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POLLEN MORPHOLOGY OF *CYCLANTHERA* AND *SICYOS* SPECIES (CUCURBITACEAE, SICYOEAE)

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Abstract. Lima, L. F. P & S. T. S. Miotto. 2011. Pollen morphology of *Cyclanthera* and *Sicyos* species (Cucurbitaceae, Sicyoeae). *Darwiniana* 49(1): 7-15.

Pollen morphology of eight species of *Cyclanthera* and three species of *Sicyos* was studied using light and scanning electron microscopy. Pollen grains of *Cyclanthera* have a mean polar diameter of 51.40 µm, and an equatorial mean diameter of 49.10 µm, a prolate spheroidal shape (P/E = 1.11), 4-7 zonocolporate, with circular endoapertures, and punctitegilate exine. Pollen grains of *Sicyos* have a mean polar diameter of 50.60 µm and a mean equatorial diameter of 61.30 µm, an oblate spheroidal shape (P/E = 0.88), 8-12 colpate, supra and microreticulate echinate exine. Differences among the genera and species are discussed.

Keywords. Cucurbitaceae, pollen, Sicyoeae.

Resumen. Lima, L. F. P. & S. T. S. Miotto. 2011. Morfología polínica de especies de *Cyclanthera* y *Sicyos* (Cucurbitaceae, Sicyoeae). *Darwiniana* 49(1): 7-15.

Se estudió la morfología polínica de ocho especies de *Cyclanthera* y tres especies de *Sicyos* con microscopia óptica y electrónica de barrido. Los granos de polen de *Cyclanthera* presentan un diámetro polar medio de 51,40 µm y un diámetro ecuatorial medio de 49,10 µm, con formato prolato esferoidal (P/E = 1,11), 4-7 zonacolporado con endoabertura circular y exina punctitegilada. Los granos de *Sicyos* poseen el diámetro polar medio de 50,60 µm y un diámetro ecuatorial medio de 61,30 µm, formato oblato esferoidal (P/E = 0,88), 8-12 colpados, y la exina supra y microreticulada equinada. Se discuten las diferencias entre los géneros y las especies.

Palabras clave. Cucurbitaceae, polen, Sicyoeae.

INTRODUCTION

In tropical America, the family Cucurbitaceae is represented by 53 genera and approximately 325 species (Nee, 2004). Most representatives of the tribe Sicyoeae occur in the Neotropical region, and with the highest diversity in the two genera *Cyclanthera* Schrad. and *Sicyos* L. (Jeffrey, 2005). *Cyclanthera* comprises 31 species distributed between Mexico and Argentina, and *Sicyos* about 60 species distributed in the Americas, Hawaiian islands, Galapagos and one or a few species in Australasia (Jeffrey, 2005; Sebastian et al., 2010).

The division of Sicyoeae in two subtribes is based on pollen morphology, among other morphological characteristics. Cyclantherinae is characterized by pollen grains 4-8 colporate and punctitegilate (Marticorena, 1963; Jeffrey, 1990; Shridhar & Singh, 1990; Stafford & Sutton, 1994; Khunwasi, 1998), and Sicyinae by pollen grains 7-15 colpate and echinate (Marticorena, 1963; Shridhar & Singh, 1990; Khunwasi 1998).

Based on information related to the number,

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position, and type of aperture in pollen grains, described in the literature and from personal observations, Shridhar & Singh (1990) classified Cucurbitaceae pollen grains in nine main groups or morphotypes, where grains of the species in the subtribe Sicyoeae are multicolpate and circular, and in the subtribe Cyclantherinae are multicolporate.

The first comprehensive study of the pollen morphology from species of Sicyoeae is that of Marticorena (1963), who described the morphology of pollen grains of 30 species using the NPC system. After that, some studies described the pollen morphology of selected species in Cyclantherinae, such as Ayala-Nieto et al. (1988) for *Rytidostylis carthaginensis* (Jacq.) Kuntze, and Rodriguez-Jiménez & Palácios Chávez (1998) for the genus *Echinopepon* Naud. However, the most comprehensive study is that of Stafford & Sutton (1994) who described in detail the pollen morphology of species in the subtribe Cyclantherinae and their taxonomic relevance, establishing seven pollen types, and highlighting differences among aperture number, structure and ornamentation of the exine. The work of Khunwasi (1998) includes 8 species of *Cyclanthera* (incl. *Cremastopus*) and 8 species of *Sicyos*.

For Sicyinae, cladistic studies using pollen morphology helped to solve the delimitation of the genus *Sechium* P. Br. (Lira et al., 1997a, b), now sunken into *Sicyos* (Schaefer & Renner 2011b).

Although *Cyclanthera* and *Sicyos* are among the more important genera of Cucurbitaceae, their pollen morphology is still incompletely known (Marticorena, 1963; Heusser, 1971; Stafford & Sutton, 1994; Herrera & Urrego, 1996; Khunwasi 1998). The main goal of the present study is to describe the pollen morphology of these two genera and make comparisons among species, and thus provide additional information for the understanding of the group.

MATERIAL AND METHODS

Pollen samples from eight species of *Cyclanthera* and three species of *Sicyos* were obtained from herbarium specimens (see below: Examined material). We tried to use material from the highest number of localities as possible to account for pollen variability.

Pollen samples were prepared using the acetolytic method described by Erdtman (1960). For light microscopy, slides were mounted using glycerinated jelly and sealed with transparent nail polish. The slides are deposited in the Palinological Collection at the Universidade Federal do Rio Grande do Sul and the Universidade Luterana do Brasil (PAL - ULBRA/Canoas).

For scanning electron microscopy (SEM), pollen grains previously acetolized, were mounted on stubs and coated with gold. Some grains were broken following the technique described by Claugher (1986). Samples were analyzed in an electronic microscope PHILIPS XL 20 in the Centro de Microscopia e Microanálise of the Universidade Luterana do Brasil.

The terminology used in pollen descriptions follows Punt et al. (2007).

Examined material

Cyclanthera eichleri Cogn.: BRAZIL. **Paraná**. Antonina, Rio Cotia, 16-XI-1965, *Hatschbach 12780* (MBM). *Cyclanthera hystrix* (Gill.) Arn.: ARGENTINA. **Corrientes**. Depto. Paso de Los Libres, 30-X-1973, *Schinini 7030* (CTES). **Misiones**. Depto. Cainevas, 28-VII-1987, *Vanni et al. 809* (CTES). BRAZIL. **Rio Grande do Sul**. Derrubadas, Parque Estadual do Turvo, 25-X-2006, *Schmidt s.n*. (ICN 146219). Farroupilha, 14-I-1957, *Camargo 8*5 (HAS). *Cyclanthera multifoliola* Cogn.: BRAZIL. **Minas Gerais**. Coronel Pacheco, 18-VIII-1945, *Heringer 49403* (SP). MEXICO. **Chiapas**. Nueva Tenochtitlan, 29-X-1989, *Lira el al. 961* (MBM). *Cyclanthera oligoechinata* L.F.P. Lima & Pozner: ARGENTINA. **Misiones**. Depto. Cainguas, 13-VI-2004, *Radins 19* (CTES). BRAZIL. **Paraná**. Capanema, 15-V-1966, *Lindemann 1376* (MBM). *Cyclanthera pedata* (L.) Schrad.: BRAZIL. **Minas Gerais**. Lavras, 20-XI-1989, *Gavilanes 4387* (ESAL). **Paraná**. Curitiba, Horto Guabirotuba, 30-XII-1980, *Hatschbach 43498* (MBM). *Cyclanthera quinquelobata* (Vell.) Cogn.: BRAZIL **Minas Gerais**. Sapucaí-Mirim, 06-XI-1953, *Kuhlmann 2898* (SP). **Rio Grande do Su**l. Tenente Portela, 12-I-1982, *Mattos et al. 22943* (HAS). **Palmeira das Missões**, 21-I-2007, *Araújo s.n*. (ICN 151349). **São Paulo**. Santa Isabel, Igaratá, 27-IX-

Table 1. Selected characters of *Cyclanthera* pollen, including dimensions (µm) and morphology, with references to illustrations. Abbreviations: Apert, apertures; Ex, mean value of exine thickness; O sph, oblate spheroidal; P sph, prolate spheroidal; Sp, subprolate.

Species	Polar diameter (P)	Equatorial diameter (E)	Shape	P/E	Ex	Apert	Fig.
C. eichleri	48-70 (62.0)	46-67 (58.0)	O sph	0.99	5.4	5(6)	1A-D; 2A
C. hystrix	30-55 (42.9)	29-49 (38.0)	P sph	1.12	4.1	4	1E-F; 2B-C
C. multifoliola	38-70 (50.0)	30-50 (41.8)	SP	1.23	3.9	4	1G
C. oligoechinata	30-50 (39.0)	35-50 (42.3)	O sph	0.98	4.8	5(4)	1H; 2D-E
C. pedata	62-95 (74.8)	39-80 (61.7)	SP	1.19	5.0	4,6(5)	1I; 2F
C. quinquelobata	33-64 (47.9)	25-59 (40.7)	SP	1.15	3.9	4(5)	1J-K; 2G-H
C. tenuifolia	30-53 (43.2)	25-48 (35.9)	SP	1.17	4.0	4(5)	1L-M; 2I-J
C. tenuisepala	41-83 (64.9)	47-82 (61.7)	P sph	1.04	5.4	5-6(7)	1N-P; 2K-M

1950, *Kuhlmann 2558* (SP); Jundiaí, 23-XII-1956, *Kuhlmann 2898* (SP). *Cyclanthera tenuifolia* Cogn.: BRAZIL. **Paraná**. Palmas, 14-XII-1980, *Hatschbach 43489* (MBM). **Rio Grande do Sul**. Cambará do Sul, 19-XII-1969, *Ferreira & Irgang s.n* (ICN 7273). São José dos Ausentes, 28-XII-2006, *L.F. Lima 365* (ICN). **Santa Catarina**. Caçador, Rio Castelhano, 22-XII-1990, *Krapovickas & Cristobal s.n* (CTES 43707); **São Joaquin, Campestre do Malacara**, Morro da Igreja, 21-I-1960, *Mattos 7043* (HAS). *Cyclanthera tenuisepala* Cogn.: BRAZIL. **Pernambuco**. Riacho das Almas, 27-VII-1988, *Pereira 261* (IPA). **Rio Grande do Sul**. Sério, 11-III-2007 *Freitas 253* (ICN) ECUADOR. **Tungurahua**, Valley of Rio Pastaza, 26-VII-1939, Asplund s.n. (MBM 135330). MEXICO. **Guerrero**. Teletoapan, 13-IX-1991, *Lira & Soto 1311* (MBM). *Sicyos martii* Cogn.: BRAZIL. **Ceará**. Guaramiranga, 16-VII-1908, *Ducke s.n.* (MG 1301). Pacotí, 04-VI-1983, *Fernandes & Bezerra s.n.* (EAC); 26-XI-2001, *Chaves & Andrade s.n.* (EAC). **Goiás.** Rio Parnaíba, 20km de Itumbiara, 21-XII-1972, *Rizzo 8703* (UFG). **Minas Gerais.** Juiz de Fora, Água Limpa, Faz. Experimental, XI-1969, *Krieger 790*3 (MBM). *Sicyos polyacanthus* Cogn.: BRAZIL. **Ceará**. Independência, 22-V-2008, *Vieira Neto 170* (ICN). **Paraná**. Siqueira Campos. Ribeirão do Veado, 28-3-1974, *Kummrow 471* (MBM). **Rio Grande do Sul**. Parque Estadual do Turvo, 31-X-1971, *Lindemann et al s.n.* (ICN 8889). Porto Alegre, 20-XI-2006, *Kinupp 3203* (ICN). *Sicyos warmingii* Cogn.: ARGENTINA. **Catamarca**. Dpto Ambato, 29-III-1995, *Saraiva-Toledo et al. 13109* (MBM). **Salta**. Depto. San Martin, 31-V-1980, *Pedersen 12871* (MBM).

RESULTS

Cyclanthera has pollen grains with a polar mean diameter of 51.40 µm and equatorial mean diameter of 49.10 µm, a prolate-spheroidal shape (P/E = 1.11), frequently 4-7 zonocolporate with circular endoaperture, punctitegilate exine, with enlargement in the center of the mesocolpia, where collumeles are evident (Table 1, Figs. 1 and 2).

Cyclanthera eichleri, *C. pedata* and *C. tenuisepala* have the highest pollen grain dimensions. *C. oligoechinata* has pollen grains with a smaller polar mean diameter, while *C. hystrix* and *C. tenuifolia* have the smallest means for the equatorial diameter (Table 1). Within *Cyclanthera*, there is a tendency of having a grain with subspherical shape, and shapes varying from oblate spheroidal (Fig. 1H) to subprolate (Fig. 1C-D, F, P). In relation to the exine, a thickness between 4 to 5 µm is most common. The number of apertures among the studied species varied between 4 and 6. *C. eichleri* (Fig. 1A-B) and *C. oligoechinata* have predominantly 5 apertures, *C. tenuisepala* (Fig. 1N-O) frequently has grains with 5 or

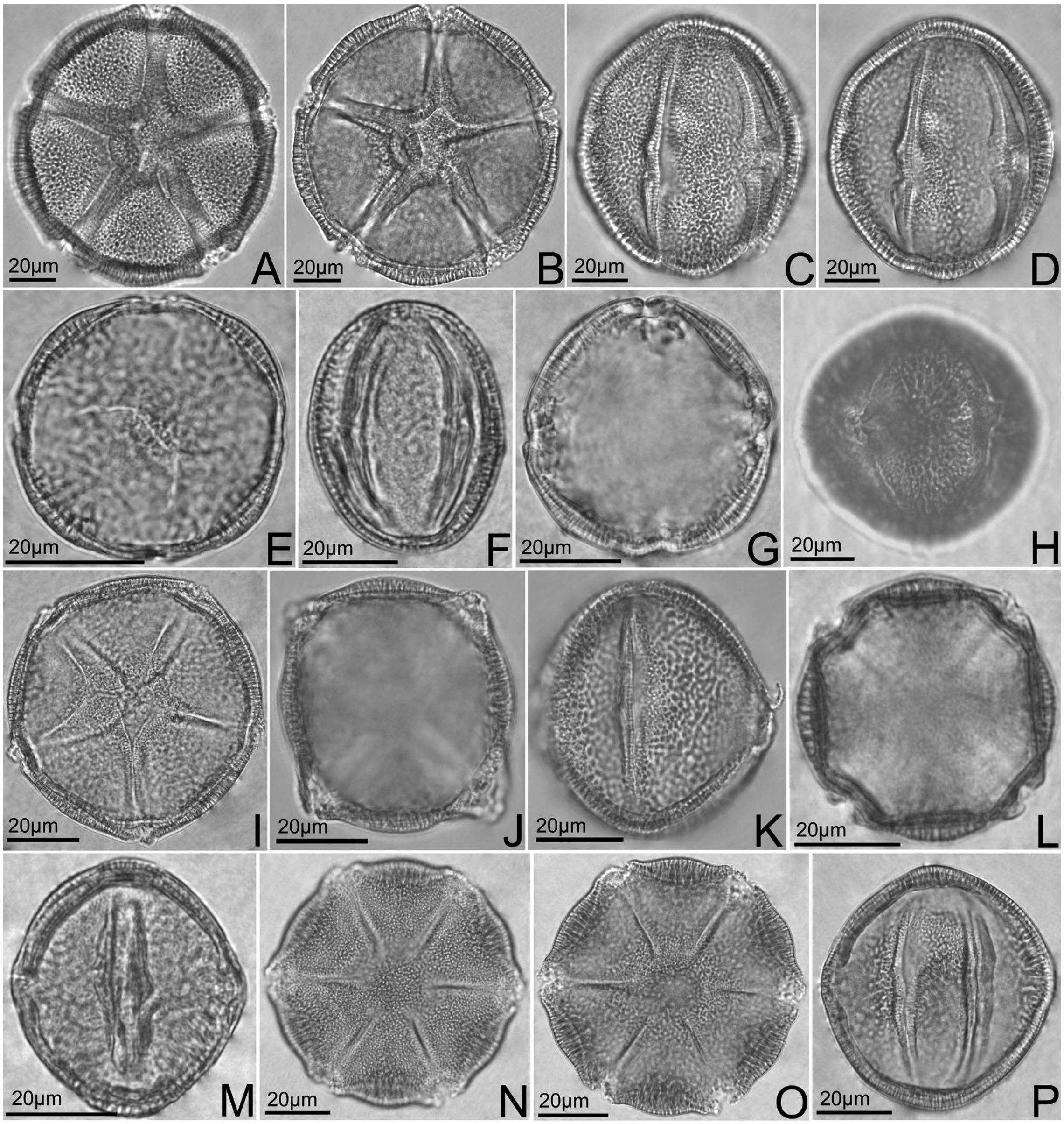

Fig. 1. Light microscopy images of *Cyclanthera* pollen grains. **A-D**, *C. eichlerii*. **A-B,** polar view. **C-D,** equatorial view. **E-F,** *C. hystrix*. **E,** polar view. **F,** equatorial view. **G,** *C. multifoliola,* polar view. **H,** *C. oligoechinata*, equatorial view. **I,** *C. pedata*, polar view. **J-K,** *C. quinquelobata*. **J,** polar view. **K,** equatorial view. **L-M,** *C. tenuifolia*. **L,** polar view. **M,** equatorial view. **N-P,** *C. tenuisepala*. **N-O,** polar view. **P,** equatorial view.

6 apertures, *C. hystrix* (Fig. 1E), *C. multifoliola* (Fig. 1G), *C. quinquelobata* (Fig. 1J), and *C. tenuifolia* (Fig. 1L) have 4 apertures, and in *C. pedata*, pollen grains have 4 or 6 apertures, rarely 5 (Fig. 1I).

Species of *Sicyos* are characterized by the presence of pollen grains with a polar mean diameter of 50.6 µm and an equatorial diameter of 61.3 µm, an oblate-spheroidal shape, invariably P/E = 0.88 (Table 2), 8-12 colpate with an echinate exine supra and microreticulate (Figs. 3 and 4).

Among the studied species, pollen grains of *Sicyos polyacanthus* have generally the highest polar and equatorial diameters, and *S. martii* the

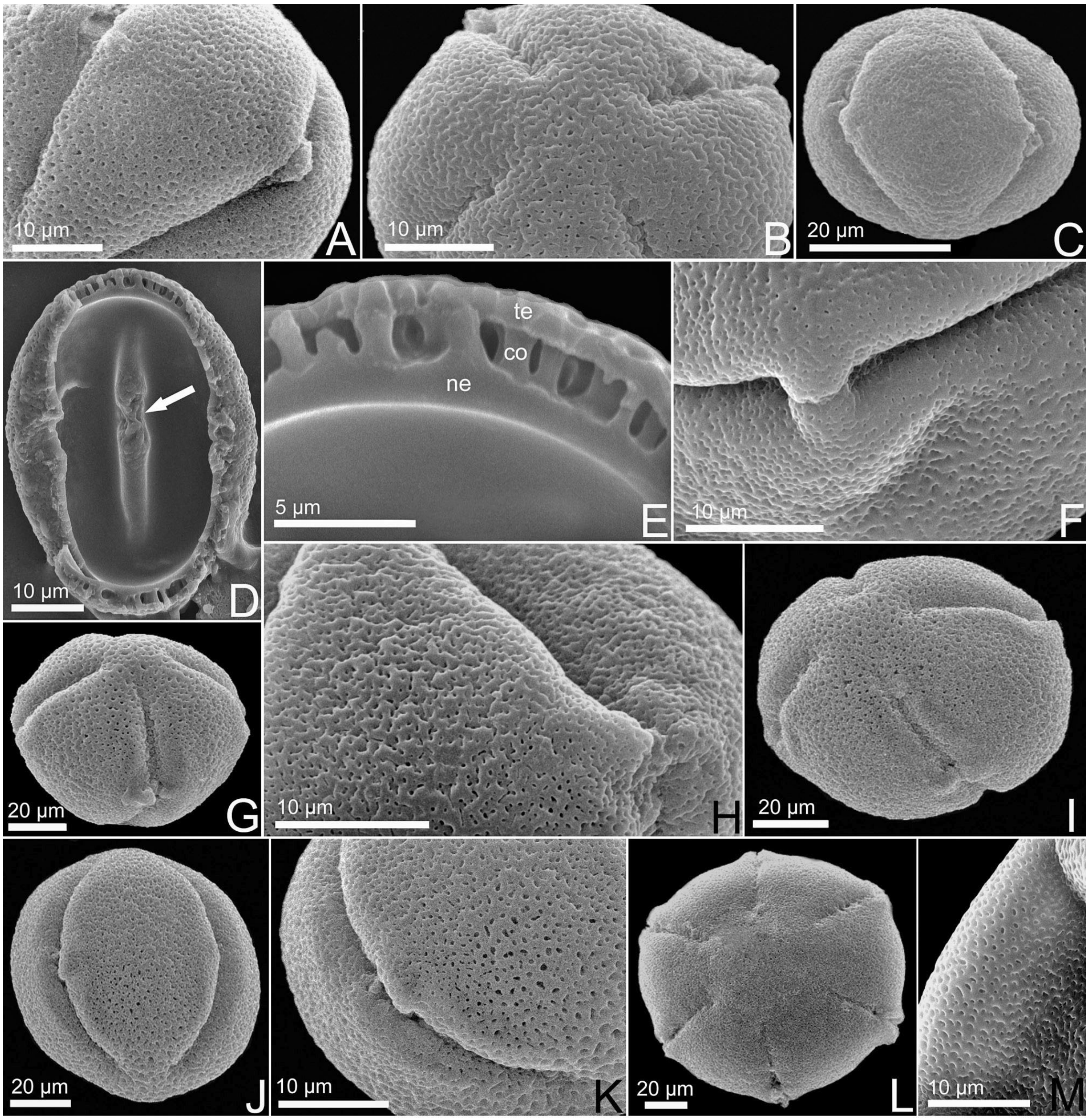

Fig. 2. SEM images of *Cyclanthera* pollen grains. **A,** *C. eichlerii*, equatorial oblique view showing details of the apertures and ornamentation. **B-C,** *C. hystrix*. **B,** polar oblique view showing details of the apertures and ornamentation. **C,** equatorial view. **D-E,** *C. oligoechinata*. **D,** section of pollen grain, showing endoaperture and exine structure. **E,** exine structure. **F,** *C. pedata*, detail of the aperture. **G-H,** *C. quinquelobata*. **G,** equatorial oblique view. **H,** details of the apertures and ornamentation. **I-J,** *C. tenuifolia*. **I,** polar oblique view. **J,** equatorial oblique view. **K-M,** *C. tenuisepala*. **K,** details of the apertures and ornamentation. **L,** polar view. **M,** details of the ornamentations.

lowest values (Table 2). In this genus the exine is thin and the spines, with length and shape of the apex variable among species, always have a translucid cavity in the apex (Fig. 3G). *S. martii* has smaller spines with a pointing apex (Table 2, Fig. 3C); in *S. polyacanthus* and *S. warmingii* the spines are longer, being robust with a round apex in the former, and thin with a pointing apex in the latter (Table 2, Fig. 3F,I). There is a high number of colpi in *S. martii*, and a smaller number in *S. polyacanthus* and *S. warmingii* (Table 2).

Table 2. Selected characters of *Sicyos* pollen, including dimensions (µm) and morphology, with references to illustrations. Abbreviations: **Apert**., Apertures; **Ex,** Mean of exine thickness; **O sph**, Oblate spheroidal.

Species	Polar diameter (P)	Equatorial diameter (E	Shape	P/E	Ex	Spine	Apert.	Fig.
S. martii	30-58 (45.9)	40-73 (57.5)	O sph	0.91	2.2	4.2	11-12	1A-C; 2F
S. polyacanthus	43-78 (53.7)	52-85 (66.7)	O sph	0.85	2.8	5.1	8-11	1D-G; 2A-B, D-E
S. warmingii	45-69 (52.2)	53-70 (59.8)	O sph	0.90	2.1	5.0	8-10	1H-I; 2C

DISCUSSION AND CONCLUSIONS

The present study supports the division of Sicyoeae into two subtribes based on pollen morphology, confirming the importance of this diagnostic characteristic for the definition of sub-tribes as pointed out by Jeffrey (1990).

Two pollen types were observed in Sicyoeae: one for *Cyclanthera* species, with puctitegilate and multicoporate pollen grains (type Cyclantherinae, *sensu* Jeffrey, 1964) and the other for species of *Sycios*, with echinate and multicolpate pollen (type Sicyinae, *sensu* Jeffrey, 1964). These two pollen types are also observed in other species and genera of the tribe (Marticorena, 1963; Shridhar & Singh, 1990; Alvarado et al., 1992; Stafford & Sutton, 1994; Lira et al., 1997a; Rodríguez-Jiménez & Palacios Chavez, 1998; García et al., 2003; Khunwasi 1998).

Comparing our data with the results presented by Khunwasi (1998), there is a compatibility between the characters discussed in both works. There is a discrepancy in measures of exine thickness for the species of *Cyclanthera*, where Khunwasi (1998) considered a variation between 7-8.4µm, while in the present study we consider a variation between 3.9-5.4µm, in the apocolpus region. This incongruence probably is provenient of measures in different regions of the pollen grain, since the mesocolpus is thickened in species of *Cyclanthera*.

The number of apertures in the pollen grains is variable in both studied genera, with higher amplitude observed in *Sicyos* (8-12 apertures) compared to *Cyclanthera* (4-6 apertures). Rodríguez-Jiménez & Palácios-Chavéz (1998) observed a highest variation (6-17 apertures) in *Echinopepon* (Cyclantherinae). However, Marticorena (1963), Alvarado et al. (1992), and Lira et al. (1997a, b) reported for other species of Sicyinae a lower variation in the number of apertures, different from what was observed for *Sicyos*.

In relation to the structure of the sporoderm of *Cyclanthera*, this study shows similarities with the *Cyclanthera* type proposed by Stafford & Sutton (1994), which includes, in addition to *Cyclanthera*, species of *Marah* Kellog, *Elateriopsis* Ernst, and *Hamburia* Seem. In these taxa, as well as in the species studied here, the exine is punctitegilate and the collumels are long.

In *Sicyos* the interpretation of the sporoderm is not clear, especially in relation to the interspinal area. Marticorena (1963) described for the pollen grains of the genera of Sicyineae "echinate or echinulate exine, covered by an apparently loose coat, formed by baculoid processes, which in some species, have a loosely reticuloid disposition". In the present study, we observed, with scanning microscopy, that the interspinal ornamentation referred by Marticorena (1963) is a microreticulum.

The presence of cavities inside the spines as observed for our *Sicyos* species is also reported for other species in the genus and in Sicyieae (Marticorena, 1963; García et al., 2003). However, García et al. (2003) observed cavities located at the base of the spines in *Sicyos parviflorus* Willd. Alvarado et al. (1992) and Lira et al. (1994; 1997a, b) did not confirm the presence of cavities in all individuals of the tribe, restricting its occurrence to the genus *Sechium* and to the species *Sechiopsis triquetra* (Ser.) Naudin. The presence or absence of these cavities are informative in the delimitation of genera and in phylogenetic studies by Lira et al. (1997a, b). However, the presence of this characteristic seems to be more widespread than considered by these authors.

Other potential characteristics for phylogenetic studies, due to their variability, are the shape of the

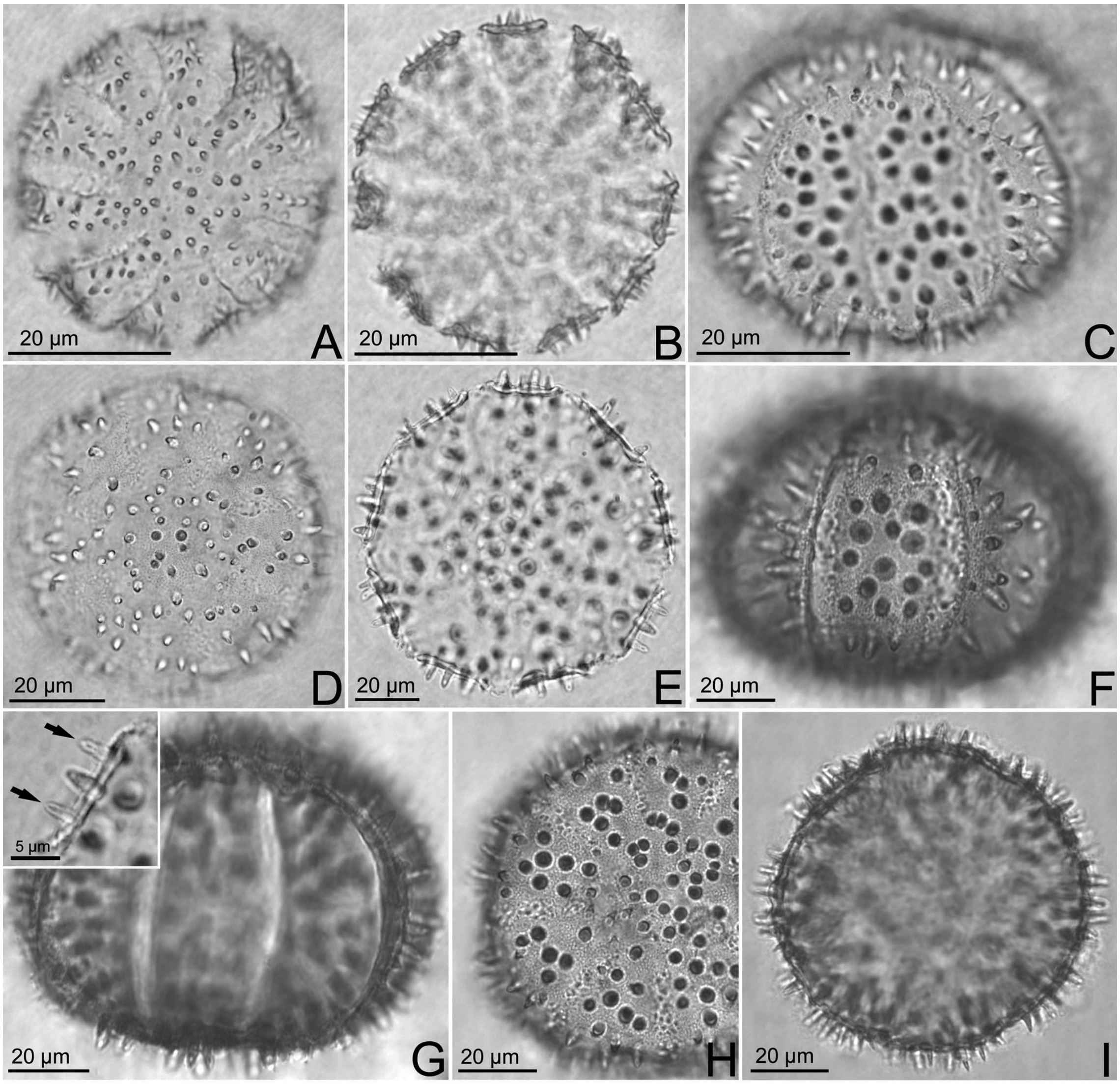

Fig. 3. Light microscopy images of *Sicyos* pollen grains. **A-C,** *S. martii*. **A,** polar view, showing the apertures and spines. **B,** polar view, equatorial focus level. **C,** equatorial view. **D-G,** *S. polyacanthus*. **D,** polar view. **E,** polar view, equatorial focus level. **F,** equatorial view. **G,** equatorial view, showing exine and spines. **H-I,** *S. warmingii*. **H,** polar view, showing the apertures and spines. **I,** polar view, showing exine.

apex and the length of the spines. These characteristics were used in this type of study by Lira et al. (1997b) for *Sechium*.

According to data from molecular phylogeny and the new proposed classification of Cucurbitaceae (Schaefer & Renner, 2011a), the genera *Sechium*, *Sechiopsis* Naudim, *Pterosicyos* Brandegee, *Sicyosperma* A. Grey, *Sicyocaulis* Wiggins, *Parasicyos* Dieterle and *Costarica* L. D. Gómez are synonymized in *Sicyos*, supporting the general pollen morphology. Just like the pollen morphology of *Pseudocyclanthera* Mart. Crov. and *Rytidostyles* Hook. & Arn.(Stafford & Sutton, 1994) strengthen the proposed inclusion of these two genera in *Cyclanthera* (Schaefer & Renner, 2011a).

In the first study on molecular phylogeny of Cucurbitaceae (Kocyan et al., 2007) the 20 sampled taxa of Sicyoeae form a clade that, according to the authors, is well supported by morphology,

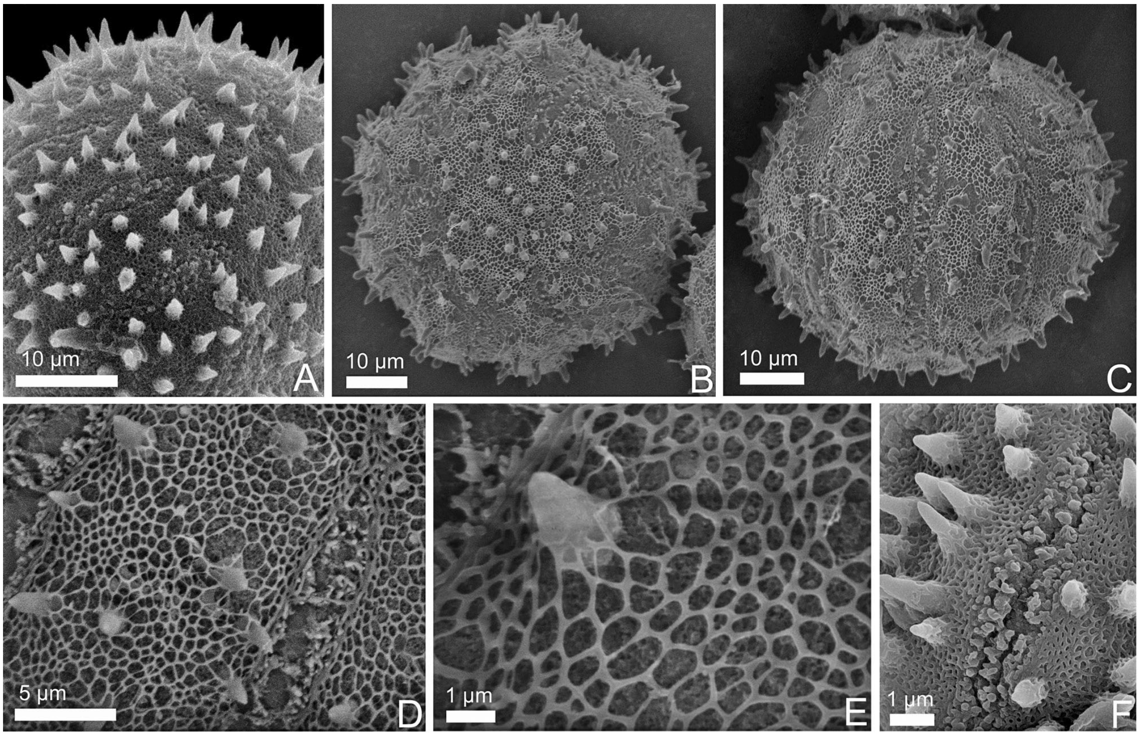

Fig. 4. SEM images of *Sicyos* pollen grains. **A,** *S. martii*, polar oblique view. **B-E,** *S. polyacanthus*. **B,** polar view. **C,** equatorial view. **D,**: details of the apertures and ornamentation. **E,**: detail of the ornamentation. **F,** *S. warmingii*, details of the apertures and ornamentation.

including pollen characteristics such as the presence of exine finely spinulose and colpate or colporate grains. As demonstrated in several pollen studies (Marticorena, 1963; Stafford & Sutton, 1994; Rodríguez-Jiménez & Palacios Chávez, 1998; Lira et al., 1997a) and in this work, species of Cyclantherinae do not have an echinate exine.

According Cogniaux (1878), *Sicyos* is divided in two sections based on the arrangement of flowers with pistils, on the shape of the fruits, and on spine peculiarities: Section *Sicyos* (to which belong *S. polyacanthus* and *S. warmingii*) that has aggregated pistillate flowers in umbellas, ovoid or oblong fruits and scabrous and retrorses spines, and Section *Atractocarpos* (which includes *S. martii*), with pistillate flowers solitary or geminate, fusiforme fruits, and arrow shaped spines. In addition, some species have been placed in *Anomalosicyos*, a genus described by Gentry (1946) to accommodate species of the section *Atractocarpos*. Thus, due to the lack of a recent review for this genus, the last was made by Cogniaux (1881), and due to the difficult taxonomy, a pollen study that includes a higher number of taxa is desirable to help elucidate several questions. Even though we analyzed a restricted number of species in the present study, it is possible to observe that these species form a group in the sections proposed by Cogniaux (1881). *Sicyos martii* presents the smallest dimensions of pollen grains and spines and the highest number of apertures when compared with *S. polyacanthus* and *S. warmingii*, in which pollen grains are larger, spines are longer, and the number of apertures is smaller.

The present study highlights the importance of the use of pollen characters for distinguishing subtribes of Sicyoeae, as suggested by Shridhar & Singh (1990) for higher hierarchical levels in Cucurbitaceae. Most important for the distinction of species or species groups are the number and type of apertures, pollen dimensions, ornamentations, and structure and thickness of exine.

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