POLLEN OF TROPICAL TREES. I. TILIACEAE

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SINCE THE FAMILY Tiliaceae is predominantly tropical, and some of its members are important elements of tropical ecosystems, we have chosen to study and describe the pollen of a few of them. We worked with five species of five different genera, representatives of the flora of tropical Mexico, each one described and illustrated in the *Manual para la Identificación de Campo de los Principales Arboles Tropicales de México*, by T. D. Pennington and J. Sarukhán. These species are: *Apeiba tibourbou* Aublet, *Belotia mexicana* (DC.) K. Schum., *Carpodiptera ameliae* Lundell, *Heliocarpus donnell-smithii* Rose, and *Luehea speciosa* Willd.

Our descriptions are accompanied by photographs taken with a Zeiss light microscope and with an AMR scanning electron microscope (SEM).

The specimens studied under the light microscope were obtained from the Herbario Nacional de México (MEXU), while those studied under the SEM were from the collections of the Harvard University Herbaria (A[1] or GH[2]). The specimens from MEXU were acetolyzed (Erdtman, 1952) and mounted with glycerine jelly; those from A or GH were coated with carbon and gold-palladium.

Pollen of most of the genera studied has been described before by various authors: *Apeiba* by Sharma (1969), *Belotia* by Erdtman (1952), *Carpodiptera* by Erdtman (1952) and by Chaudhuri (1965), and *Luehea* by Mohl (1835).

The pollen specimens are deposited in the pollen reference collection of the Paleobotanical Laboratory in the Harvard University Herbaria building and at the Palynological Section of the Museo de Micropaleontología at the Instituto de Geología Universidad Nacional Autónoma de México.

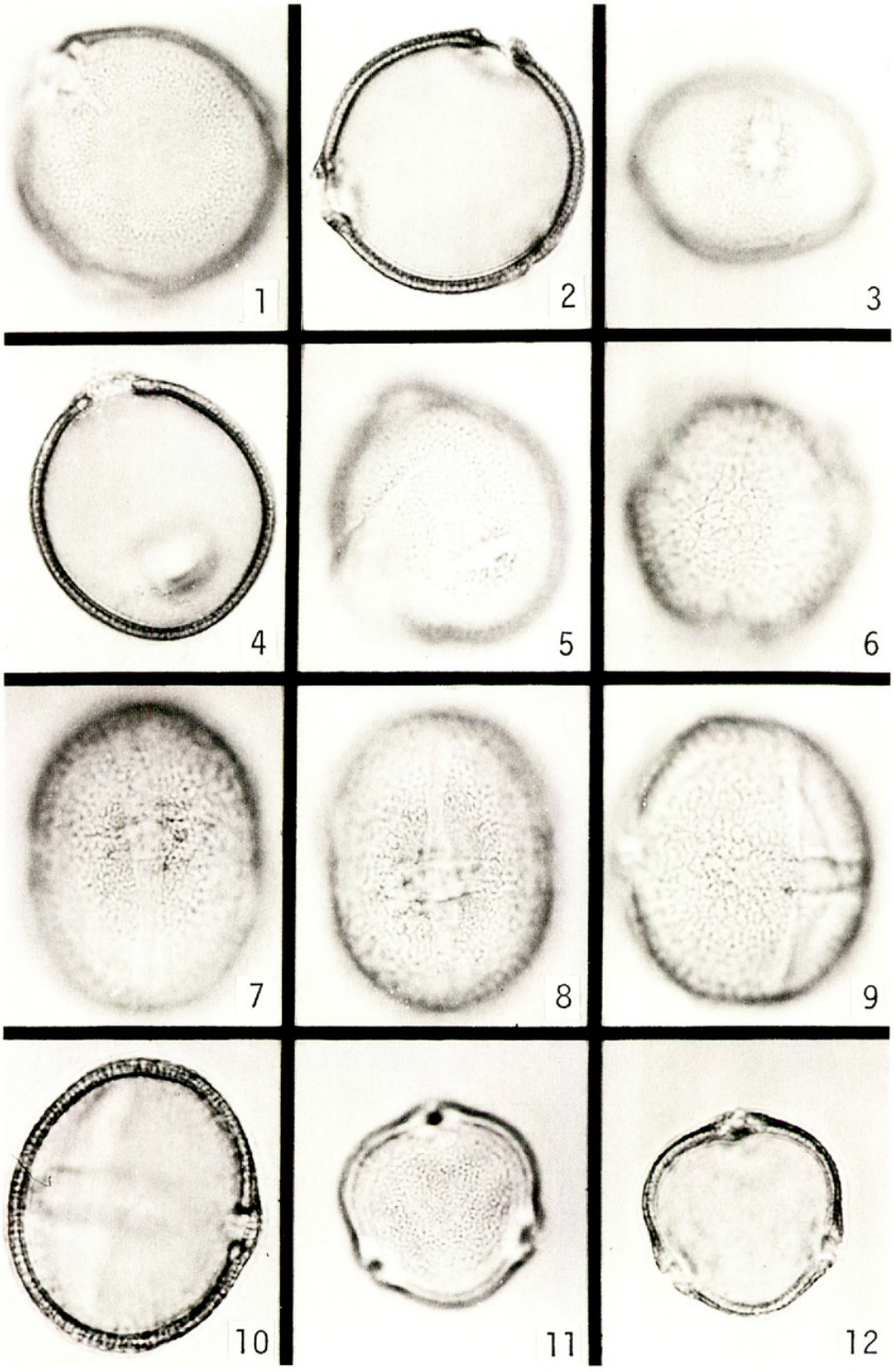
DESCRIPTIONS

Apeiba tibourbou Aublet. FIGURES 1–5, 25, 32.

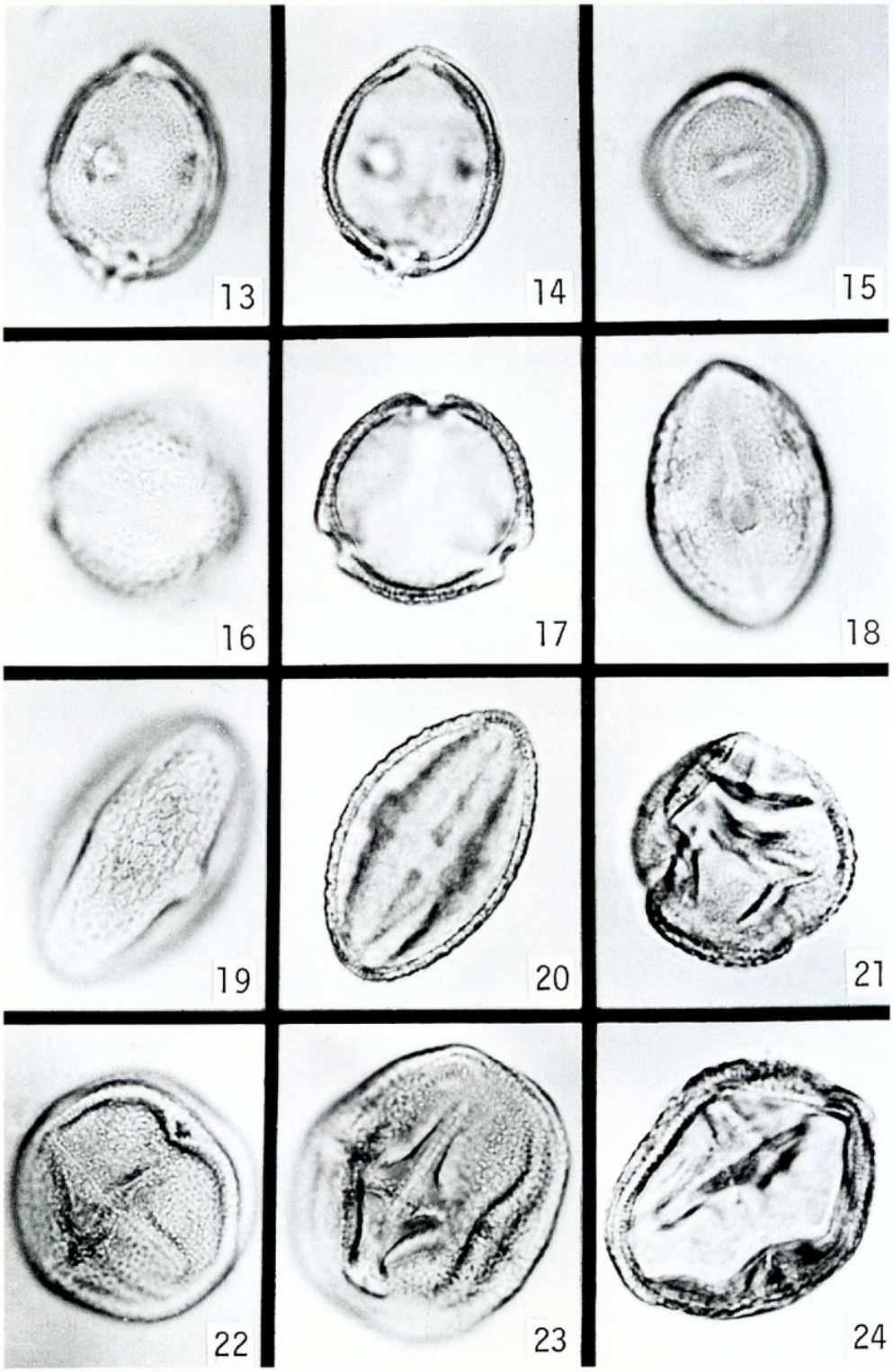
APERTURE. Brevitricolporate, colpus transversalis. Grains slightly aspidorate. When acetolyzed the colpus membrane formed by the nexine is modified. After acetolysis the remaining structure, the sexine, is psilate under the light microscope. With the SEM this structure is scabrate in unacetolyzed grains. Polar index, 0.7; colpus transversalis, 7 μm. $\times$ 3 μm.; colpi, 9.38 μm.; pore, 9 μm. $\times$ 4 μm.

ORNAMENTATION. Tectum perforate to heteroreticulate; lumina 0.3–0.8 μm., distributed at random; muri simplibaculate. Stratification clear, colum-

[1] Arnold Arboretum of Harvard University, Cambridge, Mass.
[2] Gray Herbarium of Harvard University, Cambridge, Mass.



FIGURES 1–12. 1–5, *Apeiba tibourbou* (from *Pennington & Sarukhán 9065*, Tuxtepec, Oaxaca, México), × 1000. 1, 2, polar view: 1, high focus; 2, median optical section. 3–5, equatorial view: 3, high focus (note brevicolporate aperture); 4, optical section (note effect of acetolysis on sexine of os); 5, broken grain showing well-developed colpus transversalis in compound aperture. 6–10, *Belotia mexicana* (from *Pennington & Sarukhán 9278*, Puebla, México), × 1000. 6, polar view, high focus. 7–10, equatorial view: 7, high focus (colpus transversalis covered by the sexine); 8, high focus (colpus transversalis complete); 9, high focus; 10, optical section. 11, 12, *Carpodiptera ameliae* (from *Matuda s.n.*, Tenosique, México), × 1000, polar view: 11, high focus; 12, median optical section.



FIGURES 13–24. 13–15, *Carpodiptera ameliae* (from *Matuda s.n.*, Tenosique, México), × 1000, equatorial view: 13, high focus; 14, optical section; 15, high focus. 16–20, *Heliocarpus donnell-smithii* (from *Matuda s.n.*, Acocoyagua, Chiapas, México), × 1000. 16, 17, polar view: 16, high focus; 17, median optical section. 18–20, equatorial view: 18, 19, high focus; 20, median optical section. 21–24, *Luehea speciosa* (from *Martínez-Calderón 201*, Tuxtepec and vicinity, Oaxaca, México), × 1000: 21, polar view, optical section on one side and high focus on others; 22, 23, high focus; 24, optical section (note clear stratification of sexine on one side of grain).

ellae easily seen. Exine, 1.5 μm. (ectosexine, 0.5 μm., endosexine, 0.75 μm., nexine, 0.25 μm.).

Belotia mexicana (DC.) K. Schum. FIGURES 6–10, 26, 32.

APERTURE. Tricolporate, colpus transversalis. The colpus membrane is psilate when the grain is acetolyzed, but verrucae are present close to the colpus transversalis. Without acetolysis the colpus membrane is scabrate (SEM sample). Polar index, 0.2; colpus transversalis, 24 μm. × 6.8 μm.; colpi, 25.04 μm.; pore, 3.82 μm.

ORNAMENTATION. Semitectate, supraheterobrochate. Lumen size decreasing toward the apertures. There is a wide range between the sizes of the lumina (0.3–0.8 μm.). Stratification clear; muri simplibaculate. SEM photographs show the tectum to be perforate within the lumina. Columellae visible. The nexine disappears at the level of the colpus transversalis. The ornamented sexine remains when the grains are acetolyzed. Exine, 1.6 μm. (ectosexine, 0.4 μm.; endosexine, 0.8 μm.; nexine, 0.4 μm.).

Carpodiptera ameliae Lundell. FIGURES 11–15, 27, 33.

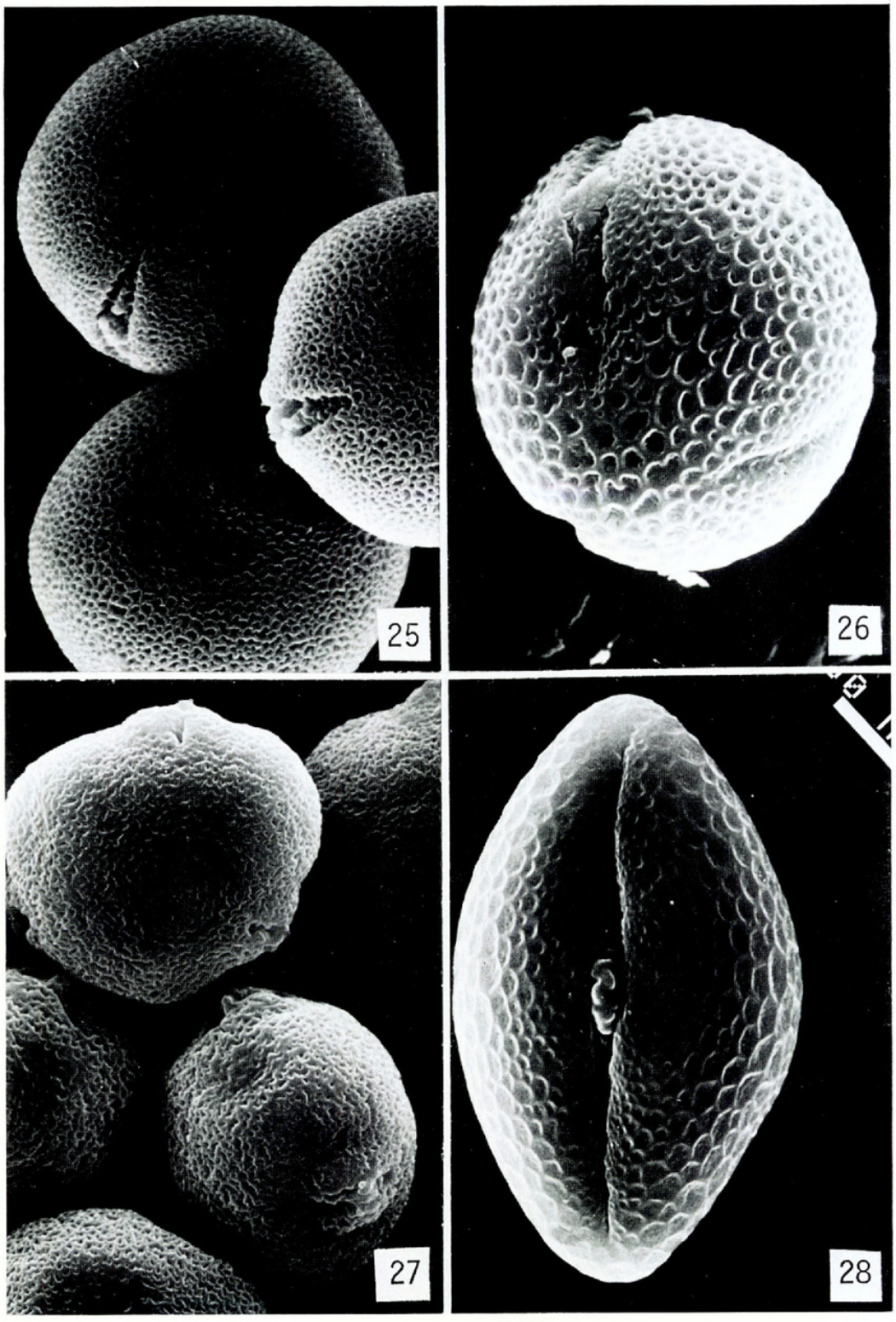
APERTURE. Tri-brevicolporate and tetra-brevitricolporate (less frequently). Aspidorate. Pore oval, meridianally elongated. Pore membrane scabrate when acetolyzed (light microscope sample). Before acetolysis the grains have a notch located in the ora region of the aperture. This notch is lost upon acetolysis, and instead it is possible to see an exoaperture. Unacetolyzed grains are endoaperturate. The membrane of the colpi is psilate (acetolyzed grains). There is a homogeneous layer constituting the endosexine at the pore level. Polar index, 0.7; colpi, 4.25 μm.; pore, 1.89 μm.

ORNAMENTATION. Infratectate, perforate, microreticulate when acetolyzed (light microscope sample). Fossulate when unacetolyzed (SEM sample) (Walker & Doyle, 1975), microrugulate. Muri simplibaculate. Exine 1.6 μm. The ratio between the ectosexine, the endosexine, and the nexine is 1:2:1.

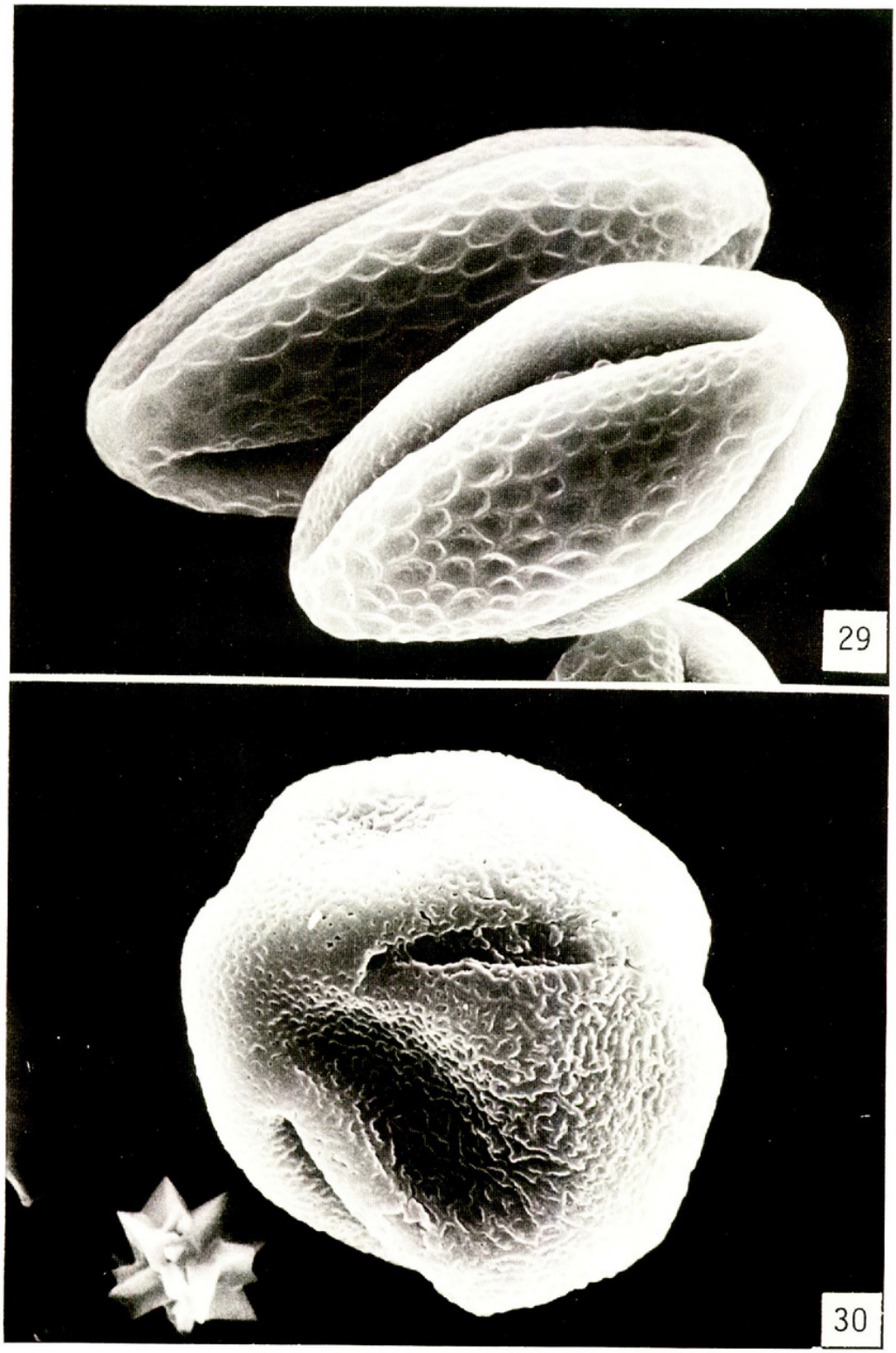
Heliocarpus donnell-smithii Rose. FIGURES 16–20, 28, 29, 34.

APERTURE. Tricolporate, endoaperturate. Colpus membrane psilate (acetolyzed grains). The grains have a notch placed at the ora of the colpus when they are unacetolyzed. The pore is anisodiametric, oval, meridianally elongated. Polar index, 0.2; colpi, 29.24 μm.; pore, 4.32 μm. × 6 μm.

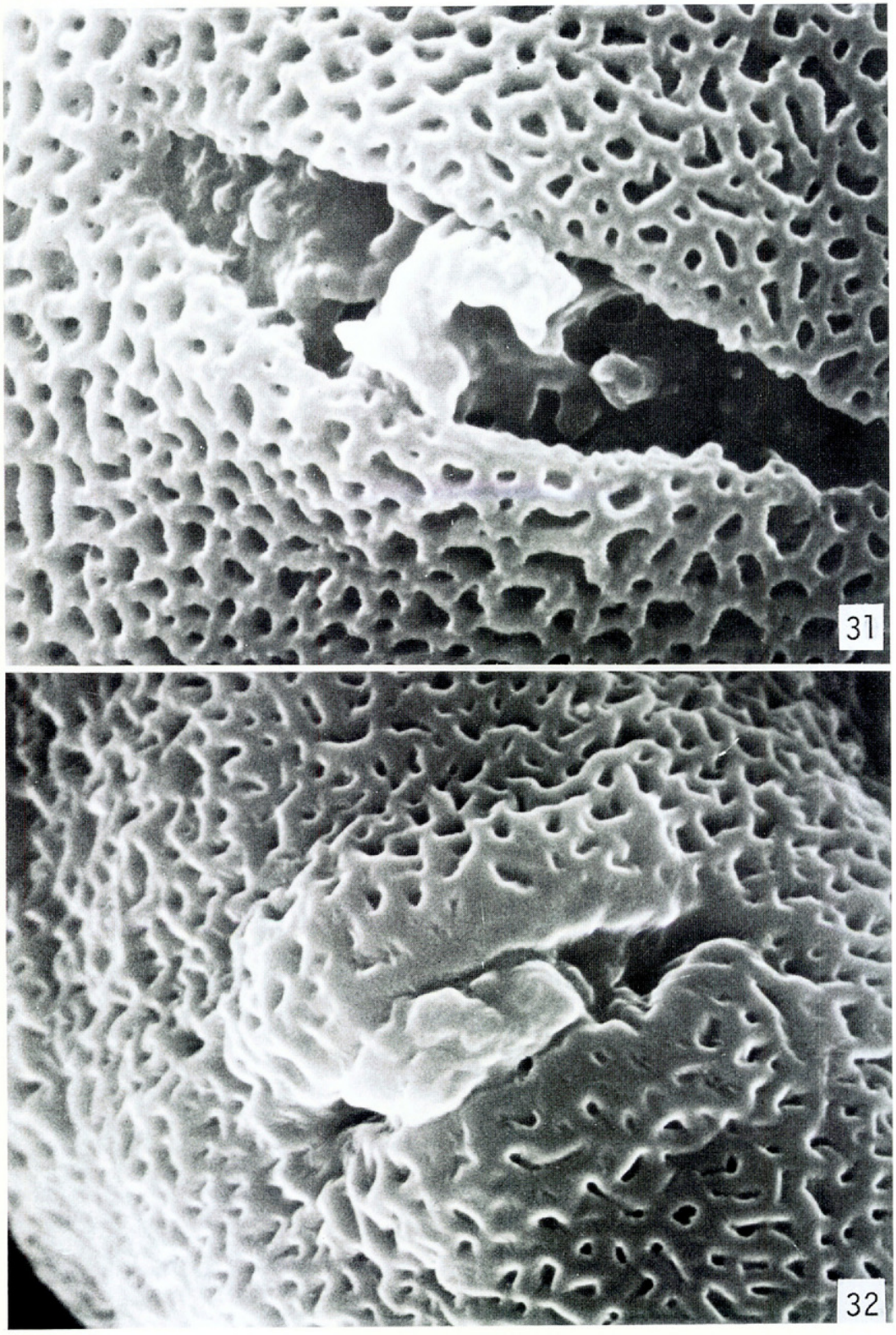
ORNAMENTATION. Tectate, supraheteroreticulate. Two classes of lumina are found. The first kind decreases in size toward the aperture; the second is smaller and is distributed uniformly across the surface among those of the first type. Muri simplibaculate. The tectum is perforate inside the lumina (SEM sample). Columellae are easily seen. At the level of the pores, the ectosexine is thin, while the endosexine is thick. Exine, 1.6 μm. (ectosexine, 0.3 μm.; endosexine, 0.8 μm.; nexine, 0.5 μm.).



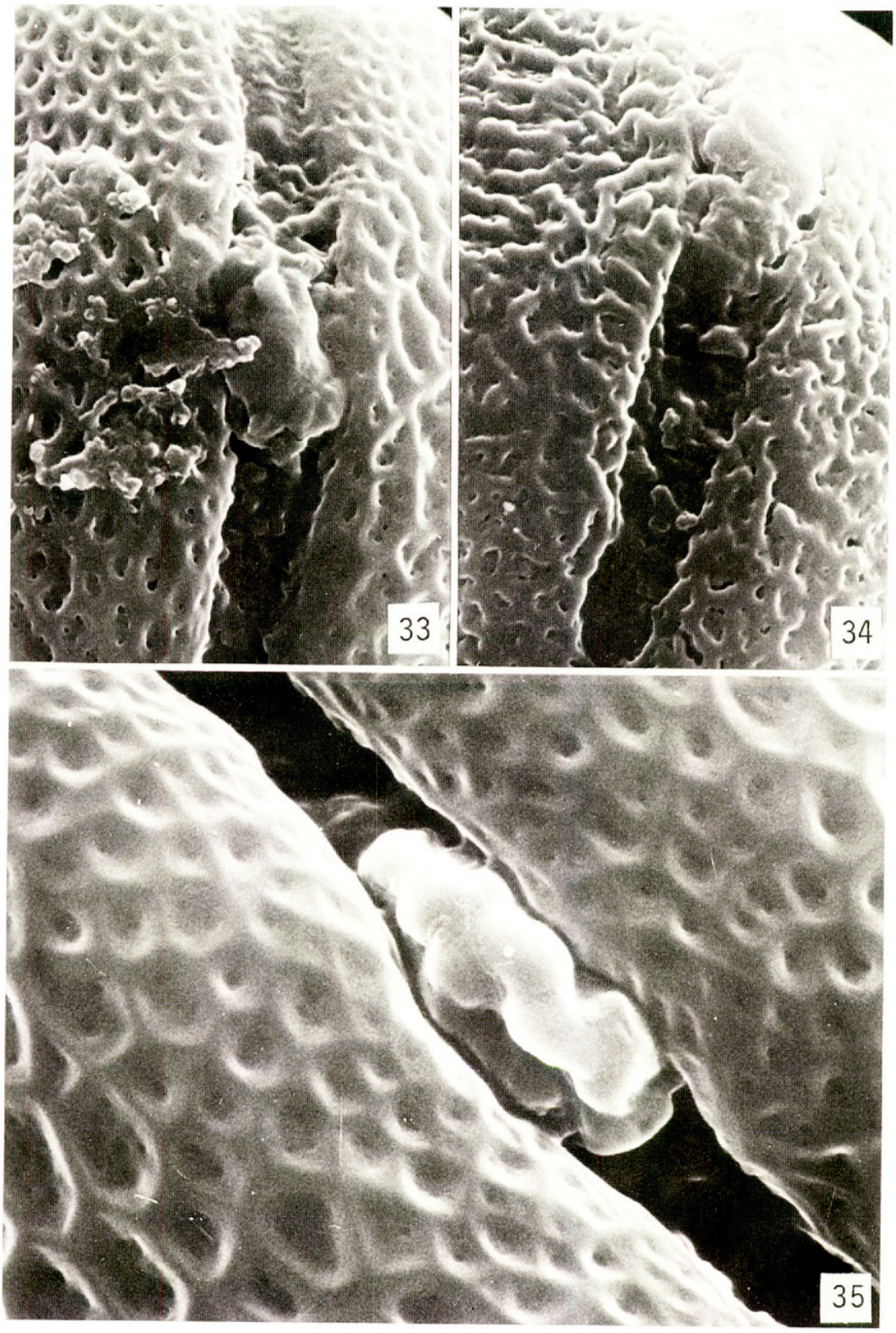
FIGURES 25–28. Scanning electron micrographs of pollen grains: 25, *Apeiba tibourbou* (from *Dressler & Jones 211*, Veracruz, México); 26, *Belotia mexicana* (from *Pennington & Sarukhán 9278*); 27, *Carpodiptera ameliae* (from *Matuda 3626*, Tabasco, México); 28, *Heliocarpus donnell-smithii* (from *Martínez-Calderón 452*, Tuxtepec, Oaxaca, México); all × 2000).



FIGURES 29, 30. Scanning electron micrographs of pollen grains: 29, *Heliocarpus donnell-smithii* (from *Martínez-Calderón 452*); 30, *Luehea speciosa* (from *Purpus 1917*, Veracruz, México); both × 2000.



FIGURES 31, 32. Scanning electron micrographs of pollen grains: 31, *Apeiba tibourbou* (from *Dressler & Jones 211*), × 10,000; 32, *Carpodiptera ameliae* (from *Matuda 3626*), × 5000.



FIGURES 33–35. Scanning electron micrographs of pollen grains: 33, *Belotia mexicana* (from *Pennington & Sarukhán 9278*), × 10,000; 34, *Heliocarpus donnell-smithii* (from *Martínez-Calderón 452*), × 10,000; 35, *Luehea speciosa* (from *Purpus 1917*), × 50,000.

Luehea speciosa Willd. FIGURES 21–24, 30, 35.

APERTURE. Tricolporate. Colpus membrane scabrate (SEM sample). Colpus transversalis 14–16 μm. long and 4–5 μm. wide. Polar index, 0.4; colpi, 23.92 μm.; pore, 5.93 μm. The unacetolyzed grains have a notch at the ora of the colpus that is lost during acetolysis.

ORNAMENTATION. Tectate, supraheteroreticulate. Lumina of the suprareticulum measure from 0.8 to 1.4 μm. Rugulate (SEM sample). Muri simplibaculate; columellae easily seen. Exine, 1.6 μm. (ectosexine, 0.4 μm.; endosexine, 0.8 μm.; nexine, 0.4 μm.).

DISCUSSION

The species of Tiliaceae studied are, in general, tricolporate. Using this feature we can determine two groups among the species observed: (1) brevitricolporate (*Apeiba tibourbou* and *Carpodiptera ameliae*), and (2) tricolporate (*Belotia mexicana*, *Heliocarpus donnell-smithii*, and *Luehea speciosa*). The pollen grains of *C. ameliae* can also be tetracolporate.

In all except *Carpodiptera ameliae* and *Heliocarpus donnell-smithii*, the aperture is a colpus transversalis (Faegri & Iversen, 1964). They have in common a colpus membrane constituted by the endexine. *Carpodiptera ameliae* has a pore membrane in addition to the other structures. *Heliocarpus donnell-smithii* and *Carpodiptera ameliae* are endoaperturate.

The pollen grains of these species were studied after two different treatments, with and without acetolysis. This produced remarkable differences between the apertures and ornamentation of grains of the same species (see text). The apparent changes were actually the result of loss of structures that had obscured other characters.

The polar index, besides other features, seems to be important as a distinguishing character. We found a correlation between the polar index and the form of the grains.

Depending on the structure, there are tectate grains (*Apeiba tibourbou*) or semitectate grains (*Belotia mexicana*); some may have supraornamentation (e.g., *Belotia mexicana*).

The width of the exine is very uniform, but differences occur in the ectosexine-endosexine-nexine ratio.

Sizes of the different structures, as well as shape, association, polarity, and symmetry, are shown in TABLE 1.

SUMMARY

Although the Tiliaceae has representatives in the temperate zone that have been well studied, the representatives of the family in the tropics have been ignored from the palynological standpoint. They are very important as components of tropical ecosystems. For this reason we have studied their pollen morphology, and that of some of the more important elements of tropical tree flora of Mexico.

TABLE 1. Pollen characteristics of five species of Tiliaceae.

	Apeiba tibourbou		*Belotia mexicana*		*Carpodiptera ameliae*		*Heliocarpus donnell-smithii*		*Luehea speciosa*	
Size	mean (μm.)	range (μm.)	mean (μm.)	range (μm.)	mean (μm.)	range (μm.)	mean (μm.)	range (μm.)	mean (μm.)	range (μm.)
POLAR AXIS	24.8	24 –26	34.64	32.8–38.4	20.8	16 –22	32.96	28 –36.8	30.56	24 –40
EQUATORIAL AXIS	33.43	28.8 –36.4	29.82	26.4–32.4	25.02	22.8 –28	23.72	20 –30.4	22.82	19.8–25.02
LUMINA	0.5	0.3 – 0.8	–	0.3– 0.8	0.4	–	1.51 (large lumina) 0.8 (small lumina)	1.2– 2 0.6– 1	0.5	0.4 0.6
COLPI	9.38	8 –12	25.04	20 –28.8	4.25	4 – 6	29.24	25.2–34.4	23.92	16.8 28.8
PORES	1.89	1.2 –24	3.82	2 – 5.6	1.89	1.2 – 2.4	4.32	3.2– 5.2	0.76	0.4– 2.8
COLPUS TRANSVERSALIS	9.5 × 4.0	9 –10 long	24 × 6.8	–	–	–	–	–	15 × 4.5	14 –16 long 4 – 5 wide
EXINE: ECTOSEXINE	0.5	–	0.4	–	0.4	–	0.3	–	0.4	–
ENDOSEXINE	0.75	–	0.8	–	0.8	–	0.8	–	0.8	–
NEXINE	0.25	–	0.4	–	0.4	–	0.5	–	0.4	–
Shape	oblate		prolate		oblate		prolate		prolate	
Association	monad		monad		monad		monad		monad	
Polarity	isopolar		isopolar		isopolar		isopolar		isopolar	
Symmetry	radial		radial		radial or bilateral		radial		radial	

Five species in five different genera are included in this paper: *Apeiba tibourbou*, *Belotia mexicana*, *Carpodiptera ameliae*, *Heliocarpus donnell-smithii*, and *Luehea speciosa*. All of them are tricolporate but some are brevitricolporate, indicating variability in the polar index. The ornamentation and structure of pollen in the species studied appear to be characteristic of the genera.

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