Revista Brasil. Bot., V.32, n.4, p.647-662, out.-dez. 2009

Palynotaxonomy of *Vernonanthura* H. Rob. (Vernonieae, Asteraceae) species from Southeast Brazil

CLAUDIA B. F. MENDONÇA[1], VANIA GONÇALVES-ESTEVES[1], ROBERTO L. ESTEVES[2,3] and ALESSANDRA D. NUNES[1]

(received: May 03, 2007; accepted: July 15, 2009)

ABSTRACT – (Palynotaxonomy of *Vernonanthura* H. Rob. (Vernonieae, Asteraceae) species from Southeast Brazil). The present work studied the pollinic characteristics of 22 species of *Vernonanthura* from Southeast Brazil. The pollen grains were acetolysed, measured, described and ilustrated under light, scanning and transmission electron microscopy. Based on the results, *Vernonanthura* was considered an euripolinic genus as pollen grains presented distinctive characteristics, mainly related to the ornamentation, the size and apertures of the pollen grains, which may serve as a further tool in the delimitation of the species.

Key words - Asteraceae, palinology, Southeast Brazil, *Vernonanthura*, Vernoniinae

RESUMO – (Palinotaxonomia de espécies de *Vernonanthura* H. Rob. (Vernonieae, Asteraceae) ocorrentes no Sudeste do Brasil). O presente trabalho estuda os grãos de pólen de 22 espécies de *Vernonanthura* ocorrentes na região sudeste do Brasil. Os grãos de pólen foram acetolisados, mensurados, descritos e ilustrados sob microscopia de luz, eletrônica de varredura e de transmissão. Com base nos resultados obtidos considerou-se *Vernonanthura* um gênero euripolínico cujos grãos de pólen apresentaram características marcantes, principalmente relacionadas à ornamentação, ao tamanho dos grãos de pólen e às características da abertura, podendo servir como uma ferramenta a mais na delimitação das espécies.

Palavras-chave - Asteraceae, palinologia, sudeste do Brasil, *Vernonanthura*, Vernoniinae

Introduction

The genus *Vernonanthura* was described by Robinson (1992) based on species of the genus *Vernonia* Schreb. with which it shares some attributes, such as thyrsoid to pyramidal inflorescences, sessile heads, minute involucral bracts, flat receptacle, glabrous corolla with distinctive longitudinal resin ducts at the lobes, tailed anther bases, oblongo-ovatae, generally glandulous; cypsela with raphids from subquadrate to oblong, and, with a pollen type A, that is echinate to sublophate, tricolporate, continuous tectum, microperforated and with prominent spines (Jones 1977).

In an analysis of the generic and subtribal status of Vernonieae, Robinson (1999) stated that the pollen type A is apparently a reversion of the lophate form and is well fixed in some groups of Neotropical Vernonieae, such as Lychnophorinae, Piptocarphinae and *Vernonia*/*Vernonanthura*.

According to Robinson (1992, 1999), *Vernonanthura* has 65 species, distributed through Mexico, the West Indies, Central and South America. In Brazil, there are about 34 species, predominantly in Southern and Southeastern regions. Furthermore, the author emphasized that the species of typical Vernoniinae (*Vernonia* s.s., *Vernonanthura* H. Rob., *Cololobus* H. Rob. and *Trepadonia* H. Rob.) are characterized by glabrous lobes of the corola and also by a pollen grains type A.

Stutts (1988) revised the subsection *Chamaedrys* of the genus *Vernonia s.l.*, setting in order the species of *Vernonanthura* in two subsections using, among other characters, the pollen grains, which, according to the author, belonged to the type B (echinolophate, tricolporate pollen grains, with a discontinuous tectum, microperforated, without polar lacunae). Based on Jones (1979), the author created a newly subgroup with some excluded species from *Chamaedrys*: the subsection *Brevifoliae*. Stutts' revision (1988) also closed the subsection *Nudiflorae*, uniting *Vernonia niduflora* Less. and *Vernonia lucida* Less. (previously subordinated to subsection *Chamaedrys*) on series *Nudiflorae*.

The present work characterized 22 species of *Vernonanthura* from Southeast Brazil, providing information to evaluate the recent classification proposed by Robinson (1999).

Material and methods

The pollen morphology of the 22 species of *Vernonanthura* that occur in Southeast Brazil was studied.

1. Universidade Federal do Rio de Janeiro, Museu Nacional, Quinta da Boa Vista, São Cristóvão, 20940-040 Rio de Janeiro, RJ, Brazil.
2. Universidade do Estado do Rio de Janeiro, Instituto de Biologia, IBRAG/DBV, Rua São Francisco Xavier 524, Maracanã, 2550-013 Rio de Janeiro, RJ, Brazil.
3. Corresponding author: esteves.vr@gmail.com

The examined material was obtained from fertile anthers of flowers in anthesis and/or from mature buds, of exsiccated specimens belonging to the following herbaria: ESA, GUA, HB, MBM, R, RB, SPF, HUFU, VIC (acronyms according with Holmgren *et al.* 1990).

For each species, one specimen was chosen as standard and it is presented in the list below, indicated by an asterisk (*) placed before the collector's name. Descriptions and illustrations were also based on this standard material. When possible, up to four specimens were analyzed for comparison in order to confirm the obtained results. The permanent slides are stored at the Laboratório de Palinologia Álvaro Xavier Moreira, Departamento de Botânica do Museu Nacional/ Universidade Federal do Rio de Janeiro.

Examined specimens: *Vernonanthura brasiliana* (L.) H. Rob. – BRASIL. Minas Gerais: Belo Horizonte, Santa Luzia, 20-VII-1955, *Luiz Roth 1455* (MBM); Diamantina, Bocaiúva, 23-VII-1998, *G. Hatschbach et al. 68123* (MBM); Ituiutaba, 16-VII-1944, *A. Macedo 66* (MBM); Patos, 11-IX-1963, **A. Castellos 24113* (GUA); Paraopeba, 13-VIII-1987, *F.A. da Silveira 126* (VIC). *V. chamaedrys* (Less.) H. Rob. – BRASIL. Minas Gerais: Barbacena, Distrito de Pinheiro Grosso, VII-1944, **J. Vidal I-232* (R); Belo Horizonte, 8-VIII-1932, *Mello Barreto 1028* (HB); Caeraneas, 2-VII-1987, *H.F. Leitão Filho et al. 19415* (MBM). *V. crassa* (Vell.) H. Rob. – BRASIL. São Paulo: Apiaí, Barra do Chapéu; 3-VI-1994, *V.C. Souza et al. 6113* (ESA); Itararé, 6-10-IX-1993, **V. C. Souza et al. 4063* (MBM); Rosana, 18-VI-1998, *M.P. Manara et al. 8* (R). *V. cuneifolia* (Gardn.) H. Rob. – BRASIL. Minas Gerais: Liberdade, 15-VI-1943, *M. Magalhães 2876* (HB); Uberlândia, Estação Ecológica do Panga, 27-VIII-1999, **M.T.O. Lema s.n.* (HUFU21231). *V. discolor* (Spreng.) H. Rob. – BRASIL. Espírito Santo: Muniz Freire, 10-X-1992, *G. Hatschbach et al. 57942* (MBM); Minas Gerais: Alto Caparão, 3-IX-1996, *V.C. Souza et al. 12215* (ESA); Rio de Janeiro: Nova Friburgo, Reserva Ecológica de Macaé de Cima, 13-IX-1990, *C.M.B. Correia et al. 215* (GUA); Parque Nacional da Tijuca, 3-X-2001, **C.A.L. de Oliveira 1885* (R); São Paulo: Município de Itararé, 16-VIII-1994, *K.D. Barreto et al. 2891* (ESA). *V. divaricata* (Spreng.) H. Rob. – BRASIL. Espírito Santo: Venda Nova, 9-XI-1993, *G. Hatschbach et al. 59707* (MBM); Minas Gerais: Diogo de Vasconcelos, 13-X-2000, *A.F. Carvalho 735* (VIC); Rio de Janeiro: Nova Friburgo, 10-X-1993, **C.M. Vieira & L.C. Gurken 436* (RB); São Paulo: São Paulo, 28-IX-1951, *W. Hoehne 3668* (MBM); São Paulo, Serra da Cantareira, s.d, *M. Koscinski s.n.* (SPF7171). *V. ferruginea* (Less.) H. Rob. – BRASIL. Minas Gerais: Curvelo, Sucuriú, 10-VIII-1980, *J.P.P. Carauta et al. 3517* (GUA); Diamantina, 19-XI-1965, **A.P. Duarte 8940 & E. Pereira 9953* (RB); Jequitibá, 31-VII-1962, *J.P. Lanna-Sobrinho 247* (GUA); Paraopeba, 2-VIII-1987, *F.A. Souza 122* (VIC); São Romão, 2-VIII-1982, *F.C.F. Silva 161* (RB). *V. ignobilis* (Less.) H. Rob. – BRASIL. Minas Gerais: Gouveia, 13-XI-1971, *G. Hatschbach et al. 27862* (MBM); Paracatu, 14-X-1965, **E. Pereira 10212 & A.P. Duarte 9302* (RB). *V. lindbergii* (Baker) H. Rob. – BRASIL. Minas Gerais: Lundréia, 6-V-1970, *J. Augusto s.n.* (MBM188056); São Paulo: Botucatu, 17-V-1977, **I. Gottsberger & G. Gottsberger 21-17577* (MBM). *V. lucida* (Less.) H.Rob. – BRASIL. Minas Gerais: Conceição do Mato Dentro, 23-XI-1997, **G. Hatschbach et al. 67442* (MBM); Jaboticatubas, 16-XI-1942, *M. Magi 2694* (HB); Serra do Cipó, 19-II-1968, *H.S. Irwin & H. Maxwell s.n.* (HB52051). *V. mariana* (Mart. ex Baker) H. Rob. – BRASIL. Minas Gerais: Conceição do Mato Dentro, 30-V-1989, **R. Esteves & V. Esteves 427* (R); Diamantina, 19-III-1997, *G. Hatschbach et al. 66506* (MBM); Diamantina, 25-VII-1998, G. *Hatschbach et al. 68252* (MBM); Presidente Kubitschek, 21-XI-1997, *G. Hatschbach et al. 67376* (MBM); Serra do Cipó, 21-V-1989, *R. Esteves & V. Esteves 440* (R). *V. membranacea* (Gardn.) H. Rob. – BRASIL. Minas Gerais: Francisco Dumont, Serra do Cabral, 16-V-2001, **G. Hatschbach et al. 72203* (MBM); Joaquim Felício, Serra do Cabral, 14-V-2001, *G. Hatschbach et al. 72005* (MBM); Virginópolis, 14-IX-2001, *E.W. Teixeira s.n.* (VIC26896). *V. montevidensis* (Spreng.) H. Rob. – BRASIL. Minas Gerais: Macieiras, 15-XI-1960, *C. Angeli s.n.* (GUA6280); Rio de Janeiro: Itatiaia, 22-X-1998, *R.L. Esteves 966* (R); São Paulo: Itararé, 6-10-IX-1993, **V.C. Souza & C.M. Sakuragui 4328* (ESA); Serra da Bocaina, 20-X-1966, *W. Hoehne 6145* (SPF); Votorantim, Serra de São Francisco, 25-I-1984, *V.F. Ferreira 3272* (GUA). *V. mucronulata* (Less.) H. Rob. – BRASIL. Minas Gerais: Serra do Curral, VII-1949, **J. Vidal s.n.* (R113249); São Paulo: Botucatu, 11-VII-1974, *L. Gottsburger s.n.* (MBM267217); Itararé, 10-IX-1993, *V.C. Souza & C.M. Sakuragui 4127* (ESA); São Paulo, 07-VIII-1946, *W. Hoehne s.n.* (SPF14198); Votorantim, Serra de São Francisco, 25-I-1984, *V.F. Ferreira 3243* (GUA). *V. oligolepis* (Sch. Bip. ex Baker) H. Rob. – BRASIL. São Paulo: Assis, 20-25-II-1988, *H.F. Leitão-Filho et al. 20658* (MBM); Itapeva, I-1958, *G. Vidal s.n.* (R113580); Itararé, 7-II-1991, **C.A. de M. Scaramuzza & V.C. Souza 2701* (MBM). *V. paludosa* (Gardn.) H. Rob. – BRASIL. Rio de Janeiro: Itatiaia, 7-VIII-1926, *A. J. Sampaio 4816* (R); ibidem, 3-VI-1902, **P. Dusén 454* (R). *V. petiolaris* (DC.) H. Rob. – BRASIL. Minas Gerais: Barbacena, VII-1944, *J. Vidal 269* (R); Liberdade, 15-VI-1943, *M. Magalhães 4394* (RB); Rio de Janeiro: Itatiaia, Campo Belo, 22-VII-1906, *E. Hermmendoff 503* (R); Nova Friburgo, Reserva Ecológica Macaé de Cima, 13-IX-1988, *C.M.B. Correia 11 et al.* (GUA); Teresópolis, Parque Nacional da Serra dos Órgãos, VIII-1952, **J. Vidal 182* (R). *V. phosphorica* (Vell.) H. Rob. – BRASIL. Espírito Santo: Alfredo Chaves, 7-VII-1996, **G. Hatschbach et al. 65250* (MBM); Rio de Janeiro: Bom Jardim, 24-VIII-1984, *J.P.P. Carauta et al.* (GUA); Paraíba do Sul, 24-VII-1984, *J.P.P. Carauta 4781 et al.* (GUA); Teresópolis, Cascata dos Amores, 7-VII-1984, *E.F. Paciornil 55* (MBM); São Paulo: São Paulo, 25-VII-1944, *W. Hoehne 1417* (SPF). *V. puberula* (Less.) H. Rob. – BRASIL. Rio de Janeiro: Nova Friburgo, 19-XII-1887, **Glaziou 17022* (R); São Paulo:

Cunha, 10-VII-1980, *A. Custodio-Filho 285* (MBM). *V. rigiophylla* (Kuntze) H. Rob. – BRASIL. Minas Gerais: São Roque de Minas, 18-VII-1995; **J.N. Nakajima et al. 1214* (R); Serra de São José, VI-1896, *A. Silveira 1257* (RB). *V. viscidula* (Less.) H. Rob. – BRASIL. Minas Gerais: Belo Horizonte, 19-V-1933, *M. Barreto 4233* (R); São Roque de Minas, 14-V-1933, *R. Romero et al. 2292* (R); Serra do Palmital, 20-VI-1884, **Glaziou 15060* (R). *V. westiniana* (Less.) H. Rob. – BRASIL. Minas Gerais: Caldas, VII-1914, *A.F. Regnell 1245* (R); São Roque de Minas, 12-I-1996, *R. Romero et al. 3289* (MBM/R); Rio de Janeiro: Japeri, 21-VII-2001, **M. Frigoleto s.n.* (GUA47702); São Paulo: Itararé, *V.C. Souza et al. 2173* (MBM); São Paulo, 10-IV-1955, *W. Hoehne 4081* (MBM).

For the study under light microscope (LM), the pollen grains were submitted to the Erdtman (1952) acetolytic method, measured up to seven days later (Salgado-Labouriau 1973), and photomicrographed. For scanning electron microscopy (SEM), non acetolysed pollen samples were mounted on stubs and coated with gold-platinum. The analysis was done in a JSM-5310 microscope in the Laboratório de Ultraestrutura Celular Hertha Meyer, Instituto de Biofísica, Universidade Federal do Rio de Janeiro. For transmission electron microscopy (TEM), the anthers were dehydrated by 2% glutaraldehyde solution, embedded in Spurr resin, and sectioned with a diamond knife on Ultra-microtome U2088.

A minimum of 25 pollen grains per sample were measured in equatorial view (polar diameter = PD and equatorial diameter = ED) in the light microscope (LM). In all the measurements, the spines were included. Statistical procedures were carried out, calculating the arithmetic mean ($\bar{x}$); the standard deviation of the mean (s_x) and the confidence interval at 95%. For the measurements of the other characteristics, such as equatorial diameter in polar view (EDPV), side of apocolpium (SA), endoapertures size and layers of exine, the arithmetic mean of 10 measurements were calculated. The same procedure was applied for the measurements of the pollen grain diameters of the comparison material.

The terminology used for pollen descriptions followed the criteria of Punt *et al.* (2007); the denomination of the polar area and the dimensions of the apertures are in accordance with the classification for the polar area index established by Faegri & Iversen (1966).

Results

The pollen grains (figures 1-99) were medium (25.0 µm to 50.0 µm) to large sized (50.0 µm to 100.0 µm) only in *V. crassa*, *V. ignobilis*, *V. lucida*, *V. oligolepis* and *V. viscidula*, isopolar, oblate spheroidal (table 1), subtriangular to subcircular amb, very small polar area (*V. crassa*, *V. ferruginea*, *V. mucronulata*, *V. oligolepis*, *V. paludosa*, *V. petiolaris* and *V. puberula*) or small (table 2), 3-colporate with a subechinolophate surface (figures 2, 8, 10, 13, 19, 22, 30, 42, 54, 57, 70, 88, 94).

Aperture – 3 colpori, delimited by sinuous muri. Colpus long to very long (table 3), the biggest 24.3 to 27.7 µm

Table 1. Pollen measurements (µm) in equatorial view of *Vernonanthura* species. ($\bar{x}$ = arithmetic mean; s_x = standard deviation of medium; CI = confidence interval; P = Polar diameter; E = equatorial diameter).

Species	Polar diameter		Equatorial diameter		P/E
	Range variation ($\bar{x} \pm s_x$)	CI 95%	Range variation ($\bar{x} \pm s_x$)	CI 95%	
V. brasiliana	42.5 (43.9 ± 0.2) 46.2	43.5-44.3	45.0 (45.8 ± 0.2) 48.7	45.4-46.2	0.95
V. chamaedrys	46.3 (48.8 ± 0.3) 51.3	48.2-49.4	52.5 (55.2 ± 0.3) 58.8	54.6-55.8	0.88
V. crassa	51.2 (52.6 ± 0.1) 53.7	52.4-52.8	57.5 (59.4 ± 0.2) 60.0	59.0-59.8	0.88
V. cuneifolia	45.0 (45.6 ± 0.2) 47.5	45.2-46.0	50.0 (51.2 ± 0.2) 53.7	50.8-51.6	0.89
V. discolor	36.2 (37.8 ± 0.2) 40.0	37.4-38.2	40.0 (41.9 ± 0.2) 43.7	41.5-42.3	0.90
V. divaricata	40.0 (41.1 ± 0.2) 42.5	40.7-41.5	40.0 (42.8 ± 0.3) 45.0	42.2-43.4	0.96
V. ferruginea	40.0 (41.8 ± 0.2) 42.5	41.4-42.2	45.0 (45.7 ± 0.2) 47.5	45.3-46.1	0.91
V. ignobilis	51.2 (53.2 ± 0.2) 55.0	52.8-53.6	53.7 (56.1 ± 0.2) 57.5	55.7-56.5	0.94
V. lindbergii	43.7 (45.0 ± 0.2) 46.2	44.6-45.4	48.7 (50.2 ± 0.2) 52.5	49.8-50.6	0.89
V. lucida	52.5 (54.5 ± 0.2) 57.5	54,1-54,9	57.5 (58.5 ± 0.2)60.0	58.1-58.9	0.93
V. mariana	37.5 (39.3 ± 0.2) 40.0	38.9-39.7	40.0 (41.9 ± 0.2) 43.8	41.5-42.3	0.93

continue

continuation

Species	Polar diameter		Equatorial diameter		P/E
	Range variation ($\bar{x} \pm s_x$)	CI 95%	Range variation ($\bar{x} \pm s_x$)	CI 95%	
V. membranacea	40.0 (41.4 ± 0.2) 43.8	41.0-41.8	42.5 (43.8 ± 0.2) 45.0	43.4-44.2	0.94
V. montevidensis	43.7 (45.7 ± 0.2) 47.5	45.3-46.1	46.2 (48.8 ± 0.2) 50.0	48.4-49,2	0.93
V. mucronulata	47.5 (48.3 ± 0.2) 50.0	47.9-48.7	50.0 (52.7 ± 0.2) 55.0	52,3-53.1	0.91
V. oligolepis	47.5 (52.1 ± 0.3) 53.8	51.6-52.7	52.5 (54.5 ± 0.2) 56.3	54.1-54.9	0.95
V. paludosa	42.5 (44.2 ± 0.2) 45.0	43.8-44.6	47.5 (48.2 ± 0.2) 51.2	47.8-48.6	0.91
V. petiolaris	43.7 (46.7 ± 0.2) 47.5	46.3-47.1	47.5 (50.1 ± 0.3) 52.5	49.5-50.7	0.93
V. phosphorica	45.0 (46.5 ± 0.2) 47.5	46.1-46.9	50.0 (51.0 ± 0.2) 52.5	50.6-51.4	0.91
V. puberula	47.5 (49.4 ± 0.3) 51.3	48.8-50.0	51.3 (53.7 ± 0.2) 55.0	53.3-54.1	0.91
V. rigiophylla	46.3 (48.1 ± 0.3) 51.3	47.5-48.7	47.5 (51.1 ± 0.3) 53.8	50.5-51.7	0.94
V. viscidula	47.5 (50.5 ± 0.2) 52.5	50.1-50.9	52.5 (55.9 ± 0.3) 58.7	55.3-56.5	0.90
V. westiniana	40.0 (42.3 ± 0.2) 43.7	41.9-42.7	45.0 (45.9 ± 0.2) 48.7	45.5-46.3	0.92

Table 2. Pollen measurements (μm) in polar view of *Vernonanthura* species. ($\bar{x}$ = arithmetic mean; s_x = medium standard; CI = confidence interval; SA = apocolpium side; EDPV = equatorial diameter in polar view and polar area index (PAI)).

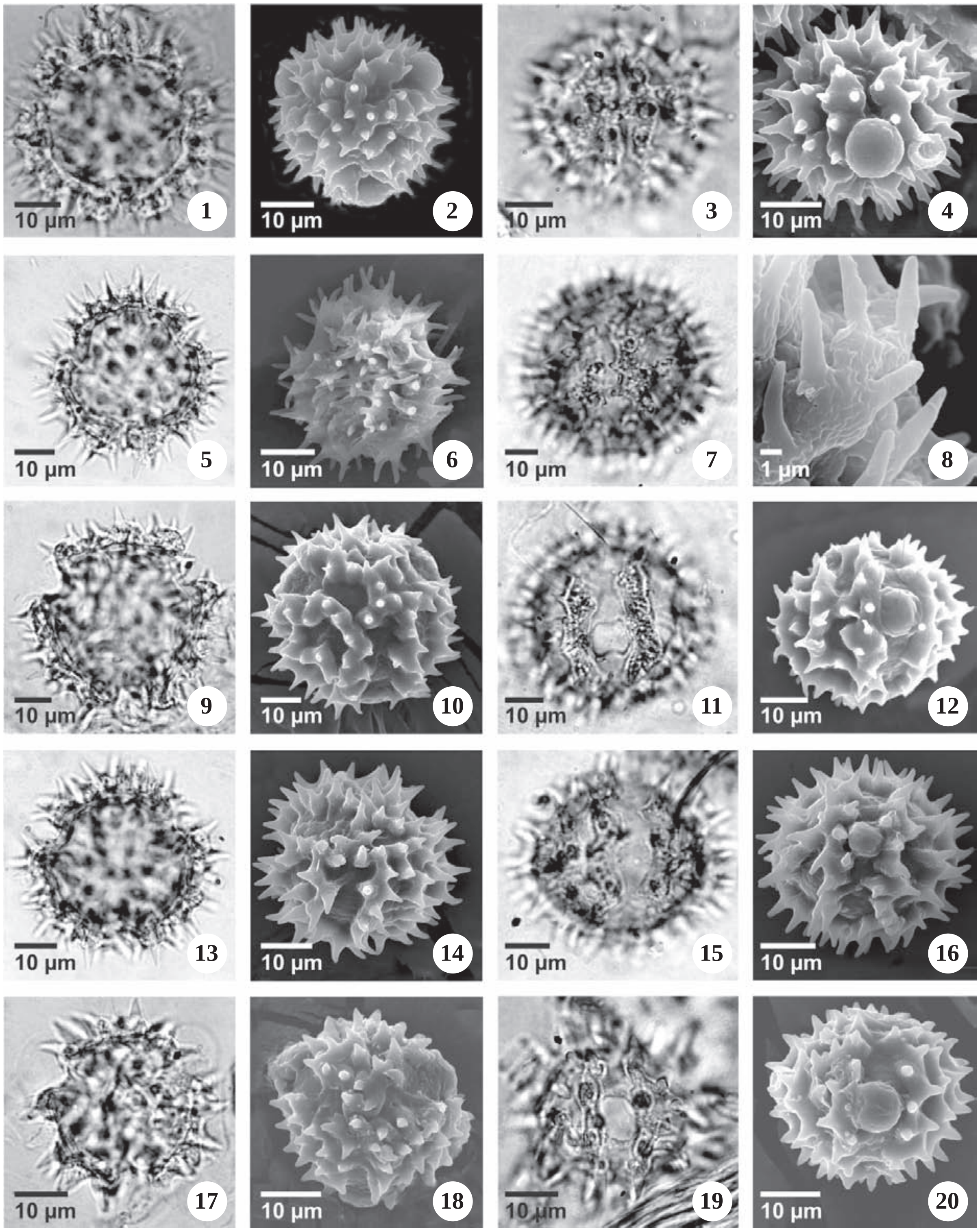
Species	Equatorial diameter	SA	PAI	Polar area
	Range variation ($\bar{x} \pm s_x$)	Range variation ($\bar{x}$)		SA/EDPV
V. brasiliana	46.2 (48.6) 50.0	15.0 (16.5) 17.5	small	0.33
V. chamaedrys	45.0 (52.5) 53.8	12.5 (15.0) 15.0	small	0.28
V. crassa	57.5 (60.8) 62.5	10.0 (12.5) 15.0	very small	0.20
V. cuneifolia	50.0 (50.6) 52.5	21.2 (22.0) 22.5	small	0.43
V. discolor	40.0 (40.9) 42.5	10.0 (11.0) 12.5	small	0.26
V. divaricata	40.0 (42.5) 43.7	12.5 (14.2) 15.0	small	0.33
V. ferruginea	42.5 (44.2) 45.0	7.5 (9.9) 11.2	very small	0.22
V. ignobilis	57.5 (58.7) 60.0	15.0 (17.9) 20.0	small	0.30
V. lindbergii	47.5 (49.5) 50.0	12.5 (14.1) 15.0	small	0.28
V. lucida	55.0 (56.8) 57.5	15.5 (16.7) 17.5	small	0.29
V. mariana	42.5 (43.4) 45.0	10.0 (11.1) 12.5	small	0.25
V. membranacea	41.3 (43.4) 45.0	10.0 (11.4) 12.5	small	0.26
V. montevidensis	46.2 (48.5) 51.2	11.2 (13.4) 15.0	small	0.27
V. mucronulata	51.2 (52.6) 53.7	12.5 (12.9) 13.7	very small	0.24
V. oligolepis	52.5 (53.9) 55.0	10.0 (12.3) 13.8	very small	0.22
V. paludosa	43.7 (46.4) 47.5	10.0 (11.5) 12.5	very small	0.24
V. petiolaris	46.2 (48.6) 50.0	10.0 (11.7) 12.5	very small	0.24
V. phosphorica	48.7 (50.6) 52.5	12.5 (13.7) 15.0	small	0.27
V. puberula	52.5 (54.4) 57.5	11.3 (12.8) 15.0	very small	0.23
V. rigiophylla	48.8 (52.9) 56.3	12.5 (13.6) 15.0	small	0.25
V. viscidula	48.7 (53.4) 55.0	20.0 (24.0) 25.0	small	0.44
V. westiniana	43.7 (45.5) 47.5	15.0 (16.5) 17.5	small	0.36

(*V. mucronulata* and *V. oligolepis*); the smallest ones 20.8 to 23.5 µm long (*V. discolor, V. mariana* and *V. montevidensis*); colpus wide varying between 3.8 µm (*V. brasiliana*) and 7.4 µm (*V. lucida* and *V. puberula*). The endoaperture is lalongate or slightly lolongate in *V. ignobilis* (table 3). Furthermore, in some species the endoapertures present a median constriction, like in *V. crassa, V. cuneifolia, V. divaricata, V. montevidensis, V. mucronulata, V. oligolepis, V. rigiophylla* and *V. viscidula* (figures 11, 15, 23, 55, 59, 63, 84, 91). In *V. brasiliana*, the muri that delimit the colpus are high difficulting the colpus observation (figures 3, 4). In SEM, ornamented membrane was observed covering the colpus (figures 14, 32, 44, 56, 60, 62).

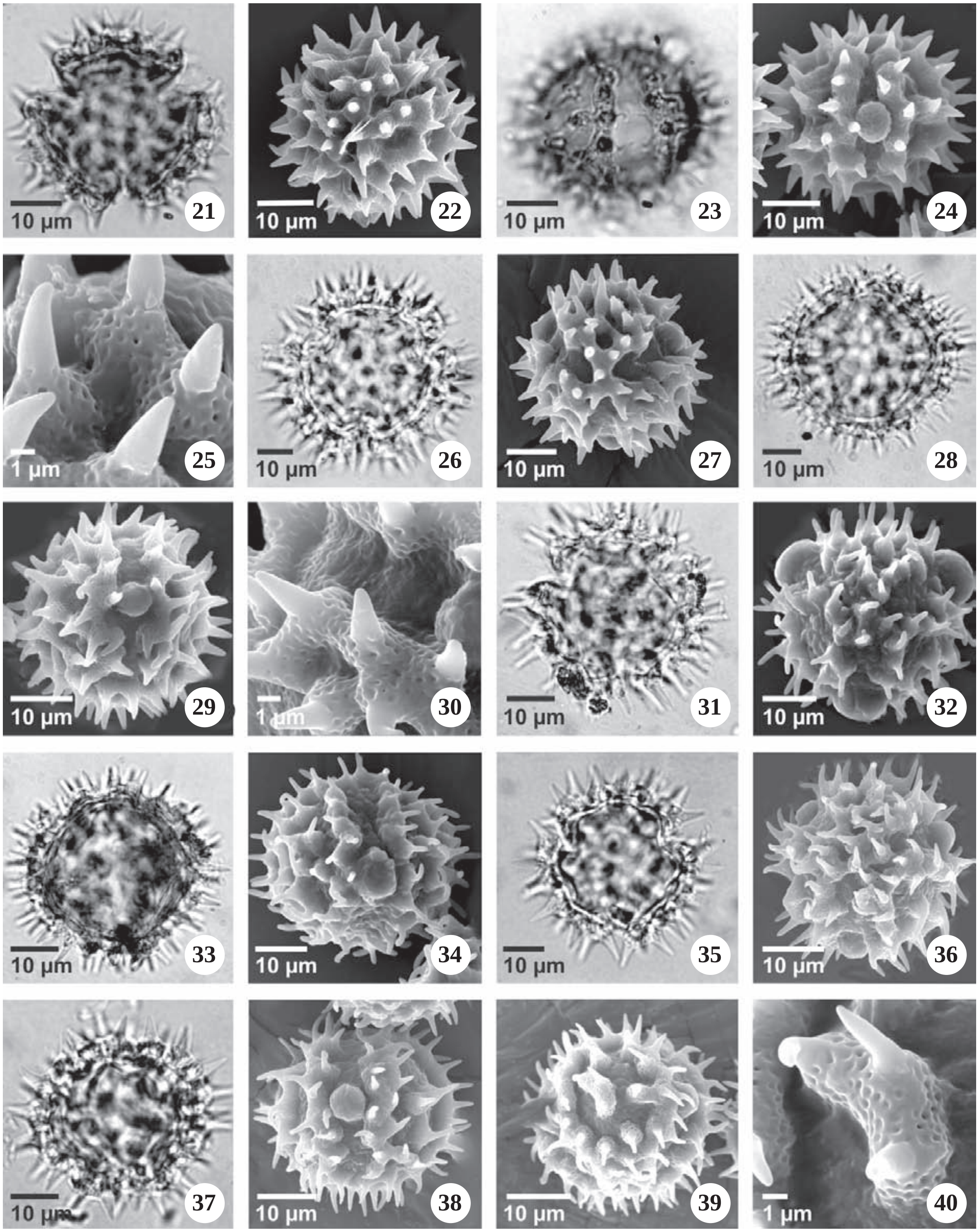
Exine – Subequinolophate, with a simplicolumellate. The sexine can be composed of very sinuous walls (*V. brasiliana, V. chamaedrys, V. lucida, V. montevidensis, V. mucronulata, V. rigiophylla,* and *V. westiniana*) or slightly sinuous in the other species. The muri may tend towards the lophate pattern, although without closed lacunae delimiting them, which can be better observed in SEM (figures 10, 16, 22, 27, 42, 52, 56, 66, 72, 77, 82, 85 and 89). In the latter pattern were found regions between the muri that may be broad or narrow, psilate to lightly scabrate. In the apocolpus region, the muri may be continuous (in the majority of the species) or discontinuous (figures 14, 18, 32, 36, 47, 62, 74, 82, 89) and their concentration also varies, being possible to find muri only delimiting the apertures (*V. ignobilis, V. oligolepis*). The muri thickness in the apocolpus area varied from 1.5 in *V. membranacea* to 4.0 µm in *V. crassa*. In the mesocolpus, the organization of the muri varies and their discontinuity in some species is so great that isolated spines may be found, such as in *V. ignobilis* and *V. lindbergii* (figures 34, 39). The spines show variations in length and width (table 3). The longest spines (7.3 to 8.0 µm) were found in *V. lindbergii, V. mariana, V. phosphorica* and *V. puberula* and the shortest ones (*ca.* 3.8 µm) in *V. brasiliana, V.*

Table 3. Average (µm) size of the apertures and morphometric data of the exine of *Vernonanthura* species (n = 10).

Species	Colpus		Endoaperture		Exine layers			Muri	Spine		
	length	width	length	width	exine	sexine	nexine	width	length	width	dist.
V. brasiliana	23.5	3.8	4.5	8.5	10.0	9.0	1.0	3.4	5.0	2.0	7.5
V. chamaedrys	23.0	4.5	5.0	10.0	10.7	9.4	1.3	2.8	5.8	2.0	8.7
V. crassa	26.8	6.5	7.5	10.3	12.3	11.1	1.2	4.0	6.7	1.9	9.2
V. cuneifolia	22.1	4.2	7.0	10.3	9.9	8.9	1.0	3.6	5.0	2.0	7.8
V. discolor	20.8	4.7	7.1	8.3	8.2	7.1	1.0	2.0	3.8	2.0	6.2
V. divaricata	24.5	4.5	4.7	12.0	10.5	9.5	1.0	3.5	5.4	1.4	8.7
V. ferruginea	26.4	5.4	5.0	14.4	10.2	9.2	1.0	2.7	5.4	1.8	8.4
V. ignobilis	24.,0	6.0	11.8	11.2	12.8	11.0	1.8	2.4	6.5	2.2	10.4
V. lindbergii	24.7	6.0	7.0	10.4	12.4	11.4	1.0	2.0	7.4	1.5	8.7
V. lucida	25.4	7.4	7.4	13.0	11.0	9.8	1.2	2.0	5.3	2.0	9.0
V. mariana	21.5	4.9	5.4	10.3	12.5	11.5	1.0	2.0	7.5	2.0	9.0
V. membranacea	23.5	5.0	4.5	10.5	12.0	11.0	1.0	1.5	5.0	2.0	8.0
V. montevidensis	22.3	5.0	3.9	8.5	9.7	8.6	1.0	1.7	5.7	1.9	7.2
V. mucronulata	27.6	6.2	6.6	10.3	12.4	11.4	1.1	2.2	6.2	2.1	10.6
V. oligolepis	27.7	5.5	7.4	15.2	11.8	10.5	1.3	3.3	5.8	2.0	7.7
V. paludosa	26.5	5.5	6.7	9.0	12.6	11.4	1.2	2.4	6.4	2.0	9.2
V. petiolaris	26.7	6.5	5.3	8.7	11.1	10.1	1.1	2.2	6.2	2.0	10.0
V. phosphorica	24.3	5.2	6.0	11.6	12.1	10.9	1.1	2.0	7.3	1.9	9.2
V. puberula	26.7	7.4	8.0	12.0	13.0	11.7	1.3	3.4	8.0	2.3	9.7
V. rigiophylla	23.0	5.7	5.0	10.8	11.5	10.5	1.0	3.5	6.0	2.5	10.2
V. viscidula	23.3	5.3	6.1	10.6	11.8	10.6	1.1	2.3	5.5	2.0	9.8
V. westiniana	23.5	4.6	5.7	10.5	11.3	10.3	1.1	2.0	6.1	2.9	8.9



Figures 1-20. LM and SEM photomicrographs of the pollen grains of *Vernonanthura*. 1-4. *V. brasiliana* (*A. Castellos 24113*) – Polar view. 1. Cross section. 2. Surface of apocolpium. Equatorial view. 3-4. Aperture. 5-8. *V. chamaedrys* (*J. Vidal I-232*) – Polar view. 5. Cross section. 6. Surface of apocolpium. Equatorial view. 7. Aperture. 8. Detail of surface. 9-12. *V. crassa* (*V.C. Souza et al. 4063*) – Polar view. 9. Cross section. 10. Surface of apocolpium. 11-12. Equatorial view. Aperture. 13-16. *V. cuneifolia* (*M.T.O. Lema s.n.* HUFU21231) – Polar view. 13. Cross section. 14. Surface of apocolpium. 15-16. Aperture. 17-20. *V. discolor* (*C.A.L. de Oliveira 1885*) – Polar view. 17. Cross section. 18. Surface of apocolpium. 19-20. Equatorial view. Aperture.



Figures 21-40. LM and SEM photomicrographs of the pollen grains of *Vernonanthura*. 21-25. *V. divaricata* (*C.M. Vieira 436* & *L.C. Gurken*) – Polar view. 21. Cross section. 22. Surface of apocolpium. Equatorial view. 23-24. Aperture. 25. Surface. 26-30. *V. ferruginea* (*A.P. Duarte 8940* & *E. Pereira 9953*) – Polar view. 26. Cross section. 27. Surface of apocolpium. Equatorial view. 28. Cross section. 29. Aperture. 30. Surface. 31-34. *V. ignobilis* (*E. Pereira 10212* & *A.P. Duarte 9302*) – Polar view. 31. Cross section. 32. Surface of apocolpium. Equatorial view. 33. Cross section. 34. Aperture. 35-40. *V. lindbergii* (*I. Gottsberger* & *G. Gottsberger 21-17577*) – Polar view. 35. Cross section. 36. Surface of apocolpium. Equatorial view. 37. Cross section. 38. Aperture. 39. Mesocolpium. 40. Detail of surface.

cuneifolia, *V. discolor* and *V. membranacea*. The width of the spines ranged between 1.4 (*V. divaricata*) and 2.9 µm (*V. westiniana*). The distance between the spines varies widely, ranging from 6.2 (*V. discolor*) to 10.6 µm (*V. mucronulata*). The nexine is always thinner than the sexine (table 3). In SEM, the differences in quantity and size of the perforations can be better observed at the base of the spines, and also the details of the muri previously described, as well as the presence of perforations throughout their extension, with spines which are apart in their superior part. In TEM (figure 99), long, thick, solid columella can be observed supporting spines, which are linked by a thick tectum.

Comments – Table 4 shows that the results found in the specimens for comparison mostly present values of polar

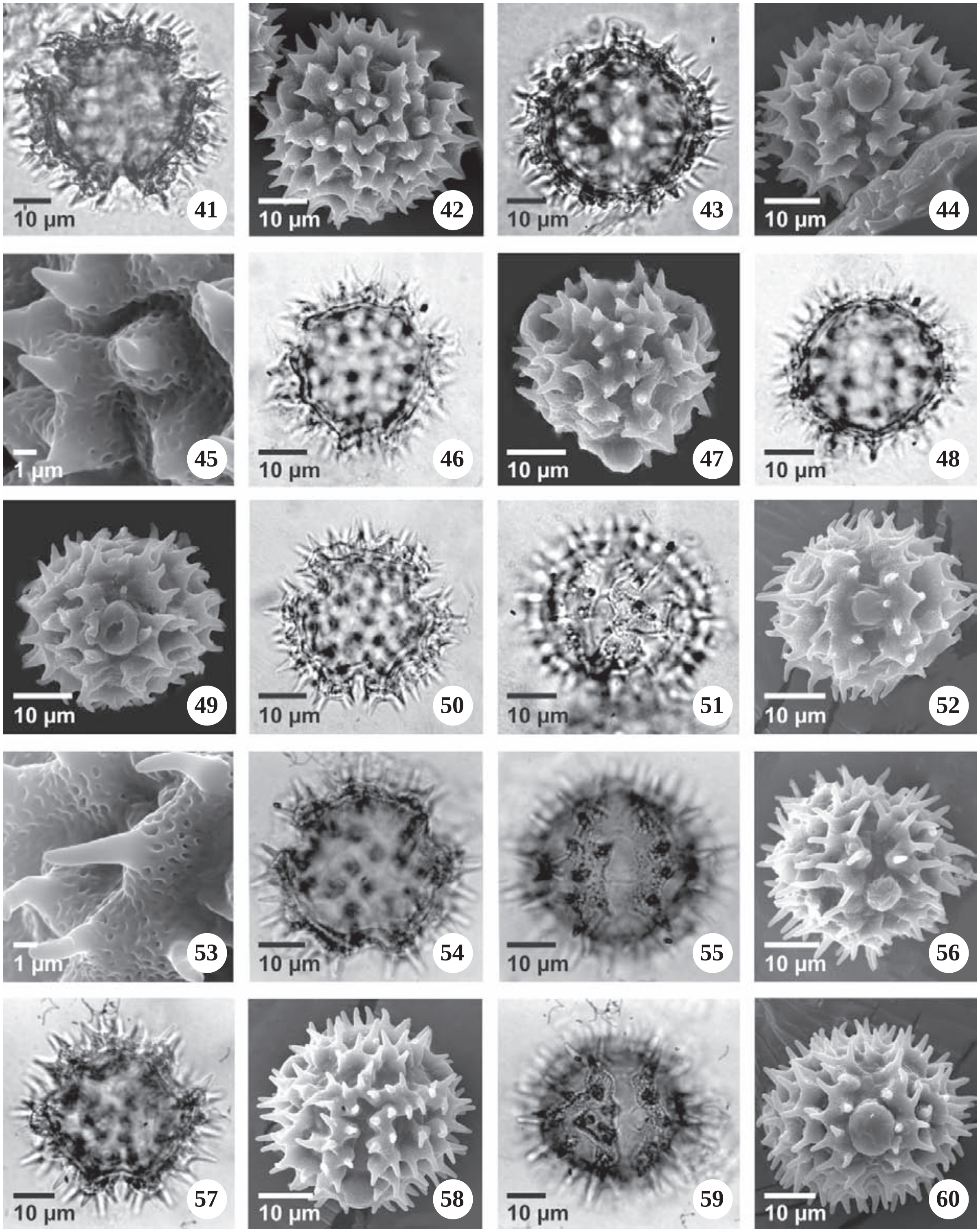
Table 4. Measures (µm) of pollen grains of comparison material (n = 10). (P = polar diameter; E = equatorial diameter; EDPV = equatorial diameter in polar view; SA = apocolpium side and polar area index (PAI)).

Especimens	Polar diameter $\bar{x}$	Equatorial diameter $\bar{x}$	P/E	Shape	EDPV $\bar{x}$	SA $\bar{x}$	PAI
V. brasiliana							
Luiz Roth 1455	42.8	46.1	0.92	oblate spheroidal	44.6	15.0	0.33
G. Hatschbach et al. 68123	43.0	45.7	0.94	oblate spheroidal	44.7	11.2	0.25
A. Macedo 66	43.5	46.9	0.92	oblate spheroidal	48.0	13.7	0.28
F.A. da Silveira 126	40.5	43.0	0.94	oblate spheroidal	42.8	13.0	0.30
V. chamaedrys							
Mello Barreto 1028	46.6	58.2	0.80	suboblate	48.3	16.7	0.34
H.F. Leitão Filho et al. 19415	47.5	55.9	0.84	suboblate	48.4	14.1	0.29
V. crassa							
V.C. Souza et al. 6113	54.0	59.0	0.91	oblate spheroidal	61.2	14.0	0.22
M.P. Manara et al. 8	53.2	58.3	0.91	oblate spheroidal	60.9	15.6	0.25
V. cuneifolia							
M. Magalhães 2876	47.0	51.7	0.90	oblate spheroidal	48.1	20.0	0.41
V. discolor							
G. Hatschbach et al. 57942	38.3	41.7	0.91	oblate spheroidal	43.3	10.8	0.24
V.C. Souza et al. 12215	40.1	42.6	0.94	oblate spheroidal	41.6	10.1	0.24
C.M.B. Correia et al. 215	38.5	41.9	0.91	oblate spheroidal	40.9	11.4	0.27
K.D. Barreto et al. 2891	39.2	42.1	0.93	oblate spheroidal	43.0	11.1	0.25
V. divaricata							
G. Hatschbach et al. 59707	41.6	49.8	0.83	suboblate	43.1	13.5	0.31
A.F. Carvalho 735	40.1	44.6	0.90	oblate spheroidal	44.2	13.9	0.31
W. Hoehne 3668	40.9	44.5	0.91	oblate spheroidal	41.9	12.9	0.30
M. Koscinski s.n. (SPF7171)	41.3	43.8	0.94	oblate spheroidal	42.5	13.9	0.32
V. ferruginea							
J.P.P. Carauta et al. 3517	41.0	46.2	0.88	oblate spheroidal	44.7	11.7	0.26
J.P. Lanna-Sobrinho 247	41.6	45.6	0.91	oblate spheroidal	42.6	10.7	0.25
F.A. Souza 122	42.4	46.2	0.91	oblate spheroidal	43.9	12.0	0.27
F.C.F. Silva 161	40.3	45.0	0.89	oblate spheroidal	43.0	13.9	0.32
V. ignobilis							
G. Hatschbach et al. 27862	53.0	56.1	1.05	prolate spheroidal	58.7	17.9	0.30
V. lindbergii							
J. Augusto s.n. (MBM188056)	45.2	51.9	0.87	suboblate	49.6	15.0	0.30
V. lucida							
M. Magi 2694	55.9	58.1	0.96	oblate spheroidal	56.3	16.5	0.29

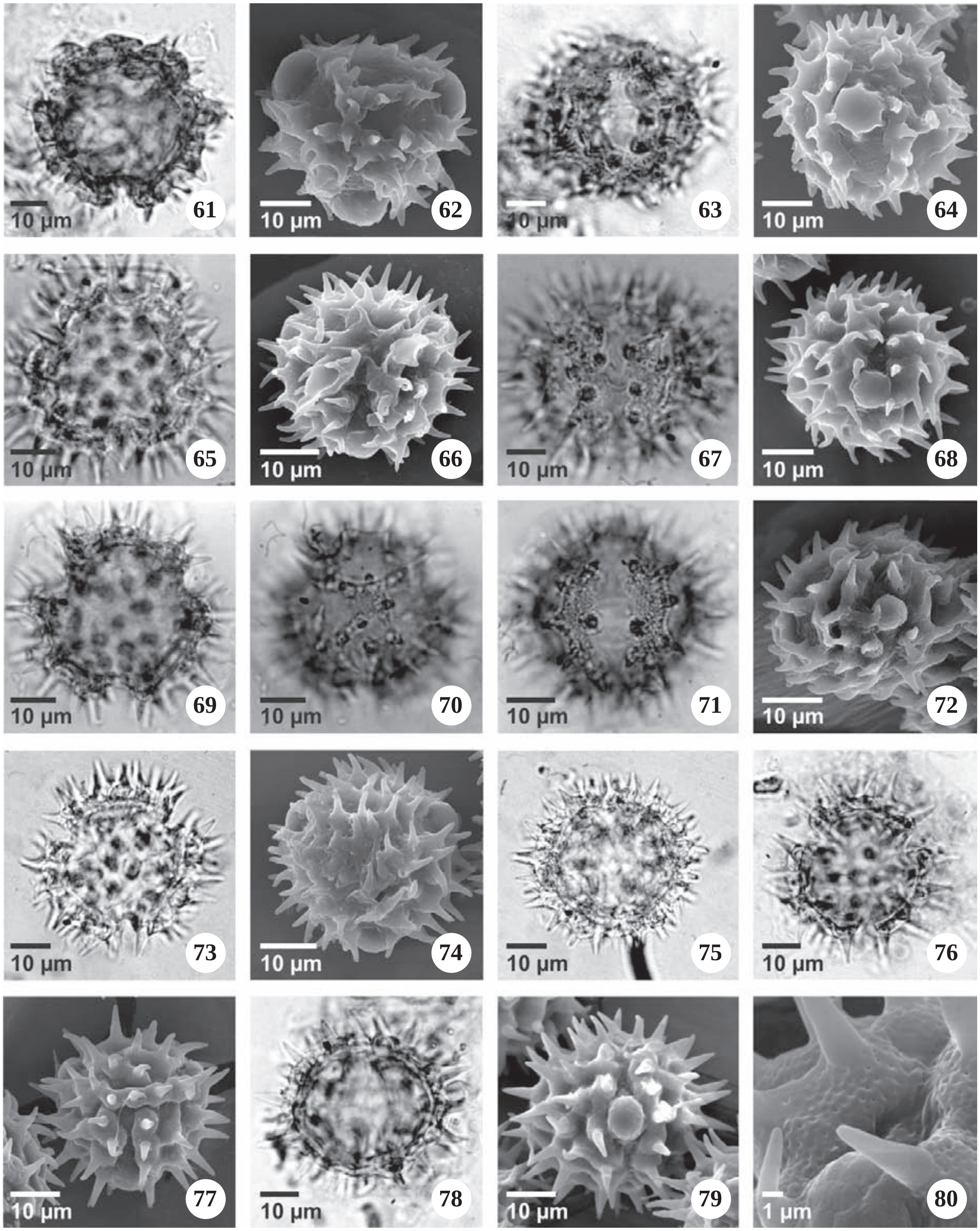
continue

continuation

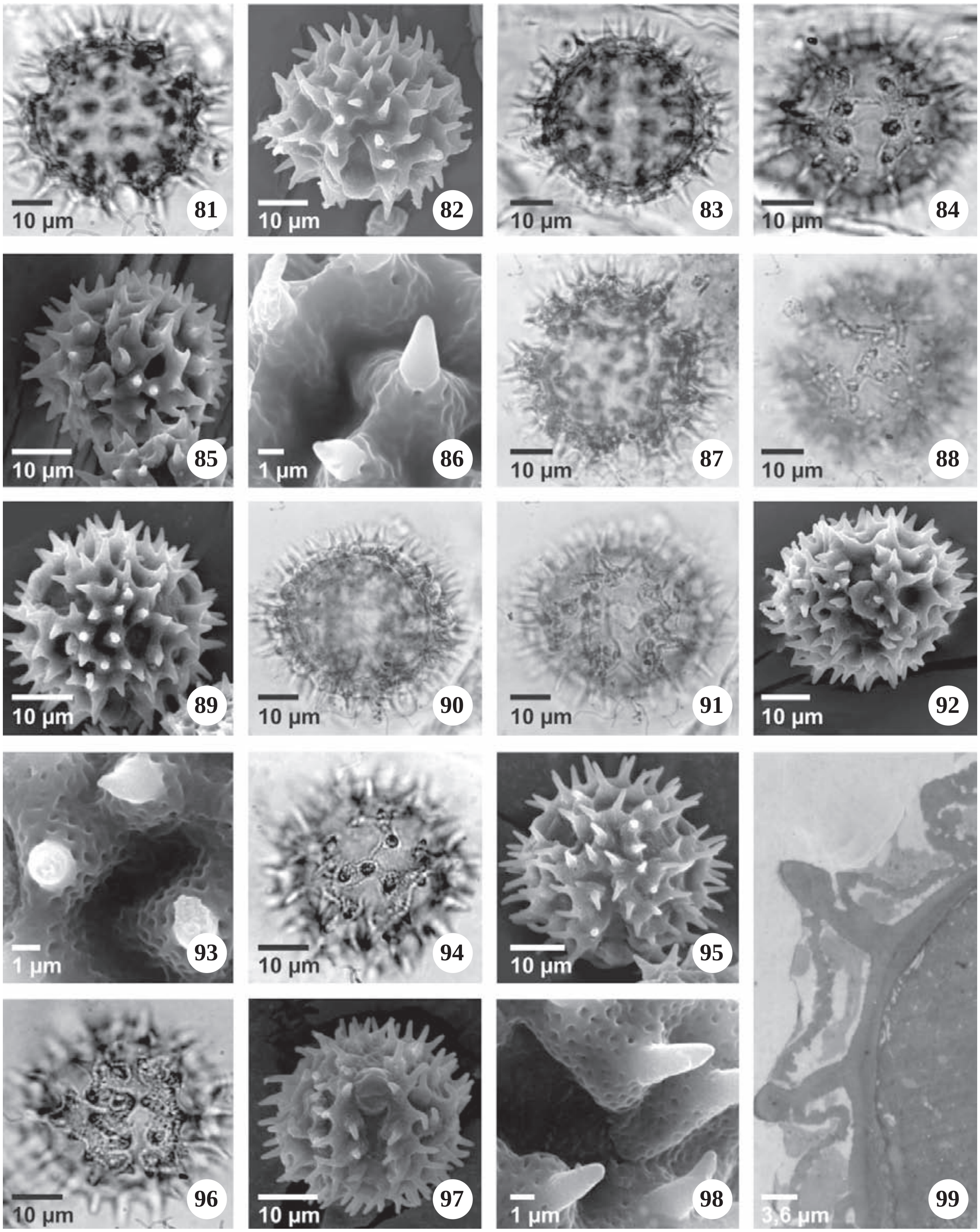
Especimens	Polar diameter $\bar{x}$	Equatorial diameter $\bar{x}$	P/E	Shape	EDPV $\bar{x}$	SA $\bar{x}$	PAI
H.S. Irwin e H. Maxwell s.n. (HB52051)	56.9	58.2	0.97	oblate spheroidal	57.0	16.9	0.29
V. mariana							
G. Hatschbach et al. 66506	38.6	40.5	0.95	oblate spheroidal	42.6	11.2	0.26
G. Hatschbach et al. 68252	39.9	42.6	0.93	oblate spheroidal	43.9	12.8	0.29
G. Hatschbach et al. 67376	39.4	41.2	0.95	oblate spheroidal	44.0	12.0	0.27
R. Esteves e V. Esteves 440	40.2	43.0	0.93	oblate spheroidal	42.2	12.5	0.29
V. membranacea							
G. Hatschbach et al. 72005	40.0	44.8	0.89	oblate spheroidal	44.0	10.6	0.24
E.W. Teixeira s.n. (VIC26896)	40.7	44.1	0.92	oblate spheroidal	43.4	12.2	0.28
V. montevidensis							
C. Angeli s.n. (GUA6280)	46.6	50.5	0.92	oblate spheroidal	49.5	14.0	0.28
R.L. Esteves 966	47.4	49.4	0.95	oblate spheroidal	51.6	14.2	0.27
W. Hoehne 6145	45.9	48.2	0.95	oblate spheroidal	51.4	14.3	0.27
V.F. Ferreira 3272	47.5	49.1	0.96	oblate spheroidal	51.5	14.5	0.28
V. mucronulata							
L. Gottsburger s.n. (MBM267217)	50.3	53.2	0.94	oblate spheroidal	52.8	14.1	0.26
V.C. Souza e C.M. Sakuragui 4127	49.1	50.9	0.96	oblate spheroidal	50.1	14.0	0.27
W. Hoehne s.n. (SPF14198)	49.8	53.3	0.93	oblate spheroidal	50.9	11.3	0.22
V.F. Ferreira 3243	48.9	54.3	0.90	oblate spheroidal	55.0	14.5	0.26
V. oligolepis							
H.F. Leitão-Filho et al. 20658	53.1	55.9	0.94	oblate spheroidal	55.4	18.3	0.33
G. Vidal s.n. (R113580)	48.8	52.9	0.92	oblate spheroidal	53.4	13.8	0.25
V. paludosa							
A.J. Sampaio 4816	43.0	47.8	0.89	oblate spheroidal	46.9	11.3	0.24
V. petiolaris							
J. Vidal 269	47.1	50.2	0.93	oblate spheroidal	50.5	11.0	0.21
M. Magalhães 4394	45.3	49.3	0.91	oblate spheroidal	49.8	12.4	0.24
E. Hermmendoff 503	46.7	49.4	0.94	oblate spheroidal	49.0	11.3	0.22
C.M.B. Correia et al. 11	46.0	50.8	0.90	oblate spheroidal	48.6	11.8	0.24
V. phosphorica							
J.P.P. Carauta 4833 et al.	45.6	50.1	0.91	oblate spheroidal	51.2	15.0	0.29
J.P.P. Carauta 4781 et al.	46.9	50.6	0.92	oblate spheroidal	51.9	15.0	0.28
E.F. Paciornil 55	46.9	52.1	0.90	oblate spheroidal	52.7	16.4	0.31
W. Hoehne 1417	47.3	50.9	0.92	oblate spheroidal	51.5	14.9	0.28
V. puberula							
A. Custodio-Filho 285	49.4	54.0	0.91	oblate spheroidal	51.5	13.0	0.25
V. rigiophylla							
A. Silveira 1257	46.9	51.4	0.91	oblate spheroidal	51.0	14.5	0.28
V. viscidula							
M. Barreto 4233	52.3	57.4	0.91	oblate spheroidal	51.4	20.1	0.39
R. Romero et al. 2292	49.8	55.5	0.89	oblate spheroidal	54.7	20.5	0.37
V. westiniana							
A.F. Regnell 1245	41.7	46.0	0.90	oblate spheroidal	45.7	15.7	0.34
R. Romero et al. 3289	42.2	46.5	0.90	oblate spheroidal	49.0	15.7	0.32
V.C. Souza et al. 2173	43.5	47.8	0.91	oblate spheroidal	47.5	16.0	0.33
W. Hoehne 4081	42.6	47.0	0.90	oblate spheroidal	46.2	15.8	0.34



Figures 41-60. LM and SEM photomicrographs of the pollen grains of *Vernonanthura*. 41-45. *V. lucida* (*G. Hatschbach et al. 67442*) – Polar view. 41. Cross section. 42. Surface of apocolpium. Equatorial view. 43. Cross section. 44. Aperture. 45. Detail of surface. 46-49. *V. mariana* (*R. Esteves* & *V. Esteves 427*). Polar view. 46. Cross section. 47. Surface of apocolpium. Equatorial view. 48. Cross section. 49. Aperture. 50-53. *V. membranacea* (*G. Hatschbach et al. 72203*) – Polar view. 50. Cross section. Equatorial view. 51-52. Aperture. 53. Detail of surface. 54-56. *V. montevidensis* (*V.C. Souza* & *C.M. Sakuragui 4328*) – Polar view. 54. Cross section. Equatorial view. 55-56. Aperture. 57-60. *V. mucronulata* (*J. Vidal s.n.* R113249) – Polar view. 57. Cross section. 58. Surface of apocolpium. Equatorial view. 59-60. Aperture.



Figures 61-80. LM and SEM photomicrographs of the pollen grains of *Vernonanthura*. 61-64. *V. oligolepis* (*C.A. de M. Scaramuzza* & *V.C. Souza 2701*) – Polar view. 61. Cross section. 62. Surface of mesocolpium. Equatorial view. 63-64. Aperture. 65-68. *V. paludosa* (*P. Dusén 454*) – Polar view. 65. Cross section. 66. Surface of apocolpium. Equatorial view. 67-68. Aperture. 69-72. *V. petiolaris* (*J. Vidal 182*) – Polar view. 69. Cross section. 70. Surface of apocolpium. Equatorial view. 71-72. Aperture. 73-75. *V. phosphorica* (*G. Hatschbach et al. 65250*) – Polar view. 73. Cross section. 74. Surface of apocolpium. Equatorial view. 75. Cross section. 76-80. *V. puberula* (*Glaziou 17022*) – Polar view. 76. Cross section. 77. Surface of apocolpium. Equatorial view. 78. Cross section. 79. Aperture. 80. Detail of surface.



Figures 81-99. LM and SEM photomicrographs of the pollen grains of *Vernonanthura*. 81-86. *V. rigiophylla* (*J.N. Nakajima et al. 1214*) – Polar view. 81. Cross section. 82. Surface of mesocolpium. Equatorial view. 83. Cross section. 84-85. Aperture. 86. Detail of surface. 87-93. *V. viscidula* (*Glaziou 15060*) – Polar view. 87. Cross section. 88-89. Surface of apocolpium. Equatorial view. 90. Cross section. 91-92. Aperture. 93. Detail of surface. 94-99. *V. westiniana* (*M. Frigoleto s.n.* GUA47702) – Polar view. 94-95. Surface of apocolpium. Equatorial view. 96-97. Aperture. 98. Detail of surface. 99. Detail of exine estructure (TEM).

and equatorial diameters within the limits of variation of its respective standard specimen. Regarding the shape, only the following specimens showed differences considering the standard material: *V. chamaedrys* (*Mello Barreto 1028*, *H.F. Leitão Filho et al. 19415*), *V. divaricata* (*G. Hatschbach et al. 59707*), *V. ignobilis* (*G. Hatschbach et al. 27862*) and *V. lindbergii* (*J. Augusto s.n.* MBM188056).

Key to the species of *Vernonanthura* based on pollen morphology

1. Large sized pollen grains (50.0-100.0 μm)
   2. Very small polar area (< 0.25 μm)
      3. Endoaperture with a median constriction; continuous muri tending towards the lophate pattern; walls distributed uniformly in the apocolpus .... *V. crassa*
      3. Endoaperture without a median constriction; discontinuous wall not tending towards the lophate pattern; muri in the apocolpus only delimiting the apertures .... *V. oligolepis*
   2. Small polar area (0.25-0.50 μm)
      4. Pollen grains with IC 95% ≥ 53.9 μm, colpus > 25.0 μm long; muri very sinuous; continuous .... *V. lucida*
      4. Pollen grains with IC 95% < 53.6 μm; colpus ≤ 24.0 μm; muri slightly sinuous; discontinuous
         5. Pollen grains with IC 95% DP = 52.7-53.6 μm; endoapertures lightly lolongate (11.8 × 11.2 μm); without a median constriction; walls in the apocolpium only delimiting the aperture .... *V. ignobilis*
         5. Pollen grains with IC 95% DP = 50.1-51.9 μm; endoaperture clearly lalongate (6.1 × 10.6 μm); with a median constriction; muri distributed uniformly in the apocolpium .... *V. viscidula*
1. Medium sized pollen grains (25.0-50.0 μm)
   6. Very small polar area (≤ 0,25 μm)
      7. Endoapertures with a median constriction; colpus *ca.* 27.6 μm long; interspinal distance *ca.* 10.6 μm .... *V. mucronulata*
      7. Endoaperture without a median constriction; colpus < 26,7 μm long; interspinal distance ≤ 10,0 μm
         8. Pollen grains with IC 95% DP = 48.8-50.0 μm; muri tending towards the lophate pattern; spine > 8.0 μm long .... *V. puberula*
         8. Pollen grains with IC 95% DP ≤ 47.1 μm; muri not tending towards the lophate pattern; spine ≤ 6.4 μm long
            9. Pollen grains with IC 95% DP = 41.4-42.2 μm; endoapertures > 14.0 μm wide; spine < 5.5 μm long .... *V. ferruginea*
            9. Pollen grains with IC 95% DP ≥ 43.8 μm; endoapertures ≤ 9.0 μm wide; spine > 6.0 μm long .... *V. paludosa*, *V. petiolaris*
   6. Small polar area (> 0.25 μm)
      10. Pollen grains with muri tending towards the lophate pattern
         11. Muri slightly sinuous
            12. DP = 40.7-41.8 μm .... *V. divaricata*, *V. membranacea*
            12. DP > 45.0 μm or < 39.7 μm
               13. Endoapertures with a median constriction; spines ≤ 5.0 μm long .... *V. cuneifolia*
               13. Endoapertures without a median constriction; spines ≥ 7.5 μm long .... *V. mariana*
         11. Muri very sinuous
            14. Muri continuous; DP = 45.3-46.1 μm .... *V. montevidensis*
            14. Muri discontinuous; DP > 47.5 μm or < 42.7 μm
               15. DP = 47.5-48.5 μm; endoapertures with a median constriction .... *V. rigiophylla*
               15. DP = 41.8-42.7 μm; endoapertures without a median constriction .... *V. westiniana*

10. Pollen grains with muri slightly or very sinuous and not tending towards the lophate pattern
    16. Muri very sinuous, continuous
        17. DP = 43.5-44.2 µm .... *V. brasiliana*
        17. DP = 48.2-49.4 µm .... *V. chamaedrys*
    16. Muri slightly sinuous discontinuous
        18. DP = 37.3-38.2 µm; colpus *ca*. 20.8 µm long; spine *ca.* 3.8 µm long .... *V. discolor*
        18. DP ≥ 44.5 µm; colpus > 24.3 µm long; spine > 7.3 µm long
            19. DP = 44.5-45.0 µm .... *V. lindbergii*
            19. DP = 46.1-46.9 µm .... *V. phosphorica*

Discussion

The 22 species of *Vernonanthura* presented homogeneous pollen grains regarding the shape (oblate spheroidal), the type of aperture (3 colpori) and the organization of the ornamentation patterns. They differ in size (medium or large), polar area (very small or small), endoapertures configurations (with or without a median constriction) and ornamentation details. Based on these differences, mostly species can be distinguished, with the exception of *Vernonanthura paludosa* × *V. petiolaris* and *V. divaricata* × *V. membranacea*.

There are few studies about the pollen morphology of *Vernonia* species moved to the genus *Vernonanthura* (Robinson 1992).

Stix (1960) recognized 42 different pollen types in the Asteraceae based on the ornamentation and structure of the exine. Within the *Lychnophora* type was included *Vernonia diffusa* Less. (= *Vernonanthura divaricata*) that has been analyzed in this work. The species examined here shows similar characteristics as the *Lychnophora* type designated by Stix (1960).

Kingham (1976) studied the pollinic morphology of the Vernonieae and established six pollen types based on the exine organization. Among the analyzed species, *Vernonia brasiliana* (L.) Druce (= *Vernonanthura brasiliana*) was placed in type VI by the author (subechinolophate to echinate, tricolporate with microperforated muri). The author further emphasized that there was a possibility of a subdivision for the type, based on the organization of the spines (these may be regularly or irregularly spaced) and by the number of perforations in the muri. The present study confirms the classification of *Vernonanthura brasiliana* in Kingham's (1976) type VI, and the possibilities of the subdivisions suggested by him. The pollinic key here elaborated confirms Kingham's observation (1976) regarding the differences in organization of the exine (muri tending or not towards the lophate pattern).

Keeley & Jones (1977) studied the species of *Vernonia* from New World and described three pollen types called A, B and C. Some years later, Jones (1979) recognized these three types and described an additional type named "D" (pollen grains echinolophate, triporate, discontinuous tectum, microperforated). The author affirmed the occurrence of the types A and B in the subsection of *Vernonia chamaedrys* Less. and classified as type A the species *V. chamaedrys, V. crassa, V. cuneifolia, V. montevidensis, V. mucronulata, V. puberula, V. rigiophylla* and *V. viscidula*, all them analyzed in this study. For the subsection *Nudiflorae*, the author reports only the type A, in which, among others, lie the species *V. brasiliana, V. mariana* and *V. westiniana*. The present study confirms the classification of the pollen grains as suggested by Jones (1979) based on the ornamentation pattern and the apertural type, according to which the *Vernonanthura* species present type A pollen grains.

Robinson (1999) pointed out that pollen morphology is a useful characteristic for the taxonomy of the Vernonieae and, according to the author, it is inexplicable that taxons are still described without pollen details. However, Robinson (1999) applied imprecise terms in his brief descriptions, such as rhizomate form (= ramification of the columellae) and baculate of the crests (= muri) of the lophate exine. The author suggested that the pollen type A, found in *Vernonanthura*, is apparently, a reversion of the lophate shape, which was maintained on some groups of Neotropical Vernonieae, such as *Vernonia/Vernonanthura*. In our study, the proposition for *Vernonanthura* made by Robinson (1999) was not supported, because some species presented typical subechinolophate pollen grains, and, in others, a tendency towards the lophate pattern. Even so, at the moment, it can not be confirmed which of the two types is more basal, as phylogenetic studies will possibly be required for elucidation.

Mendonça & Gonçalves-Esteves (2000) described the pollen morphology of some species of the tribe

Vernonieae occurring in the Carapebus "restinga" in Rio de Janeiro. Among studied species, *Vernonia beyrichii* Less. (*Vernonanthura beyrichii* (Less.) H. Rob.) is outstanding as it presents large pollen grains, isopolar, prolate spheroidal, triangular amb, small polar area, tricolporate, subechinolophate. This species seems very similar to *Vernonanthura ignobilis*, due to the pollen size and the small polar area, but it can be separated by the prolate spheroidal shape, endoapertures notably lalongate (10 × 7.0 μm) and the slightly sinuous muri tending towards a lophate pattern, distributed uniformly in the apocolpium.

DeVore *et al.* (2000), using TEM, accepted the definitions made by Skvarla *et al.* (1977) about the "anthemoide" pattern (non-caveate exine, long basal columella, above which it has shorter columellae alternating with internal tectum). According to authors, Lactuceae, Liabeae and Vernonieae present the "liabioide-antemoide" pattern as derived from an ancestral caveate shared with Asteroideae. The "antemoide" pattern evolved inside the subfamily Asteroideae. In our study, *Vernonanthura westiniana*, the single species analyzed with TEM, showed a pattern similar to the "antemoide", mainly due to the lack of cava.

In an analysis of the pollen variability of the plants from Campos de Jordão, Melhem *et al.* (2003) described 41 species of Compositae, including *Vernonia polyanthes* Less. (*Vernonanthura phosphorica*) and *Vernonia westiniana* Less. (*Vernonanthura westiniana*). Confronting the results found by the authors against those observed here, differences were ascertained, mainly in relation to the ornamentation. The authors described the exine as lophate, while in this study the sexine was considered subechinolophate. The authors suggested that the pollen of *Vernonanthura phosphorica* is large sized, and that the pollen of *V. westiniana* presents spherical shape. In our study, these species are considered medium size with an oblate spheroidal shape. However, the disparity in the results may be attributed to the incorrect taxonomic identification of the analyzed taxa.

Skvarla *et al.* (2005) described the pollen grains of eight North American species of *Vernonia s.s.* and three of *Elephantopus*. The authors concluded that the first genus presents subechinolophate exine with two types of columellae; in the first, the columellae are individual, solid, larger, *ca.* 2 μm in diameter and support the spine; in the second type, the columellae are smaller, *ca.* 1 μm diameter, less solid and do not support the spine. The pollen grains of the *Vernonanthura* species analyzed here, in both SEM and TEM (*Vernonanthura westiniana*), were similar (subechinolophate, tricolporate) to the *Vernonia s.s.* described by Skvarla *et al.* (2005). Based on the results found, it is considered that the evaluation of the pollen grain, does not reinforce the separation of those species currently maintained by Robinson (1988, 1994) in *Vernonia s.s*. because *Vernonanthura* presents subechinolophate and tricolporate pollen.

From the obtained results, *Vernonanthura* was considered an euripolinic genus whose pollen grains presented typical morphological characteristics, mainly regarding to the ornamentation, the size of the pollen grains and the features of the aperture, and all them may serve as further tools in delimitation of the species.

Acknowledgements – The authors thank MSc. Diego Knop for the english review; to Laboratório de Ultraestrutura Celular, of the Institute of Biophysics, Universidade Federal do Rio de Janeiro (UFRJ), with special thank to Noêmia Rodrigues Gonçalves, technician in scanning electron microscopy. Furthermore, we wish to thank Faperj (proc. E-26/171.071/03); CNPq (proc. 481595/2004-0) and the third author's productivity scholarship; and Capes for the first author's doctorate scholarship.

References

DEVORE, M.L., ZHAO, Z., JANSEN, R.K. & SKVARLA, J. 2000. Utility of trends in pollen morphology for phylogenetic analyses: an exemple using subfamilies Barnadesioidese and Cichoroideae (Asteraceae). *In* Pollen and Spores: morphology and biology (M.M. Harley, C.M. Morton and S. Blackmore, eds.). Royal Botanic Gardens, Kew, p.399-412.

ERDTMAN, G. 1952. Pollen morphology and plant taxonomy – Angiosperms. Almqvisit & Wiksel, Stockholm.

FAEGRI, G. & IVERSEN, J. 1966. Textbook of modern pollen analysis. 2nd ed. Scandinavian University Books, Copenhagen.

HOLMGREN, P.K., HOLMGREN, N.H. & BAINETT, L.G. 1990. Index Herbariorum. Part 1: The Herbaria of the world. 8nd ed., New York Botanical Garden, New York.

JONES, S.B. 1977. Vernonieae – systematic review. *In* The biology and chemistry of the Compositae (V.H. Heywood, J.B. Harbone & B.L. Turner, eds.). Academic Press., London, p.503-521.

JONES, S.B. 1979. Synopsis and pollen morphology of *Vernonia* (Compositae: Vernonieae) in the New World. Rhodora 81:425-447.

KEELEY, S.C. & JONES, S. 1977. Taxonomic implications of external pollen morphology to *Vernonia* (Compositae) in the West Indies. American Journal of Botany 64: 576-584.

KINGHAM, D.L. 1976. A study of the pollen morphology of Tropical African and certain other Vernonieae (Compositae). Kew Bulletin 31:9-26.

MELHEM, T.S., CRUZ-BARROS, M.A.V., CORRÊA, A.M.S., MAKINO-WATANABE, H., SILVESTRE-CAPELATO, M.S.F. & GONÇALVES-ESTEVES, V. 2003. Variabilidade polínica em plantas de Campos de Jordão (São Paulo, Brasil). Boletim do Instituto de Botânica 16:9-104.

MENDONÇA, C.B.F. & GONÇALVES-ESTEVES, V. 2000. Morfologia polínica de algumas espécies da tribo Vernonieae (Compositae Giseke) ocorrentes na restinga de Carapebus, Rio de Janeiro. Hoehnea 27:131-142.

PUNT, W., BLACKMORE, S., NILSSON, S. & LE THOMAS, A. 2007. Glossary of pollen and spore terminology. Review of Paleobotany and Palynology 143:1-81.

ROBINSON, H. 1988. Studies in the *Lepidaploa* complex (Vernonieae: Asteraceae) V – The new genus *Chrysolaena*. Proceedings of the Biological Society of Washington 101:952-958.

ROBINSON, H. 1992. A new genus *Vernonanthura* H. Rob. (Vernonieae: Asteraceae). Phytologia 73:65-76.

ROBINSON, H. 1994. New combinations in American Vernonieae (Asteraceae). Phytologia 76:27-29.

ROBINSON, H. 1999. Generic and subtribal classification of American Vernonieae. Smithsonian Contributions to Botany, Washington.

SALGADO-LABOURIAU, M.L. 1973. Contribuição à palinologia dos cerrados. Academia Brasileira de Ciências, Rio de Janeiro.

SKVARLA, J.J., TURNER, B.L., PATEL, V.C. & TOMB, A.S. 1977. The pollen morphology in the Compositae and in morphologically related families. *In* The biology and chemistry of the Compositae (V.H. Heywood, J.B. Harborne & B.L.Turner, eds). Academic Press., London, p.141-248.

SKVARLA, J.J., DEVORE, M.L. & CHISSOE, W.F. 2005. Lophate sculpturing of Vernonieae (Compositae) pollen. Review Palaeobotany and Palynology 133: 51-68.

STIX, E. 1960. Pollenmorpholosgische untersuchungen na Compositen. Grana Palynologica 2:41-114.

STUTTS, J.G. 1988. Taxonomic revision of *Vernonia* subsect. *Chamaedrys* (Compositae: Vernonieae). Rhodora 90: 37-99.