **P-Q.** *Urvillea rufescens* Cambess. **P.** Polar view, aperture and ornamentation; **Q.** Equatorial view, ornamentation; **R.** *Urvillea ulmacea* Kunth., polar view, ornamentation. **S-T.** *Urvillea uniloba* Radlk. **S.** Polar view, ornamentation; **T.** Equatorial view, aperture. Scale bars: **D-D'**, **H-H'**, **N-N'**, **O-O'** = 5 μm; **A-C**, **E-G**, **I-M**, **P-T** = 10 μm.

Analysis of quantitative data

Based on the measurements of pollen grains in equatorial view and comparing the means and the interval of the diameters, it was observed that most of the *Paullinia* and *Serjania* species have pollen grains with larger diameters (Fig. 8A, B). *Cupania vernalis* differs from other species by having the smallest polar diameter. All other species analyzed form a large group by the polar diameter values in equatorial view, especially *S. laroutteana*, with the largest pollen grains (Fig. 8A). *Diatenopteryx sorbifolia* has the smallest equatorial diameter of pollen grains (Fig. 8B); also with low values of equatorial diameter are the species *Dilodendron bipinnatum* and *Matayba elaeagnoides*, whereas the other species form a group with the highest values for this diameter (Fig. 8B).

The principal components analysis (PCA, Fig. 9) is an exploratory analysis of quantitative data of the Sapindaceae pollen grains. This analysis was performed with seven metric variables measured in the studied pollen grains (Tab. 5) with the first two axes summarizing 83.47 % of the total data variation in their two axes.

The first axis was the most significant for species ordination and summarized 52.19 % of the total variation of the analyzed data. This component explained the variance based mainly on the values of width aperture (WAPE) and equatorial diameter in equatorial view (EDEV), respectively (Tab. 5). Additionally, in the first axis it was observed that the species *Paullinia elegans* and *Paullinia spicata* were separated from the other species due to the values of width aperture. On the other hand, most of the *Serjania* species (*S. hebecarpa*, *S. laruotteana, S. orbicularis*, *S. pinnatifolia* and *S. tristis*) were separated because of the values of the equatorial diameter in equatorial view (EDEV).

The second axis of the principal components analysis explains 31.28 % of the metric variability of the pollen grains of the species analyzed here. The most significant variables for ordering on this axis, as well as on axis 1, were width aperture (WAPE) and equatorial diameter in equatorial view

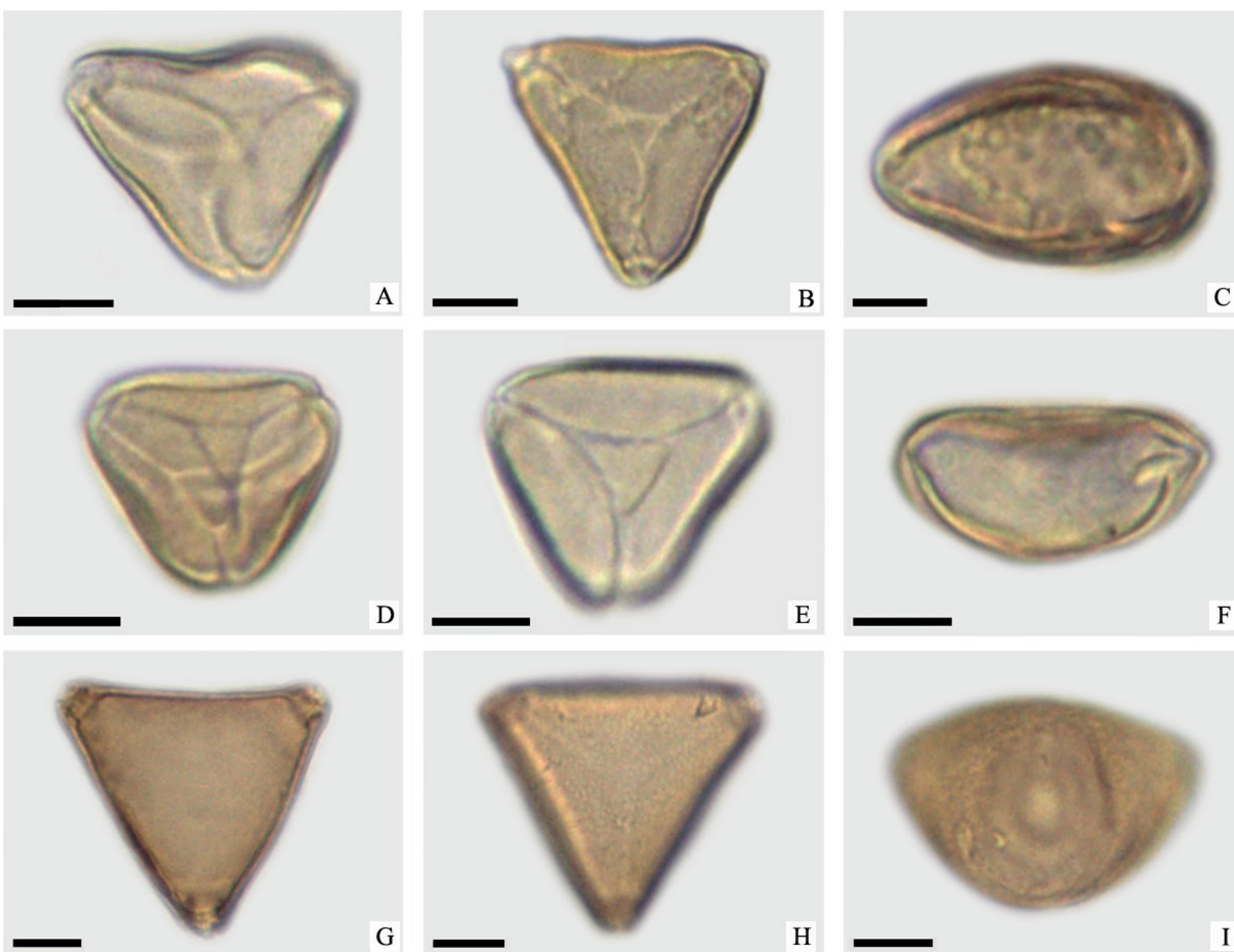

Figure 6. Photomicrographs of the Sapindaceae pollen grains. Type IIIb. **A-C.** *Cupania vernalis* Cambess. **A.** Polar view, parasyncolporate on both poles; **B.** Polar view, parasyncolporate aperture; **C.** General aspect, equatorial view. **D-F.** *Matayba elaeagnoides* Radlk. **D.** Polar view, parasyncolporate on both poles; **E.** Polar view, parasyncolporate aperture; **F.** General aspect, equatorial view. **G-I.** *Serjania fuscifolia* Radlk. **G.** General aspect, polar view; **H.** Polar view, aperture and ornamentation; **I.** Equatorial view, aperture. Scale bars: 10 µm.

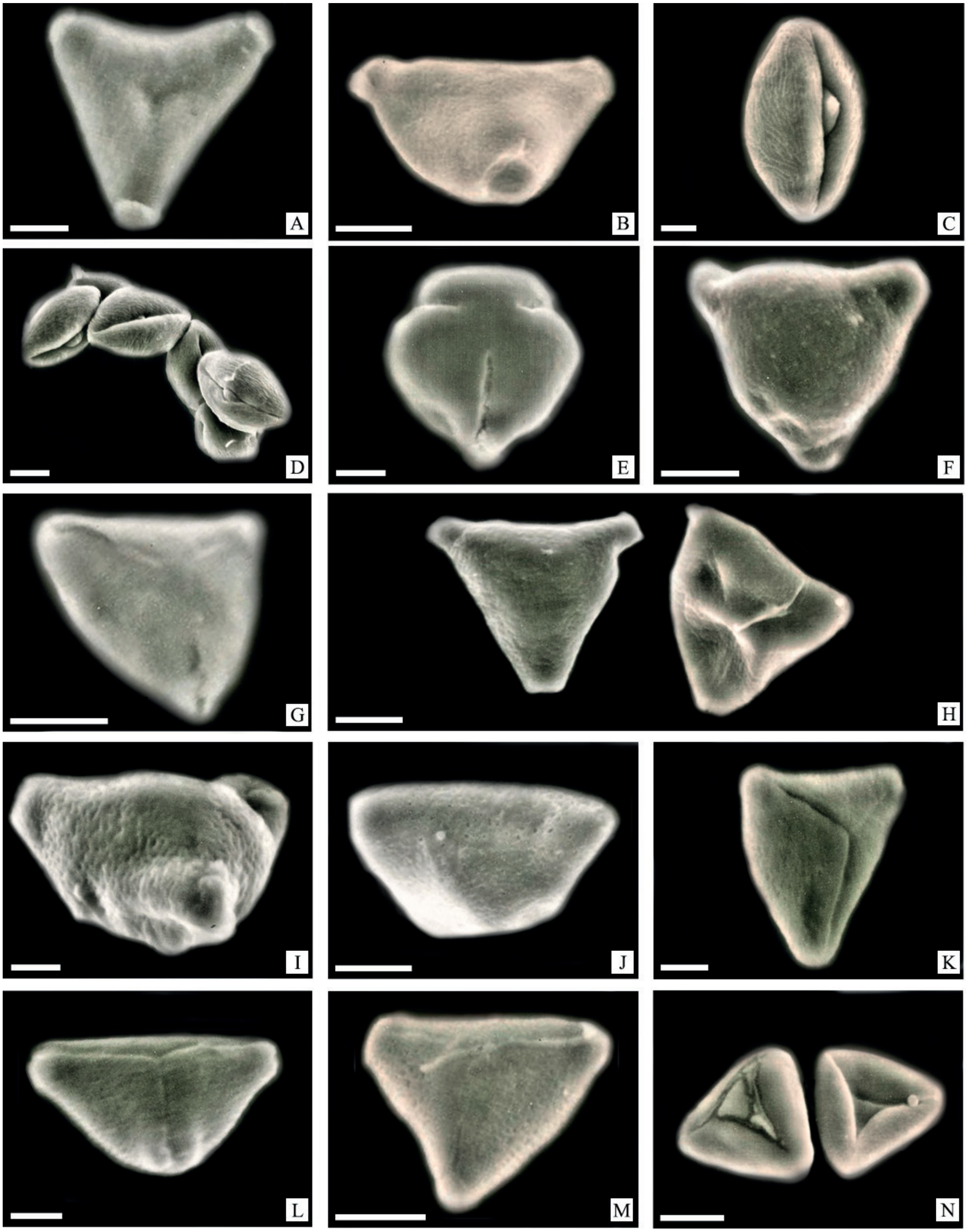

Figure 7. Scanning electron micrographs (SEM) of the Sapindaceae pollen grains. Type I. **A-B.** *Paullinia spicata* Benth. **A.** General aspect, polar view; **B.** General aspect, equatorial view; Type II. **C-D.** *Dilodendron bipinnatum* Radlk. **C.** Equatorial view, aperture and ornamentation; **D.** Several pollens grains. **E.** *Magonia pubescens* A. St-Hil.; polar view; Type IIIa. **F.** *Cardiospermum grandiflorum* Sw.; polar view. **G.** *Serjania caracasana* (Jacq.) Wild.; polar view. **H-I.** *Serjania lethalis* A. St. Hil. **H.** Polar views; **I.** Equatorial view; **J.** *Serjania pinnatifolia* Radlk., equatorial view. **K-L.** *Urvillea laevis* Radlk. **K.** Polar view; **L.** Polar view; **M.** *Urvillea ulmacea* Kunth., polar view; Type IIIb; **N.** *Matayba elaeagnoides* Radlk., polar view. Scale bars: 10 μm.

Table 3. Quantitative data of Brazilian Sapindaceae pollen grain, *n* = 25. R = Range (µm); x = Mean (µm); s_x = Standard deviation (µm); s = Standard error (µm); CI = Confidence interval in 95 % (µm); V = Coefficient of variability (%).

Species	Polar diameter in equatorial view				Equatorial diameter in polar view			
	(R) x ±sx	s	CI	V	(R) x ±sx	s	CI	V
Allophylus racemosus	(15.38 – 23.08) 19.90 ± 0.60	2.99	(18.67 – 21.13)	15.01	(25.64 – 33.33) 29.95 ± 0.41	2.06	(29.10 – 30.80)	06.87
Cardiospermum grandiflorum	(15.38 – 25.64) 19.69 ± 0.66	3.29	(18.34 – 21.05)	16.69	(25.64 – 48.72) 36.82 ± 1.15	5.73	(34.46 – 39.18)	15.56
Cupania vernalis	(12.82 – 15.38) 14.26 ± 0.26	1.30	(13.72 – 14.79)	09.11	(25.64 – 33.33) 29.85 ± 0.51	2.55	(28.80 – 30.90)	08.55
Diatenopteryx sorbifolia	(15.38 – 23.08) 19.49 ± 0.33	1.66	(18.81 – 20.17)	08.49	(17.95 – 23.08) 21.13 ± 0.31	1.53	(20.50 – 21.76)	07.25
Dillodendron bipinnatum	(17.95 – 25.64) 21.85 ± 0.40	1.98	(21.03 – 22.66)	09.04	(20.51 – 28.21) 25.64 ± 0.39	1.96	(24.83 – 26.45)	07.64
Magonia pubescens	(23.08 – 33.33) 27.08 ± 0.56	2.78	(25.93 – 28.22)	10.26	(25.64 – 38.46) 31.49 ± 0.58	2.92	(30.29 – 32.69)	09.26
Matayba elaeagnoides	(12.82 – 23.08) 16.62 ± 0.49	2.47	(15.60 – 17.63)	14.86	(23.08 – 28.21) 25.90 ± 0.36	1.81	(25.15 – 26.64)	07.00
Paullinia elegans	(17.95 – 25.64) 22.67 ± 0.35	1.76	(21.94 – 23.39)	07.78	(35.90 – 46.15) 40.62 ± 0.62	3.11	(39.33 – 41.90)	07.66
Paullinia spicata	(23.08 – 28.21) 25.62 ± 0.30	1.49	(25.00 – 26.63)	05.80	(25.64 – 48.72) 40.21 ± 0.97	4.84	(38.21 – 42.20)	12.03
Paullinia stipularis	(15.00 – 25.00) 20.40 ± 0.62	3.12	(19.11 – 21.69)	15.29	(25.00 – 37.50) 32.10 ± 0.57	2.86	(30.90 – 33.28)	08.90
Serjania caracasana	(17.95 – 33.33) 21.85 ± 0.81	4.06	(20.17 – 23.52)	18.60	(30.77 – 46.15) 35.90 ± 0.86	4.32	(34.12 – 37.68)	12.02
Serjania fuscifolia	(17.95 – 25.64) 22.46 ± 0.47	2.37	(21.48 – 23.44)	10.57	(33.33 – 45.15) 38.56 ± 078	3.88	(36.97 – 40.16)	10.06
Serjania hebecarpa	(25.64 – 30.77) 26.97 ± 0.30	1.50	(26.36 – 27.59)	05.57	(38.46 – 48.72) 46.26 ± 0.69	3.43	(44.84 – 47.67)	07.42
Serjania laruotteana	(20.51 – 38.46) 28.21 ± 0.82	4.12	(26.51 – 29.90)	14.61	(38.46 – 53.85) 46.97 ± 0.91	4.55	(45.10 – 48.85)	09.68
Serjania lethalis	(15.38 – 28.21) 22.87 ± 0.69	3.47	(21.44 – 24.30)	15.15	(28.21 – 43.59) 37.23 ± 0.96	4.80	(35.25 – 39.21)	12.90
Serjania meridianalis	(12.82 – 23.08) 19.08 ± 0.57	2.87	(17.89 – 20.26)	15.07	(28.21 – 38.46) 31.59 ± 0.57	2.84	(30.42 – 32.76)	08.99
Serjania orbicularis	(21.92 – 31.16) 26.64 ± 0.50	2.51	(25.21 – 27.28)	09.58	(35.12 – 55.76) 46.31 ± 1.03	5.14	(44.19 – 48.43)	11.10
Serjania pinnatifolia	(17.50 – 35.00) 25.70 ± 0.81	4.05	(24.03 – 27.37)	15.77	(27.50 – 50.00) 43.70 ± 1.17	5.87	(41.28 – 46.12)	13.43
Serjania tristis	(15.38 – 28.21) 22.67 ± 0.57	2.84	(21.50 – 23.84)	12.51	(35.90 – 48.72) 43.69 ± 0.64	3.18	(42.38 – 45.00)	07.28
Urvillea laevis	(12.82 – 23.08) 16.51 ± 0.59	2.97	(15.29 – 17.74)	17.97	(25.64 – 35.90) 31.49 ± 0.56	2.82	(30.33 – 32.65)	08.96
Urvillea rufescens	(15.00 – 25.00) 18.60 ± 0.54	2.71	(17.48 – 19.72)	14.56	(30.00 – 37.50) 30.90 ± 1.23	3.00	(30.66 – 33.14)	09.40
Urvillea ulmacea	(12.82 – 23.08) 19.28 ± 0.58	2.88	(18.10 – 20.47)	14.93	(25.64 – 38.46) 32.72 ± 0.62	3.08	(31.45 – 33.99)	09.40
Urvillea uniloba	(15.83 – 30.77) 20.92 ± 0.60	3.02	(19.68 – 22.17)	14.45	(17.95 – 38.46) 33.03 ± 0.93	4.64	(31.11 – 34.94)	14.05

Table 4. Measurements (in µm) of Brazilian Sapindaceae pollen grain, apertures and exine (n = 10). WCI = Width colpus index.

Species	Pore	Ectoaperture		Endoaperture		Exine	Sexine	Nexine
		Width	WCI	Length	Width			
Allophylus racemosus	2.06	-	-	-	-	2.17	1.62	0.55
Cardiospermum grandiflorum	-	1.21	30.42	1.02	0.88	2.00	1.48	0.52
Cupania vernalis	-	1.26	23.69	0.71	0.69	1.80	1.36	0.44
Diatenopteryx sorbifolia	-	1.74	12.14	3.30	3.63	2.58	1.92	0.66
Dillodendron bipinnatum	-	1.79	14.32	4.40	3.50	2.15	1.57	0.58
Magonia pubescens	-	1.72	15.34	5.58	4.40	2.61	1.92	0.69
Matayba elaeagnoides	-	1.54	16.81	0.50	0.47	1.92	1.46	0.46
Paullinia elegans	5.65	-	-	-	-	1.96	1.41	0.55
Paullinia spicata	4.27	-	-	-	-	2.57	1.95	0.62
Paullinia stipularis	1.29	-	-	-	-	2.25	1.68	0.57
Serjania caracasana	-	1.39	25.82	0.53	0.40	2.16	1.57	0.59
Serjania fuscifolia	-	1.40	27.54	0.52	0.44	1.95	1.44	0.51
Serjania hebecarpa	-	1.41	32.80	0.75	0.59	2.16	1.51	0.65
Serjania laruotteana	-	1.80	26.09	1.51	1.45	2.52	1.92	0.60
Serjania lethalis	-	1.43	26.03	1.04	1.06	2.05	1.55	0.50
Serjania meridianalis	-	1.36	23.22	0.69	0.63	2.55	2.01	0.54
Serjania orbicularis	-	1.57	29.49	0.53	0.44	2.22	1.65	0.57
Serjania pinnatifolia	-	1.38	31.66	0.92	0.88	2.08	1.53	0.55
Serjania tristis	-	1.80	24.27	1.15	0.62	1.91	1.45	0.46
Urvillea laevis	-	1.20	26.24	0.68	0.70	2.17	1.59	0.58
Urvillea rufescens	-	1.85	17.24	0.78	0.76	2.11	1.59	0.52
Urvillea ulmacea	-	1.24	26.38	0.97	0.94	1.94	1.44	0.50
Urvillea uniloba	-	1.65	20.01	1.87	1.58	2.12	1.60	0.52

Table 5. Pearson & Kendall correlation coefficients for pollen grain metric variables of the first and the second axis of PCA ordination in Sapindaceae species.

Variables		Principal components	
		Axis 1	Axis 2
PDEV	(polar diameter equatorial view)	0.3815	0.4297
EDEV	(equatorial diameter in equatorial view)	0.3991	0.7125
WAPE	(widht aperture)	0.8286	-0.5413
EXIN	(exine value)	0.0681	0.0047
SEXI	(sexine value)	0.0444	-0.0262
NEXI	(nexine value)	0.0445	0.0076
SHAP	(shape)	-0.0058	-0.1181

(EDEV) (Tab. 5). It was observed that, due to the variable EDEV, the species of *Serjania* (except *S. meridionalis*) were grouped on the positive side of the second axis.

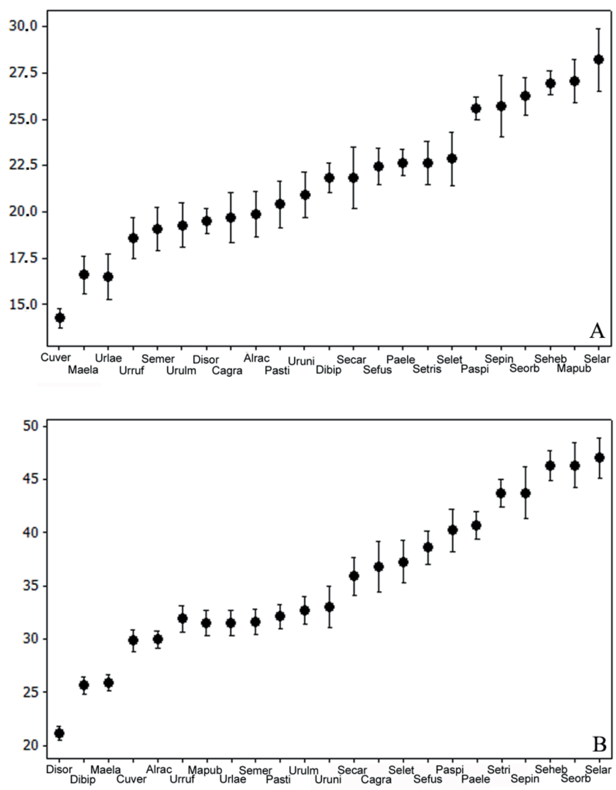

Figure 8. Representation of the confidence interval of the mean in 95 % of the Sapindaceae pollen grains. **A.** Polar diameter in equatorial view. **B.** Equatorial diameter in equatorial view. The higher and lower boundaries show the confidence interval; the average circle shows the arithmetic mean. Alrac = *Allophylus racemosus*, Cagran = *Cardiospermum grandiflorum*, Cuver = *Cupania vernalis*, Dilbi = *Dilodendron bipinnatum*, Disor = *Diatenopteryx sorbifolia*, Magpu = *Magonia pubescens*, Matela = *Matayba elaeagnoides*, Paela = *Paullinia elegans*, Paspi = *Paullinia spicata*, Pasti = *Paullinia stipularis*, Serca = *Serjania caracasana*, Serfus = *Serjania fuscufolia*, Serheb = *Serjania hebecarpa*, Serlar = *Serjania laruotteana*, Serlet = *Serjania lethalis*, Sermer = *Serjania meridionalis*, Seorb = *Serjania orbicularis*, Serpin = *Serjania pinnatifolia*, Sertri = *Serjania tristis*, Urvlae = *Urvillea laevis*, Urvru = *Urvillea rufescens*, Urvulm = *Urvilea ulmacea*, Urvuni = *Urvillea uniloba*.

In the similarity analysis (Cluster analysis, Fig. 10) we observed that the studied species formed two groups by the measurements made on their pollen grains. The first group includes the species *Paulinia elegans* and *P. spicata* (as was also observed in the PCA). The other species comprise the second group of the analysis, and 80 % of similarity arranged most *Serjania* species within this large group (*S. pinnatifolia*, *S. orbicularis* and *S. herbecarpa* presented about 97 % of similarity - Type III - subtype a). In addition, *Diatenopteryx sorbifolia*, *Dilodendron bipinnatum* and *Magonia pubescens* are closely related (both Type II - with approximately 55 % of similarity). Most Type III species - subtypes a and b (except for the previously treated *Serjania* species) were grouped with 65 % of similarity. Within this grouping, the presence of *Allophylus racemosus* and *Paullinia stipularis* can be observed distant from other Type I species. The species *Serjania fuscifolia* and *Serjania lethalis* were 100 % similar to each other. Thus, cluster analysis (which includes pollen grain quantitative data) can partly confirm the definition of pollen types (based on qualitative data - details of apertures), since Type II species are grouped separately from the others and the majority of Type III species (subtypes a and b) also form groups among themselves. In this analysis, the quantitative data do not confirm qualitative data for Type I species.

Discussion

The pollen grains of the Type I porate have been analyzed palynologically by several authors, such as Cruz & *Melhem* (1984), Luz & Barth (1999), Perdiz (2011), Perdiz *et al.* (2012), Acevedo-Rodriguez *et al.* (2011) and Marinho (2017). All these studies confirm the 3-porate aperture for Type I species (genera *Allophylus* and *Paullinia*).

Cruz & Melhem (1984) reported reticulate pollen for *Allophylus*, as observed in this study; however, Luz & Barth (1999) cited rugulate and microreticulate ornamentation for species of this genus, and Perdiz (2011) described perforate pollen grains. Analyzing the pollen of *Paullinia* species, Cruz & Melhem (1984) described reticulate ornamentation, Perdiz *et al.* (2012) cited perforate pollen grains for *P. unifoliata* , and in a detailed study about the palynology of the genus, Marinho (2017) presented perforate and scabrate pollen grains for the analyzed species. Thus, *Allophylus* and *Paullinia* species show variations in the ornamentation of their pollen grains with smaller or larger lumina, which define perforated, microreticulate or reticulate ornamentation; nevertheless, the 3-porate type of aperture is constant for the species of these genera.

Pollen grains of *Diatenopteryx* (pollen type II) were studied by Luz & Barth (1999) and Acevedo-Rodriguez *et al.* (2011), and these authors presented aperture data similar to those analyzed here; however, the microreticulate pollen grains observed for *Diatenopteryx sorbifolia* were not described by these authors, who reported striate-rugulate

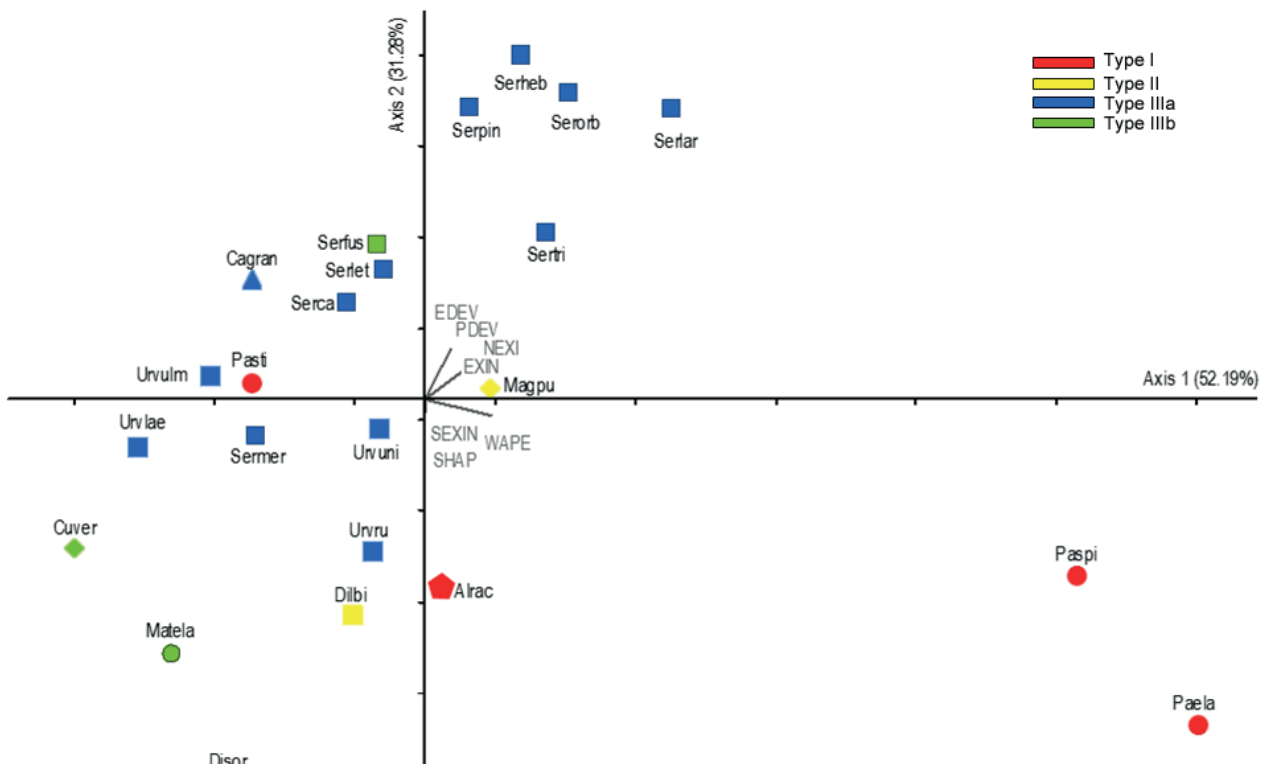

Figure 9. Principal component analysis performed with the pollen metrical variables from Sapindaceae species. Alrac = *Allophylus racemosus*, Cagran = *Cardiospermum grandiflorum*, Cuver = *Cupania vernalis*, Disor = *Diatenopteryx sorbifolia*, Dilbi = *Dilodendron bipinnatum*, Magpu = *Magonia pubescens*, Matela = *Matayba elaeagnoides*, Paela = *Paullinia elegans*, Paspi = *Paullinia spicata*, Pasti = *Paullinia stipularis*, Serca = *Serjania caracasana*, Serfus = *Serjania fuscufolia*, Serheb = *Serjania hebecarpa*, Serlar = *Serjania laruotteana*, Serlet = *Serjania lethalis*, Sermer = *Serjania meridionalis*, Seorb = *Serjania orbicularis*, Serpin = *Serjania pinnatifolia*, Sertri = *Serjania tristis*, Urvlae = *Urvillea laevis*, Urvru = *Urvillea rufescens*, Urvulm = *Urvilea ulmacea*, Urvuni = *Urvillea uniloba*.

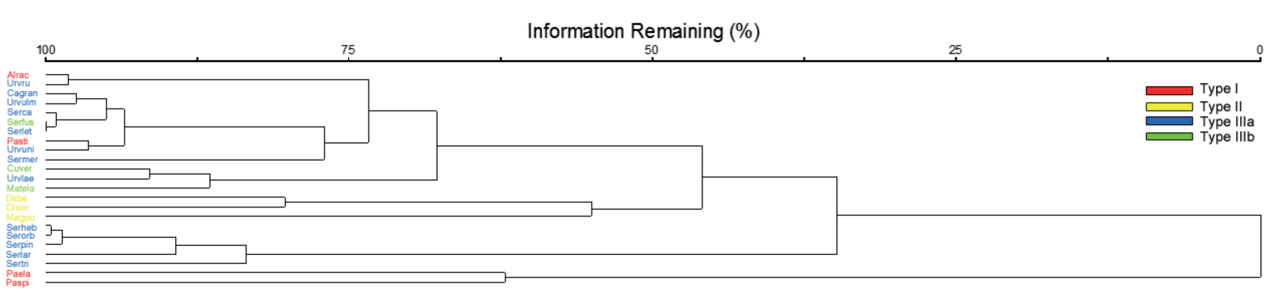

Figure 10. Cluster analysis (UPGMA and Euclidean distance) performed with the pollen metrical variables from Sapindaceae species. Alrac = *Allophylus racemosus*, Cagran = *Cardiospermum grandiflorum*, Cuver = *Cupania vernalis*, Dilbi = *Dilodendron bipinnatum* Disor = *Diatenopteryx sorbifolia*, Magpu = *Magonia pubescens*, Matela = *Matayba elaeagnoides*, Paela = *Paullinia elegans*, Paspi = *Paullinia spicata*, Pasti = *Paullinia stipularis*, Serca = *Serjania caracasana*, Serfus = *Serjania fuscufolia*, Serheb = *Serjania hebecarpa*, Serlar = *Serjania laruotteana*, Serlet = *Serjania lethalis*, Sermer = *Serjania meridionalis*, Seorb = *Serjania orbicularis*, Serpin = *Serjania pinnatifolia*, Sertri = *Serjania tristis*, Urvlae = *Urvillea laevis*, Urvru = *Urvillea rufescens*, Urvulm = *Urvilea ulmacea*, Urvuni = *Urvillea uniloba*.

pollen grains, which may indicate a variation in pollen morphology ornamentation for the genus.

For *Dilodendron*, Acevedo-Rodriguez *et al.* (2011) characterized the pollen grains as colporate and with striate ornamentation, which was also verified in this study. These same authors studied the pollen grains of *Magonia* (Type II), characterizing them as tetrads, colporate and with striate-gemate ornamentation. We also observed colporate pollen grains in *Magonia pubencens*, but pollen in monads and with microreticulate ornamentation.

Besides the type of aperture, the quantitative data also confirm the similarity among species of pollen type II (*Diatenopteryx sorbifolia*, *Dilodendron bipinnatum* and *Magonia pubencens*) as we can see in the cluster analysis. The studied species of pollen type II have suboblate or oblate spheroidal pollen grains which also differentiate them from other species analyzed (pollen types I and III).

Cardiospermum pollen grains (Type III - subtype a) are described in the literature as monad, heteropolar, 3-colporate, reticulate ornamentation with perforation (Acevedo-Rodriguez *et al.* 2011; Perveen 2000; Ferrucci & Urdampilleta 2011a, 2011b), confirming the results obtained here for *C. grandiflorum*. However, Ferrucci & Anzotegui (1993) described colpoids for this species and Acevedo-Rodriguez *et al.* (2011) cited 3-demicolporate pollen grains in the genus, characteristics that were not observed in the present study.

Data on *Serjania* pollen morphology (Type III) have been described by Cruz & Melhem (1984), Ferrucci & Anzotegui (1993), Ham & Tmolik (1994), Somner & Ferrucci (2009) and Acevedo-Rodriguez *et al.* (2011). These authors suggest the presence of heteropolar pollen grains, 3-syncolporate (hemi or demisyncolporate) with variations in shape and ornamentation, reticulate (Cruz & Melhem 1984) psilate, perforate or slightly rugulate (Ferrucci & Azontegui 1993), perforate or perforate-fossulate (Ham & Tmolik 1994), perforate (Somner & Ferrucci 2009) and perforate-reticulate (Acevedo-Rodriguez *et al.* 2011). Our results confirm the type of aperture described for *Serjania* species, except for *S. fuscifolia* with 3-parasyncolporate pollen grains (Type III - subtype b). Regarding ornamentation, the *Serjania* pollen grains analyzed here have microreticulate or reticulate exine, confirming the data of Cruz & Melhem (1984) and Acevedo-Rodriguez *et al.* (2011).

Heteropolar and 3-syncolporate pollen grains such as those described in type III subtype a for *Urvillea* species have also been described by Ferrucci & Anzotegui (1993) and Acevedo-Rodriguez *et al.* (2011). Ferrucci & Anzotegui (1993) observed oblate pollen grains with microreticulate or foveolate ornamentation for *U. laevis*, *U. ulmacea* and *U. uniloba*, while Acevedo-Rodriguez *et al.* (2011) cited for *U. ulmacea* a perforate-reticulate ornamentation. In the present work, oblate pollen grains were also observed, but with microreticulate (*Urvillea laevis, U. rufescens*) or reticulate ornamentation (*U. ulmacea, U. uniloba*) following the definitions proposed by Punt *et al.* (2007).

The species of the genera *Cupania* and *Matayba* described here with 3-parasyncolporate pollen grains (type III - subtype b) have already been described with syncolporate or parasyncolporate apertures (Cruz & Melhem 1984; Luz & Barth 1999; Perdiz 2011; Acevedo-Rodriguez *et al.* 2011). Cruz & Melhem (1984) reported for *Cupania vernalis* 3-syncolporate and reticulate pollen grains. To Perdiz (2011), the pollen grains of *Cupania racemosa* have 3-parasyncolporate apertures, and Acevedo-Rodriguez *et al.* (2011) report for the species of this genus syncolporate or parasyncolporate pollen grains, with regulate ornamentation. Our data for *C. vernalis* corroborate the data of Luz & Barth (1999), who observed grains of 3-parasyncolporate pollen with rugulate ornamentation.

Syncolporate and parasyncolporate pollen grains with psilate, perforate, reticulate, rugulate and pilate ornamentation are also described for *Matayba* species. Muller & Leenhouts (1976) describe the genus with syncolpate pollen grains, with small endoapertures and psilate, perforate or reticulate sexine. Erdtman (1952), Luz & Barth (1999) and Perdiz (2011) characterize the apertures of *Matayba* as 3-parasyncolporate, and the rugulate (with perforations) ornamentation was observed by Luz & Barth (1999) in *Matayba cristae*, *M. elaeagnoides*, *M. guianensis* and *M. juglandifolia*. Acevedo-Rodriguez *et al.* (2011) indicate that there may be a variation between syncolporate or parasyncolporate pollen grains in the genus and cite the rugulate ornamentation. *Matayba elaeagnoides* was also analyzed by Cruz & Melhem (1984), having parasyncolporate and isopolar pollen grains with pilate ornamentation. This same species described here also has parasyncolporate pollen grains, but with psilate ornamentation. The morphological differences reported for *Matayba* pollen grains may contribute to the definition of the genus as eurypalynos.

This study indicated that the qualitative characteristics of the aperture types and, in some cases, the ornamentation of the pollen grain, are important characters to describe the genera of Sapindaceae, establishing pollen types for the analyzed species. In addition, quantitative data (pollen grain measurements) confirm, in some cases, the attributes used to define pollen types. The results reinforce the importance of studying pollen morphology for the distinction and identification of genera and species and reaffirm the eurypalynous character of Sapindaceae.

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