สัณฐานวิทยาของเรณูของพันธุ์ไม้บางสกุลในวงศ์ Euphorbiaceae ในประเทศไทย

นางสาวกัญดา เกษตรสินสมบัติ

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POLLEN MORPHOLOGY OF SOME GENERA OF EUPHORBIACEAE IN THAILAND

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เรณูจากดอกเพศผู้ของพันธุ์ไม้วงศ์เปล้า (Euphorbiaceae) ในประเทศไทย จำนวน 70 ชนิด นำมาผ่านกระบวนการอะซิโตไลซิส เพื่อศึกษาลักษณะสัณฐานวิทยาของเรณูโดยกล้องจุลทรรศน์แบบใช้แสงและกล้องจุลทรรศน์อิเลกตรอนแบบส่องกราด จัดทำคำบรรยายลักษณะของเรณู รูปวิธานจำแนกแบบของเรณู พร้อมภาพประกอบ รวมทั้งเสนอสายสัมพันธ์ของลักษณะสัณฐานวิทยาของเรณู ตัวอย่างพรรณไม้แห้งและตัวอย่าง สไลด์ต้นแบบของเรณูได้เก็บไว้ ณ พิพิธภัณฑ์พืชศาสตราจารย์กสิน สุวตะพันธุ์ ภาควิชาพฤกษศาสตร์ คณะวิทยาศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย

จากการศึกษาพบลักษณะสัณฐานวิทยาของเรณูเป็น 15 โดยถือตามลักษณะของช่องเปิด และลักษณะของลวดลายของผนังเรณูเป็นสำคัญ เรณูกลุ่มที่มีช่องเปิด พบช่องเปิดหลายแบบได้แก่ 3-colpate, 3-colporate , 4-(5)-colporate, 7-11-heterodiploporate และ pantopolyporate โดยรูปแบบของช่องเปิดส่วนใหญ่ที่พบคือ 3-colporate ซึ่งเรณูที่มีช่องเปิดแบบนี้พบแบบลวดลายบนผนังเรณูหลากหลาย ได้แก่ granulate, scabrate, baculate, clavate, perforate, reticulate และ striate ในขณะที่กลุ่มที่ไม่พบช่องเปิดและกลุ่มที่มีช่องเปิดแบบ 3-colpate มีลวดลายบนผนังเรณูแบบ “croton pattern” ซึ่งเป็นลวดลายบนผนังเรณูที่มีความโดดเด่นเฉพาะตัว

การศึกษานี้นอกจากจะได้ข้อมูลสำคัญทางสัณฐานวิทยาของเรณูวงศ์ Euphorbiaceae แล้ว สามารถนำไปใช้ประกอบเพิ่มเติมเป็นลักษณะทางสัณฐานของงานทางพฤกษอนุกรมวิธาน และศึกษาสายสัมพันธ์ของพืชวงศ์ Euphorbiaceae ได้

ภาควิชา พฤกษศาสตร์ ลายมือชื่อนิสิต กัญดา เกษตรสินสมบัติ
สาขาวิชา พฤกษศาสตร์ ลายมือชื่ออาจารย์ที่ปรึกษา ชุมพล คุณวาสี
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KEY WORD : POLLEN / POLLEN MORPHOLOGY / EUPHORBIACEAE
KUNDA KASETSINSOMBAT : POLLEN MORPHOLOGY OF SOME GENERA OF EUPHORBIACEAE IN THAILAND. THESIS ADVISOR : CHUMPOL KHUNWASI, Ph.D. THESIS CO-ADVISOR : ASSOC. PROF. KOSUM PYRAMARN. 124 pp. ISBN 974-333-062-3.

Pollen materials from seventy euphorbiaceous species in Thailand were treated by the acetolysis method. The acetolysed pollen grains were studied on morphology by means of light and scanning electron microscopes. Pollen descriptions, key to pollen types, photomicrographs of all studied species and the phylogenetic trends based mainly on pollen morphology had been presented. The herbarium specimens and pollen-type slides were kept in the Professor Kasin Suvatabandhu Herbarium, Chulalongkorn University (BCU).

Fifteen pollen types are recognised based mainly on apertures and ornamental patterns. The aperturate pollen grains are 3-colpate type, 3-colporate type, 4-(5)-colporate type, 7-11-heterodiploporate type, and pantopolyporate type. The majority of the studied pollen is 3-colporate type. This pollen type has colporate aperturation possibly have diverse exine sculpturing which vary from ornamentation with projecting elements (granules, scabrae, baculae and clavae) to perforation, reticulation and striation. Whereas all inaperturate type and 3-colpate type have "croton pattern" which show distinctive projecting elements on the exine.

According to this study, it is ascertained that pollen morphology of the family Euphorbiaceae can be of taxonomic value and as the supporting evidence to the morphological study and phylogenetic study.

ภาควิชา พฤกษศาสตร์ ลายมือชื่อนิสิต .....

สาขาวิชา พฤกษศาสตร์ ลายมือชื่ออาจารย์ที่ปรึกษา .....

ปีการศึกษา 2542 ลายมือชื่ออาจารย์ที่ปรึกษาร่วม .....

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CHAPTER I

INTRODUCTION

The Euphorbiaceae is one of the largest families of angiosperms. It consists about 300 genera and 7,500 species, distributed all over the world in tropical and temperate regions (Jones and Luchsinger, 1987). This family is distinctive in account of nearly most of list species having economical importance for the following products: the brazilian rubber tree or para (*Hevea brasiliensis*), Castor oil (*Ricinus communis*), cassava and tapioca (*Manihot esculenta*), tung oil (*Aleurites fordii*) and numerous ornamental plants. Many species are medicinal value as well as poisonous plants, causing.

According to Airy Shaw (1972), approximately 400 species of 73 euphorbiaceous genera were found in Thailand. They were classified into 11 tribes and 23 subtribes (Table 1). The distinguished characters of this family are existence of sap; tiny, unisexual flowers and trilocular ovary.

Conforming to Erdtman (1952), a great variations in pollen morphology were observed. Therefore, it is interesting and meriting to do research on palynology of the euphorbiaceous plants in Thailand, where less palynological works have been done. It is expected that the results obtained from this study will be an essential information for the taxonomic study of Thai Euphorbiaceae, as well as, any pollen analysis researches in the future. The classification system of the Euphorbiaceae used in this present study was based on Airy Shaw (1972).

Aims of the thesis are:-

1. to study pollen morphology: to present pollen descriptions and to construct key of pollen types;
2. to collect the herbarium specimens and the pollen type slides of some genera of the Euphorbiaceae in Thailand and deposit them in the academic herbaria for further reference.

Table 1 Classification of the Euphorbiaceae (From Airy Shaw, 1972).

Tribe	Subtribe	Genera
Phyllantheae	Phyllanthinae	*Phyllanthus*, ***Glochidion***, *Actephila*
	Securineginae	*Margaritaria, Securinega, Richereriella*
	Andrachninae	*Leptopus, Chorisandrachne*
	Sauropodinae	***Breynia***, *Sauropus, Synostemon*
	Drypetinae	*Drypetes*
Bridelieae	-	*Cleistanthus*, ***Bridelia***
Baccaureeae	-	*Baccaurea, Aporusa*
Crotoneae	Crotoninae	***Croton***
	Chrozophorinae	*Sumbaviopsis*, ***Thyrsanthera***, *Chrozophora*
	Mallotinae	***Mallotus***, *Melanolepis*, ***Macaranga***, ***Trewia***, *Ptychopyxis, Endospermum*
	Blumeodendrinae	*Blumeodendron, Botryophora*
	Agrostistachydinae	*Chondrostylis, Agrostistachys*
	Alchorneinae	*Alchornea*, ***Sampantaea***, *Wetria*, ***Cleidion***
	Mercurialinae	*Mercurialis, Claoxylon*
	Homonoiinae	***Homonoia***, *Lasiococca, Spathiostemon*
	Plukenetiinae	*Pachystylidium, Cnesmone, Megistostigma, Pterococcus*
	Dalechampiinae	*Dalechampia*
	Cladogyninae	*Cladogynos*
	Erismanthinae	*Erismanthus*
	Epiprininae	*Epiprinus, Koilodepas*
Acalypheae	-	*Acalypha*
Ricineae	-	*Ricinus*
Jatropheae	Jatrophinae	*Jatropha, Manihot, Aleurites*, ***Vernicia***, *Elateriospermum, Omphalea*
	Codiaeinae	***Blachia***, *Strophioblachia, Pantadenia*, ***Baloispermum***
	Ostodinae	***Ostodes***, *Fahrenheitia, Dimorphocalyx*, ***Trigonostemon***
Chaetocarpeae	-	*Chaetocarpus*
Suregadeae	-	***Suregada***
Cheiloseae	-	*Neoscortechinia*
Euphorbieae	Hippomaninae	*Hura, Sapium, Excoecaria, Sebastiania, Glyphostylus, Homalanthus*
	Euphorbiinae	*Euphorbia*

CHEPTER II

REVIEW OF LITERATURES

1. Taxonomic background

1.1 Morphological character of the Euphorbiaceae

Euphorbiaceae is one of the most diverse families in habit, habitat, and morphology of the flowering plants.

Habit, herbs, climbers, shrubs, or trees; some xerophytic and cactus-like, often with a milky sap. **Leaves** mostly alternate, simple or compound, often reduced or deciduous in xerophytic species; with stipules. **Inflorescences** various, often condensed, hence giving the appearance of a single flower, a cyathium; plants monoecious or dioecious. **Flowers** unisexual, actinomorphic. Calyx of 5 sepals or none. Corolla of 5 petals or usually none. Androecium of 1 to many stamens, free or united, rudimentary ovary often present in the male flowers. Gynoecium a compound pistil of 3 united carpels, with 3 locules, ovules solitary or paired, placentation axile, ovary superior, styles free or united at base (Fig. 1). **Fruit,** a schizocarp, capsule, drupe or berry. **Seed** often with a conspicuous caruncle (Jones and Luchsinger, 1987).

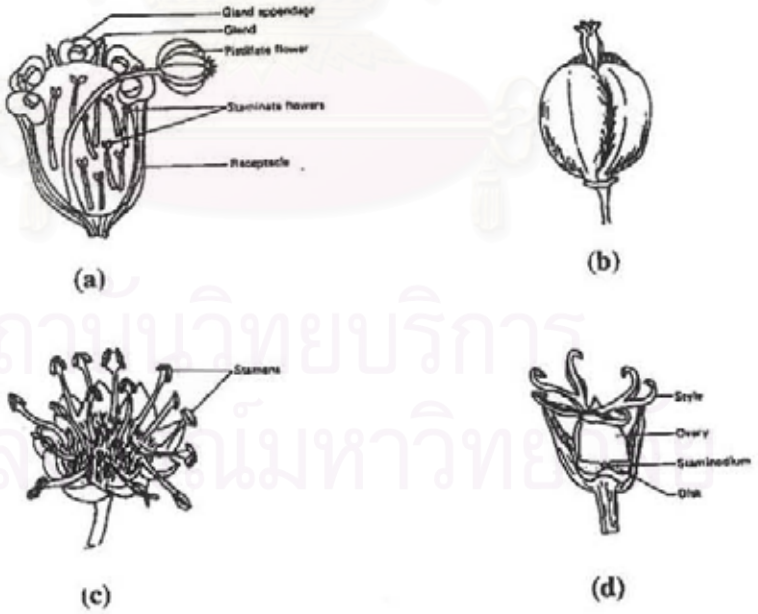


Figure 1 Diagrammatic drawing of typical floral structures of family Euphorbiaceae. (a) Single inflorescence (cyathium), (b) Three-lobed schizocarp, (c) Staminate flower, (d) Pistillate flower (From Jones and Luchsinger, 1987).

1.2 Taxonomy and position of the Euphorbiaceae

Euphorbiaceae is a very large family, in which the taxonomic position and the relationships to its allied family, are still uncertain. Bentham and Hooker, in 1830, placed the Euphorbiaceae in the Monochlamydeae, a group that accommodates the dicots families which have extremely reduced flowers (Khan, 1968). The system of Engler and Prantl (1896) and Bessey (1915) put Euphorbiaceae together with many families, under the Geraniales, while Hallier (1912) placed it in Passionales. Whilst modern taxonomists placed Euphorbiaceae in the Euphorbiales with some other families (Takhtajan, 1969; Radford et al, 1974; Cronquist, 1981). However, some taxonomists classified it in a single family of the order Euphorbiales (Hutchinson, 1926 and Jones and Luchsinger, 1987).

Recently, it was classified in the Malpighiales in regarded to molecular data done by Chase et al in 1993, together with other 30 morphologically heterogenous families, such as Clusiaceae, Rhizophoraceae and Passifloraceae (cited in Judd et al, 1999).

Takhtajan (1969) divided the family Euphorbiaceae into 5 subfamilies as follow:

Subfamilies 1. Phyllanthoideae, composed 14 genera: *Phyllanthus, Glochidion, Actephila, Breynia, Sauropus, Synostemon, Drypetes, Antidesma, Leptopus, Cleistanthus, Bridelia, Aporusa, Baccaurea, Hypmenocardia, Bischofia.*

Subfamilies 2. Oldfieldioideae, composed 3 genera: *Austrobuxus, Oldfieldia, Androstachys.*

Subfamilies 3. Acalyphioideae, composed 18 genera: *Clutia, Chaetocarpus, Microdesmis, Panda, Agrostistachys, Chrozophora, Crotonogynopsis, Alchornea, Ricinus, Mercurialis, Cleidion, Macaranga, Claoxylon, Mallotus, Acalypha, Homonoia, Cnemone, Tragia.*

Subfamilies 4. Crotonoideae, composed 13 genera: *Hevea, Manihot, Suregada, Jatropha, Codiaeum, Blachia, Croton, Ricinodendron, Aleurites, Pimeleodendron, Sapium, Hippomane, Hura.*

Subfamilies 5. Euphorbioideae, composed 5 genera: *Euphorbia, Chamaesyce, Monadenium, Synadenium, Pedianthus.*

Van Welzen (1998) presented a new analytical identification key to genera of Euphorbiaceae in Thailand. It is based on the taxa treated by Airy Shaw (1972). The present key comprised 82 genera and included other genera for instance *Antidesma, Daphniphyllum, Galearia, Microdesmis,* etc., which are often recognised in other families.

In discussions of systematic position of this family (Airy Shaw, 1972)., the crucial problem is focused on genera or species level and the family limitation. Some author included genera *Antidesma* in Euphorbiaceae whereas some excluded it (Van Welzen, 1998). Recently, much more knowledge in botany and many important data from morphology, anatomy, phytochemistry, palynology, genetics and others related major subjects are used to determine, identify, and group the taxa phylogenetically.

2. Palynology background

The Euphorbiaceae is considered eurypalynous (Erdtman, 1952). A number of research works on pollen morphology of this family have been done since the past decades. Most of them have provided the overview data of the family or some certain taxa based mainly on the European species, and some are included in regional pollen flora. However, pollen morphological accounts for south-east Asian taxa, especially Thai species, are very rare.

The following are the most relevant information to this research.

Erdtman (1952) studied pollen morphology of 225 species from 150 genera of Euphorbiaceae. He stated that this family showed distinctly eurypalynous, recogniszed by many apertural types, variously diversed ornamentation and exine stratification.

Punt (1962) investigated pollen morphology of Euphorbiaceae. His classification was based on the system of Pax, Hoffmann and Skottsberg, which subdivided this family into two subfamilies, i. e. Phyllanthoideae and Crotonoideae. In Phyllanthoideae, he recognised 23 pollen types and 10 subtypes, assemblaged into three groups of pollen types and corresponded with the system of classification belong to Pax in 1924. On the other hand, 53 pollen types and 15 subtypes were recognised within the latter. However, pollen types which had croton-pattern of ornamentation was, by the way, the most attractive group. He suggested putting all genera which possesed croton-pattern pollen into one group.

Punt (1967) studied pollen morphology of the genus *Phyllanthus*. He concluded that some pollen types occurring in this genus were arranged into morphological series which were based on seven evolutionary trends, recognised by him. He also gave a discussion on *Phyllanthus* pollen to its taxonomic position and relationships with some primitive genera.

Khan (1968) studied pollen morphology of 97 species belonged to 40 genera of Indian elements. He pointed out that the Euphorbiaceae is a good example of eurypalyny in angiosperms. All apertural type, excluding the monocolpate and monoporate, can be found in this family. He, then, suggest that the origin of the Euphorbiaceae seems not to relate to the "Magnolian" stock, but possibly from Rosales.

Erdtman (1969) also added that Euphorbiaceae was a heterogeneous and, in a palynological-taxonomic connection, particularly interesting family. A preliminary pollenmorphological-mapping of the family, checking off, group by group, the genera with characteristic sexine pattern (croton-pattern) etc. yielded data which have led to certain, probably soundly based, taxonomic improvements.

Huang (1972) studied pollen morphology of 54 species belong to 25 genera of Euphorbiaceae found in Taiwan. He recognised 5 apertural types, i. e. inaperturate, 3-colpate, 3-5-colporate, 4-6-porate, and heteroporate, as well as 5 sculptural types of tectum, i. e. psilate, scabrate, verrucate, gemmate, and baculate.

Lobreau-Callen, Punt and Schmid (1988) examined pollen morphology of 46 Phyllanthus species native to New Caledonia. The five pollen types were separated mainly by their apertural characters, i. e. *P. acinacifolius, P. aeneus, P. loranthoides, P. casticum* and *P. virgatus*. The first three were the closely related pollen types, which were found in species included in subgenus *Gomphidium*, s.l., the latter two were found in species belonging to the subgenus *Kirganelia* sect. *Anisonema* and subgenus *Isocladus* sect. *Macraea*, respectively. They established five evolutionary trends and these were used to explain the pollen morphological series from the most primitive *P. acinacifolius* types to the more advance *P. aeneus* type via the intermediate *P. loranthoides* type.

El-Ghazaly and Chauhary (1993) examined pollen morphology of 60 species of the genus *Euphorbia*. They pointed out the eurypalyny of this genus. The seven recognised pollen types were distinguished mainly by their ornamentation as well as the polarity and detail of ora. Pollen description of each type was provided together

with the geographical distribution and their evolutionary relationships was suggested by them.

Nowicke (1994) studied pollen morphology of 69 species representing 34 genera from 12 of 13 tribes of subfamily Crotonoideae. According to this study, the vast majority of tribes included in Crotonoideae have inaperturate grains, the remaining have colpate and porate aperture. However all Crotonoideae exine show a similar architecture of croton structure, but with various ornamentations of subunits, i.e. psilate, striate, furrowed and ridges, or pitted, and echinate. She concluded that the structure found in Crotonoideae pollen, is very uncommon in pollen of any other subfamily. Moreover, the predominance of inaperturate grains found in this subfamily and the rarity in the remaining Euphorbiaceae, also the restricted condition of inaperturate grain in dicotyledons, would imply the monophyly of inaperturate tribes.

Table 2. Systematic position of the Euphorbiaceae

	Systematic position of Euphorbiaceae in the systematic of:								
	Bentham and Hooker (1880)*	Engler and Prantl (1896)*	Bessey 1915)*	Hallier (1912)*	Hutchinson (1926)*	Takhtajan (1969)**	Radford el al. (1974)***	Cronquist (1981)****	Jones and Luchsiger (1987)*****
Order	Achalamidosporae	Geraniales	Geraniales	Passionales	Euphorbiales	Euphorbiales	Euphorbiales	Euphorbiales	Euphorbiales
Famillies	Loranthaceae Santalaceae Balanophoraceae *Euphorbiaceae* Balanopsidaceae	Geraniaceae Oxalidaceae Tropaeolaceae Linaceae Humoriaceae Erythroxylaceae Zygophyllaceae Cneoraceae Rutaceae Simarubaceae Burseraceae Meliaceae Malpighiaceae Trigoniaceae Vochysiaceae Tremandraceae Polygalaceae Dichapetalaceae *Euphorbiaceae* Calletrichaceae	Simarubaceae Rutaceae Erythroxylaceae Linaceae Limnathaceae Balsaminaceae Oxalidaceae Geraniaceae Calletrichaceae *Euphorbiaceae* Tremandraceae Polygalaceae Malpighiaceae Meliaceae Burseraceae	Malsheribiaceae Turneraceae Passifloraceae Salicaceae *Euphorbiaceae* Flacourtiaceae Achariaceae	*Euphorbiaceae*	Buxaceae Simmondsiaceae Daphniphyllaceae *Euphorbiaceae* Dichapetalaceae Pandaceae Picrodendraceae	Buxaceae *Euphorbiaceae* Daphniphyllaceae Aextoxicaceae Pandaceae	Buxaceae Simmondsiaceae Pandaceae *Euphorbiaceae*	*Euphorbiaceae*

* From Journal of palynology (india). Khan, 1968.
** From Flowering Plants Origin and Dispersal, Takhtajan and Jeffrey, 1969.
*** From Vacular Plant Systematics, Radford, 1974
**** From An Integrated System of Classification of Flowering Plants, Cronquist. 1981.
***** From Plant Systematics, Jones and Luchsinger, 1987.

CHAPTER III

MATERIALS AND METHODS

Materials for palynological study

1. Materials for field work and sample collection

1.1 Paper envelopes
1.2 A plant press, size 30x46 cm
1.3 A pair of hand pruners
1.4 Plastic bags
1.5 Hand-lens
1.6 Camera
1.7 Collector's number card
1.8 Color slides film (Kodak 100)
1.9 Color printed film (Kodak 100)

2. Materials for pollen slide prepaaration and pollen morphological study

2.1 10 % Potassium hydroxide
2.2 Glacial acetic acid
2.3 Acetic acid anhydride
2.4 Concentrated sulphuric acid
2.5 70 %, 95 %, absolute ethyl alcohol
2.6 Distilled water
2.7 Benzene
2.8 Acetone
2.9 Silicone oil AK 2,000
2.10 Paraffin
2.11 Immersion oil
2.12 Paper envelopes
2.13 Label stickers
2.14 Sieving crucible
2.15 Pyrex beaker 50 ml., 100 ml.
2.16 Vials
2.17 Hot plate
2.18 Warm plate
2.19 Centrifuge and centrifuge tubes
2.20 Microscopic slides and cover glasses
2.21 Micrometer, scale 1:100 micron
2.22 Light microscope (model Nikon AFX 35) at the Professor Kasin Suvatabhandhu Herbarium, Department of Botany, Faculty of Science, Chulalongkorn University
2.23 Scanning electron microscope (model JEOL: JSM-5410 LV) at Technological Research Equipment Center, Chulalongkorn University.
2.24 Black-white negative films (Kodak TMAX 100 for LM and Kodak VP 120 for SEM)
2.25 Pollen materials: fresh materials, herbarium specimens (Table 3)

Methods

1. Field work and sample collection

Field collection for herbarium specimens and pollen materials were made through many provinces in Thailand during 1997 fo 1999. Ten to twenty mature flowers of each species were kept and dried in paper envelopes. In addition, three duplications of plant specimens were collected and have been kept in the Forest Herbarium, Royal Forest Department (BKF) and the Kasin Suvatabhandhu Herbarium, Department of Botany, Chulalongkorn University (BCU). The transparency slides of each species were also taken.

2. Pollen slide preparation and pollen morphological study

Most of the pollen samples were taken from fresh specimens were collected in the field (Table 3). Some of them were obtained from the specimens deposited in BCU and BKF. The botanical names of those specimens referred in this study were approved by taxonomists who work on the revision project "The study of Euphorbiaceae in Thailand".

For LM, the pollen samples were treated by the acetolysis method (Fig.2) and preserved in silicone oil AK 2,000 (Andersen, 1960). The acetolysed pollen grains were mounted on microscopic slides and sealed with paraffin. Pollen morphological observations and photographs were made under a Nikon AFX 35. Permanent type slides of all samples are deposited at BCU.

For SEM, acetolysed pollen grains were dried and directly mounted on stubs with double-sided adhesive tape. In case that acetolysed pollen grains is not available, due to the small amount of pollen materials, dry non-acetolysed grains were used. The pollen grains were, then, coated with gold by using a Bazer-sputter coater for 5 minutes, and observed by SEM model JEOL JSM-5410 LV. The SEM micrographs were taken with 1,000 to 15,000 magnification at 15 kV .

Pollen morphological descriptions were concentrated on apertural characters and ornamentation. The measurement of polar axis, equatorial axis and polar field index were based on at least 20 pollen grains. Finally, key to pollen types for the identification was constructed.

Terminology used in this work is a combination of those used by Erdtman (1952), Faegri and Iversen (1950), and Punt (1962).

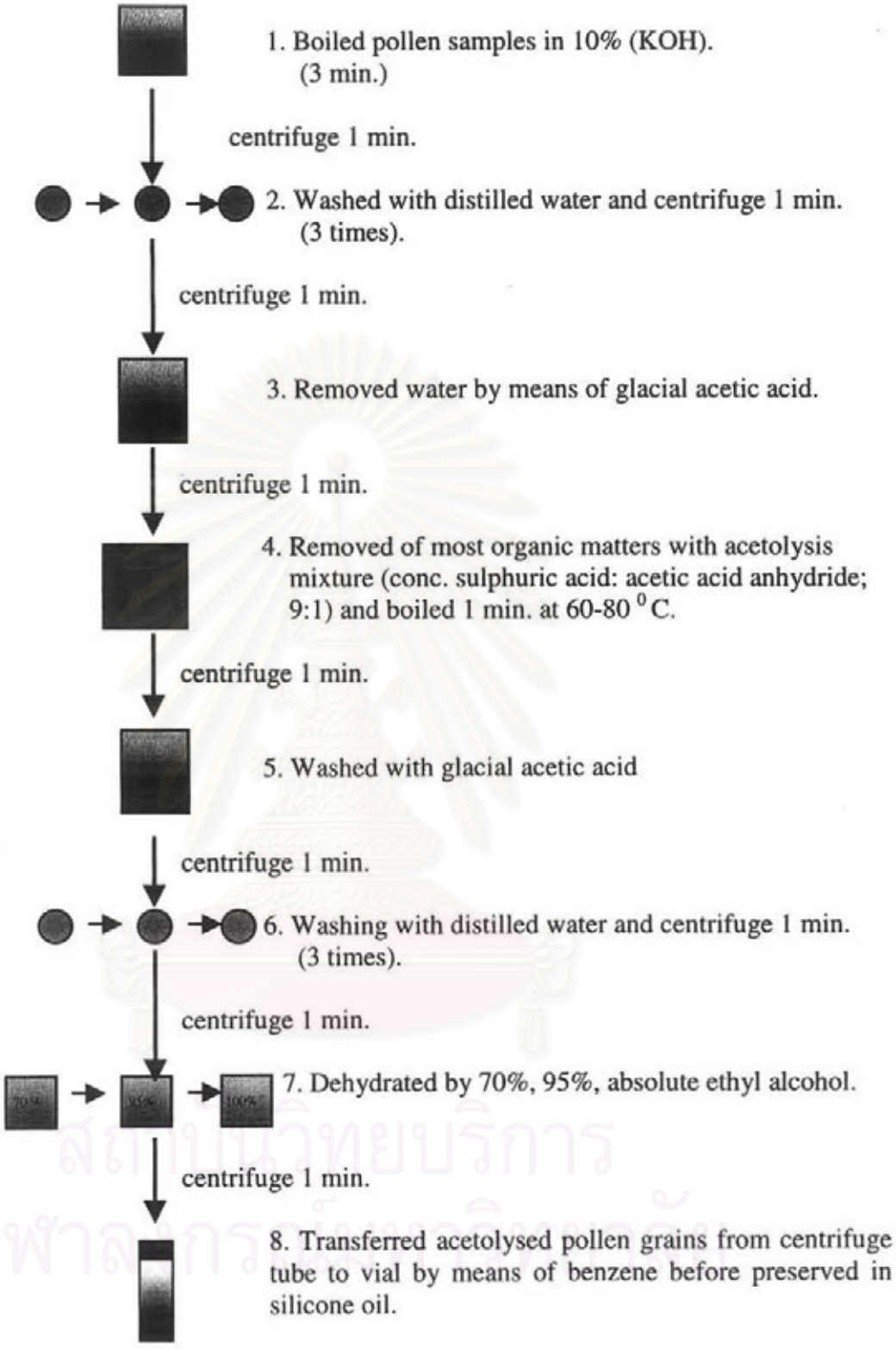


Figure 2 Acetolysis method (Erdtman, 1960).

Table 3 List of the investigated specimens.

Specimens	Collection	Herbarium
BACCAUREA		
1. *B. bracteata* Muell. Arg.	PEN: Toh Deang Peat Swamp Forest, Narathiwat / C. Niyomdham 5163 / 17 Sep.1997 / BKF 115932	BKF
2. *B. kunstleri* King ex Gage	PEN: Nakhon Si Thammarat, Alt. 250 m. / J. F. Maxwell 86-145 / 4 Mar. 1989 / BKF 084972	BKF
3. *B. lanceolata* Muell. Arg.	PEN: Nakhon Si Thammarat Alt. 100-200 m. / U. Damsri 95 / 5 Apr. 1992	BCU
4. *B. motleyana* Muell. Arg.	PEN: Khao Sam Nuk, Narathiwat / Alt. 50 m. / C. Niyomdham and W. Ueachirakan 1988 / 1 Apr. 1989 / BKF 091242	BKF
5. *B. ramiflora* Lour.	SE: Chachoengsao, Alt. 90 m. / Kosum et al. 09 / 13 Dec. 1997	BCU
BALIOSPERMUM		
6. *B. effusum* Pax et Hoffm.	N: Doi Inthanon, Chiang Mai, Alt. 1400-1700 m. / K. Larsen & S. Larsen 34395 / 11 Sep. / BKF 64597	BKF
7. *B. micranthum* Muell. Arg.	N: Inthanon Nat. Park, Chiang Mai, Alt. 1600 m. / Phengklai C. et al 7095 / 28 Jul.1988 / BKF 94022	BKF
8. *B. montanum* Muell. Arg.	SE: Chachoengsao, Alt. 100 m./ Kosum et al. 26 / 13 Dec. 1997	BCU
	N: Mae-Rim, Chaing Mai, Alt. 800-900 m. / Kosum et al. 64 / 17 Jan. 1998	BCU
9. *B. siamense* Craib	N: Doi Sutep, Chaing Mai, Alt.1,300 m./ TDBS 5011 / 15 Sept. 1995 / BKF 28026	BKF
BLACHIA		
10. *B. siamensis* Gagnep.	SW: Khao Sam Roi Yod Nat. Park, Prachuap Khiri Khan, Alt 10 m. / Kosum et al. 129 / 5 Jun. 1998	BCU
BREYNIA		
11. *B. fruticosa* Craib	NE: Phuphan Nat. Park, Sakon Nakhon-Kalasin / Alt 500 m. / Kosum et al. 160 / 11 Jun. 1998	BCU
12. *B. glauca* Craib	SW: Khao Sam Roi Yod Nat. Park, Prachuap Khiri Khan, Alt. sea level / Kosum et al. 122,126-127 / 5 Jun. 1998	BCU

(Table 3 continued)

Specimens	Collection	Herbarium
13. *B. vitis-idaea* Ficher	NE: Phuphan Nat. Park, Sakon Nakhon-Kalasin / Alt 500 m. / Kosum et al. 166 / 9 Jul. 1998	BCU
BRIDELIA		
14. *B. harmandii* Gagnep.	NE: Phuphan Nat. Park, Sakon Nakhon-Kalasin / Alt 500 m. / Kosum et al. 149, 158 / 9 Jul. 1998	BCU
15. *B. ovata* Decne	C: Bangkok / Kosum et al. 132 / 12 Jan. 1999	BCU
16. *B. stipularis* Bl.	N: Khunkorn Waterfall Forest Park, Chiang Rai, 600-800m. / Kosum et al. 23 / 14 Oct. 1997	BCU
17. *B. tomentosa* Bl.	N: Khunkorn Waterfall Forest Park, Chaing Rai, Alt. 400-800 m. / Kosum et al. 22 / 12 Oct. 1997	BCU
	N: Mae-Rim, Chaing Mai, Alt. 1,000 m. / Kosum et al. 18 / 22 Oct. 1997	BCU
CLEIDION		
18. *C. spiciflorum* (Burm. f.) Merr.	N: Khunkorn Waterfall Forest Park, Chiang Rai, Alt. 600-800 m. / KK 522 / 11 Oct. 1997	BCU
CROTON		
19. *C. bonplandianus* Baill.	SW: Khao Sam Roi Yod Nat. Park, Prachuap Khiri Khan, Alt 0-2 m. / Kosum et al. 128 / 5 Jun. 1998	BCU
20 *C. cascarilloides* Raeusch.	C: Siri Ruckhachati Garden, Nakhon Pathom, Kosum et al. 23 Alt 0-2 m. / 5 Nov. 1998	BCU
21. *C. crassifolius* Geisel.	NE: Phuphan Nat. Park, Sakon Nakhon-Kalasin, Alt 500 m. / Kosum et al. 150 / 9 Jul. 1998	BCU
22. *C. caudatus* Geisel	PEN: Haadd Yai, Song Kha, Alt.150 m. / J.F.Maxell 86-262 / 27 Apr. 1986 / BKF 93662	BCU
23. *C. hutchinsonianus* Hoss.	SW: Kanchanaburi / Kosum et al. 85-86 / 15 Feb. 1998	BCU
24. *C. kerrii* Airy Shaw	NE: Phuphan Nat. Park, Sakon Nakhon-Kalasin / Alt 500 m. / Kosum et al. 170 / 11 Jul. 1998	BCU
25. *C. kongensis* Gagnep.	NE: Phuphan Nat. Park, Sakon Nakhon-Kalasin / Alt 500 m. / Kosum et al. 161 / 11 Jul. 1998	BCU

(Table 3 continued)

Specimens	Collection	Herbarium
CROTON (continued)		
26. *C. poilanei* Gagnep.	SE: Chachoengsao, Alt. 90 m. / Kosum et al. 11 / 14 Dec. 1997	BCU
27. *C. robustus* Kurz	N: Mae-Rim, Chiang Mai, Alt. 800-900 m. / Kosum et al. 54 / 16 Jan. 1998	BCU
28. *C. roxburghii* Black.	SW: Kanchanaburi / Kosum et al. 81-83 / 15 Feb. 1998	BCU
29 *C. sublyratus* Kurz	SE: Chachoengsao, Alt. 100 m. / Kosum et al. 75 / 10 Jan. 1998	BCU
30. *C. thorelii* Gagnep.	NE: Phuphan Nat. Park, Sakon Nakhon-Kalasin, Alt 500 m. / Kosum et al. 159, 172-173 / 11 Jul. 1998	BCU
31. *C. tiglium* L.	E: Rayong, Alt. 100 m. / Kosum et al 65 / 25 May 1997	BCU
GLOCHIDION		
32. *G. acuminatum* Muell. Arg. var. *siamense* Airy Shaw	N: Khunkorn Waterfall Forest Park, Chiang Rai , Alt. 600-800 m. / / KK 845 / 12 Jan. 1998	BCU
33 *G. arborescens* Bl.	PEN: Ranong / T. Santisuk 579 / 16 Nov. 1973 / BKF 60562	BKF
34. *G. assamicum* Hook. f.	N: Chiang-dao, Chiang Mai / Maxell 95-225 / BKF 101683	BKF
35. *G. coccineum* (Buelt-Ham.) Muell. Arg.	SW: Kanchanaburi, Soi Yok / B. Sangkhachand / 10 Feb. 1959	BKF
36. *G. daltnii* (Muell. Arg.) Kurz	N: Chiang Mai / Srimaung.xx. / BKF 2220 10 Oct. 1986	BKF
37. *G. eriocarpum* Champ.	NE: Phuphan Nat. Park, Sakon Nakhon-Kalasin, Alt 500 m. / P. Chantaranothai 1281 / 11 Jul. 1998	BKU
38. *G. glomerulatum* (Miq.) Boerl.	S: Nakhon Ratchasima, Alt 700 m. / C. F. van Bensekom et al 1662 / 17 Oct. 1969 / BKF 66090	BKF
39. *G. hirsutum* (Roxb.) Voight.	N: Chiang Mai / J. F. Maxwell 3-941 / 29 Jul. 1988 / BKF 93441	BKF
40. *G. hongkongensis* Muell. Arg.	N: Chiang Mai, Alt. 450 m. / J. F. Maxwell 3-941 / 12 Mar. 1980 / BKF 93028	BKF
41. *G. kerrii* Craib	N: Chiang Mai, Alt. 1,150 m. / 23 Oct. 1996 / BKF 115002	BKF
42. *G. lanceolarium* (Roxb.) Voight.	T. Smitinand and Th. Santisuk et al. 369 / 20 Feb. 1993 / BKF 115326	BKF

(Table 3 continued)

Specimens	Collection	Herbarium
GLOCHIDION (continued)		
43. *G. littorale* Bl.	SW: Sai Yok Yai waterfall Nat. Park, Kanchanaburi / Kosum et al. 84 / 15 Feb. 1998	BCU
44. *G. nubigenum* Hook. f.	N: Wang Saphung, Siphan, Loei, Alt. 300 m. / 28 Aug. 1958 / BKF 18352	BKF
45. *G. obscurum* (Roxb. ex Willd.)Bl.	PEN: Ban Tahng Yahng, Tahpee, Satun Alt. 25 m. / 19 Nov. 1986 / BKF 085500	BKE
46 *G. rubrum* Bl.	SW: Prachuap Khiri Khan, Alt 2-5 m. / Kosum et al. 128 / 5 Jun. 1998	BCU
47. *G. sericeum* (Blume) Zoll et Marets	PEN: Kam Phuan Khao Phota uang Kaeo, Ranong, Alt. 100 m. / T. Santisuk 814 / 11 Dec. 1976 / BKF 64143	BKF
48. *G. sphaerogynum* (Muell. Arg.) Kurz	N: Mae-Rim, Chaing Mai, Alt. 800-900 m. / Kosum et al. 53 / 16 Jan. 1998	BCU
49. *G. superbum* Baill.	PEN: Kam Phuan Khao Phota Luang Kaeo, Ranong, Alt. 100 m. / T. Santisuk 1182 / 14 Aug. 1977 / BKF 64642	BKF
HEVEA		
50. *H. brasiliensis* Muell. Arg.	PEN: Chumphon / Alt. 50-100 m. / Kosum et al 180 / 10 Mar. 1998	BCU
HOMONOIA		
51. *H. riparia* Lour.	N: Khunkorn Waterfall Forest Park, Chiang Rai , Alt. 700 m. / KK 837 / 12 Jan. 1997	BCU
MACARANGA		
52. *M. denticulata* (Bl.) Muell. Arg.	PEN: Krung Ching waterfall, Nakhon Si Thammarat, Alt. 200 m. / Kosum et al 197 / 14 Sep. 1998.	BCU
53. *M. heynei* I. M. Johnston	PEN: Phromlok Waterfall, Nakhon Si-Thammarat, Alt. 210 m. / Kosum et al 234 /12 Sep. 1998	BCU
54. *M. indica* Wight	NE: Tunkamang, Chaiyaphum, Alt. 850 m. / R. Geesink, T. Hattink, C Phengklai 7119 / 1 Jun. 1974 / BKF 073502	BKF
55. *M. kurzii* (Kuntze) Pax ex Hoffm.	N: Doi Lehn, Chaing Mai, Alt. 1,300 m. / J. F. Mexwell 97-132 / 10 Feb. 1994 / BKF 116925	BKF
56 *M. laciniata* Whitm.-Airy Shaw	PEN: Kue Leng, Yala, Alt 0 m. / R. Geesink and T. Hattink 6378 / 24 May 1979 / BKF 07834	BKF

(Table 3 continued)

Specimens	Collection	Herbarium
MACARANGA (continued)		
57. *M. lowii* King ex Hook. f.	PEN: Trang, Alt. NSL / Vanpruk 643 / 19 Mar. 1915 / BKF 13499	BKF
58. *M. pruinosa* (Miq.) Muell. Arg.	PEN: Koh kun Bet Tak Bai, Narathiwat, / 20 Aug. 1987 / BKF 0905574	BKF
59. *M. tanarius* (L.) Muell. Arg.	PEN: Chumporn / Kosum et al. 186 / 14 Sep. 1998	BCU
MALLOTUS		
60 *M. barbatus* Muell. Arg.	NE: Phuphan Nat. Park, Sakon Nakhon-Kalasin, Alt 500 m. / P. Chantaranothai 1281	BKU
61. *M. oblongifolius* (Miq.)	NE: Phuphan Nat. Park, Sakon Nakhon-Kalasin, Alt 500 m. / Kosum et al. 67 / 11 Jul. 1998	BCU
62. *M. paniculatus* (Lam.) Muell. Arg.	NE: Pah Hin Ngam, Chaiyaphom Alt 300-500 m. / Kosum et al. 138 / 10 Jul. 1998	BCU
MICROSTACHYS		
63. *M. chamaelea* (L.) Juss.	NE: Ban Don Ya Wang, Khon Khaen, / Kosum et al. 175 / 12 Jul. 1998	BCU
OSTODES		
64. *O. paniculata* Bl.	N: Khunkorn Waterfall Forest Park, Chaing Rai, Alt. 1,000 m. / KK 54 / 12 Jan. 1997	BCU
SAMPANTAEA		
65. *S. amentiflora* Airy Shaw	SE: Chachoengsao, Alt. 90 m. / Kosum et al. 12 / 14 Dec. 1997 /	BCU
SUREGADA		
66. *S. multiflora* (Juss.) Baill.	NE: Khon khaen / Kosum et al. 101 / 27 Jun. 1998	BCU
THYRSANTHERA		
67 *T. suborbicularis* Pierre ex Gagnep.	NE: Sakon Nakon, Alt. 300-500 m. / Kosum et al. 149,158 / 9 Jul. 1998	BCU
TREWIA		
68 *T. nudiflora* L.	N: Mae-Rim, Chaing Mai, Alt. 800-900 m. / Kosum et al. 59 / 16 Jan. 1998	BCU

(Table 3 continued)

Specimens	Collection	Herbarium
TRIGONOSTEMON		
69. *T. reidioides* (Kurz) Craib	NE: Sakon Nakon / Kosum et al. 149,158 / 9 Jul. 1998	BCU
VERNICIA		
70 *V. montana* Lour.	N: Khunkorn Waterfall Forest Park, Chiang Rai, Alt. 700 m. / KK 837 / 22 Apr. 1998	BCU

The studied specimens which were deposit at BCU, were collected by author. The others were obtained from the Forest Herbarium, Royal Forest Department (BKF) as reported in Table 3.

CHAPTER IV

RESULTS

1. General pollen morphology

1.1 Light microscopy

Pollen grains are usually monad and isopolar or apolar. Most of aperture types are inaperturate, 3-colporate, 4-(5)-colporate, rarely 3-colpate, diploporate and polyporate. The aperture position is basically zonoaperturate, but pantoaperturate grains are also found. The pollen grains are varying in size from small to large. Most pollen grains are spheroidal to prolate shapes. Exine can be intectate, tectate, or semitectate, sexine is usually as thick as or thicker than the nexine. The exine sculpturing can be psilate, granulate, scabrate, perforate, foveolate, microreticulate, reticulate, striate, or processed with croton pattern.

1.2 Scanning electron microscopy

The arrangement of the structure elements is croton pattern, which the head of clavae is circular or triangular shape in top view, with obtuse or acute apices, smooth surface or deeply lobed and entire or undulate margins, sometimes minute granules occur in circular rings. The other group of sexine patterns is a differentiation into perforation, foveolation, striation and reticulation. Some species have mixed ornamentaion of granulation or scabration with minute perforations.

2. Key to pollen types

1. a Ornamentation croton pattern 2
1. b Ornamentation not croton pattern, ...5
2. a Inaperturate grain.....3
2. b Aperturate grain.....4
3. a Intectate grain..... *Croton* type
3. b Semitectate grain.....*Trigonostemon reidioides* type
4. a Grain 3-colpate; baculate.....*Heavea brasiliensis* type
4. b Grain polypantoporate; clavate.....*Suregada multiflora* type
5. a Tectate grain; sexine perforate, foveolate, scabrate, psilate orgranulate.....6

5. b Semitectate grain; sexine microreticulate, reticulate, striate or striato-reticulate.....9

6. a Sexine perforate, foveolate (SEM).....7
6. b Sexine psilate or granulate, scabrate 8
7. a Sexine perforate.....*Baccaurea bracteata* type
7. b Sexine indistinctly microreticulate under LM or distinctly foveolate under SEM..... *Baccaurea kunstleri* type
8. a Sexine distinctly scabrate under SEM or psilate under L..... *Macaranga* type
8. b Sexine distinctly granulate under SEM or psilate under LM..... *Mallotus* type
9. a Sexine distinctly microreticulate.....10
9. b Sexine reticulate,striate or striato-reticulate.....11
10. a Aperture with margo..... *Microstachys chamaelea* type
10. b Aperture without margo..... *Baccaurea motleyana* type
11. a Sexine striate or striato-reticulate 12
11. b. Sexine reticulate 13
12. a Sexine distinctly striate..... *Bridelia tomentosa* type
12. b Sexine distinctly striato-reticulate..... *Bridelia harmandii* type
13. a Grain 3-colporate.....*Thrysanthera subobicularis* type
13. b Grain 4-colporate, 4-(5)colporate, (4)-5colporate, polyzonodiploporate.....14
14. a Grain 4-colporate, 4-(5)colporate or (4)-5-colporate..... *Glochidion* type
14. b Grain polyzonodiploporate..... *Breynia* type

3. Description of pollen types

3.1 *Baccaurea bracteata* type

Pollen class :	3-zonocolporate, Perforate.
Pollen unit :	Monad.
Polarity :	Isopolar.
Polar field index :	Medium, (0.31)-0.33-(0.36).
P/E ratio :	(1.14)-1.37-(1.50).
Shape class :	Prolate-spheroidal to prolate.
Size class :	Small, P = (16.00)-18.00-(20.00) µm, E = (12.00)-13.15-(14.00) µm.
Outline:	Polar view- triangular-obtuse with convex sides. Equatorial view- circular-elliptic.
Exine :	Tectate, exine medium to rather thick, (1.00)-1.22-(1.80) µm. Sexine as thick as, or thicker than the nexine.
Aperture :	3-zonocolporate. Ectoapertures- colpi rather long, (11.00)-12.00-(13.00) µm in length, narrow and usually closed, or widened at the equator, ends acute.

	Endoapertures- lalongate, pori circular or faintly elliptic-obtuse, distinct costae.
Sculpturing :	Perforate. **In LM**: tectum perforate, columellae fine to invisible. **In SEM**: tectum smooth surface with unevenly distributed, perforatiotion, pores small, less than 1.00 μ m in diameter, circular to elliptic-obtuse, the distance between the pores as long as, or longer than its diameter.
Species :	*Baccaurea bracteata* Muell. Arg. (Plate 17 A-C, Plate 18 a-c)

Note :

The *Baccaurea bracteata* type is one of the easiest pollen types, recognised by its ornamentation pattern, which tectum is clearly perforate with very small, unevenly distributed pores, the distance between pores is usually rather longer than its diameter.

3.2 *Baccaurea kunstleri* type

Pollen class:	3- zonocolporate, Foveolate and microreticulate(LM).
Pollen unit :	Monad.
Polarity :	Isopolar.
Polar field index :	Small, (0.25)-0.33-(0.44).
P/E ratio :	(1.26)-1.38-(1.44).
Shape class :	Subprolate to prolate.
Size class :	Small, P = (17.00)-17.13-(19.00) μm, E = (11.50)-12.45-(13.50) μm.
Outline:	Polar view- triangular-obtuse with convex sides. Equatorial view- elliptic-obtuse or poles are rather acute under SEM.
Exine :	Tectate, exine rather thick, (1.50)-1.84-(2.00) μm . Sexine as thick as, or thicker than the nexine.
Aperture :	3-zonocolporate. Ectoapertures-colpi rather long, (10.00)-11.60-(12.00) μm in length, broad usually, widened at the equator and tapering towards the poles, ends acute. Endoapertures- lalongate, pori circular or faintly elliptic-obtuse, distinct costae.

Sculpturing : Foveolate .

In LM: tectum microreticulate to foveolate; columellae clearly seen in surface view and in regular arrangement.

In SEM: foveolate, tectum with smooth surface; lumina very small, less than 1.00 µm, irregular in shape and size, the shape of lumina vary from rather rounded to oval shapes; vallae between the lumina are wider than the width of lumina.

Species : *Baccaurea kunstleri* King ex Gage (Plate 19 A-B, Plate 20 a-e), *B. lanceolata* Muell. Arg. (Plate 15 E-F, Plate 20 n–r)

Note :

This pollen type is very similar to *Baccaurea motleyana* type in LM, but it is clearly seen under SEM that the detail of exine sculpturing is different.

3.3 *Baccaurea motleyana* type

Pollen class: 3- zonocolporate, Microreticulate.

Pollen unit : Monad.

Polarity : Isopolar.

Polar field index : Small to medium, (0.26)-0.36-(0.49).

P/E ratio : (1.00)-1.31-(1.49).

Shape class : Subprolate to prolate.

Size class : Small, P = (13.50)-15.15-(17.50) µm,
E = (9.00)-12.18-(14.00) µm.

Outline : Polar view- circular to triangular-obtuse with concave sides. Equatorial view- circular to elliptic-obtuse (or poles are rather acute under SEM).

Exine : Semitectate, exine rather thin, (0.93)-1.12-(1.35) µm. Sexine as thick as, or thicker than the nexine.

Aperture : 3-zonocolporate. Ectoapertures-colpi rather long, slightly shorter than polar axis, (8.90)-11.92-(15.25) µm. in. length, broad, or widened at the eqautor and tapering towards the poles, ends acute or obtuse. Endoapertures- lalongate, pori elongate or faintly elliptic-obtuse, distinct costae.

Sculpturing : Microreticulate.
In LM: tectum microreticulate, columellae rather coarse, clearly seen in surface view and in regular arrangement.
In SEM: tectum with smooth surface, lumina very small, less than 1.00 µm in diameter, circular or oval, shape and size of lumina are rather regularly, muri with ridge as broad as, or broader than the breadth of the lumina.

Species : *Baccaurea motleyana* (Muell. Arg.) Muell. Arg. (Plate 19 C-D, Plate 20 f-m); *B. ramiflora* Lour. (Plate 19 E-F, Plate 18 d-h)

3.4 *Breynia* type

Pollen class: 7-10-zonodiploporate, Reticulate.
Pollen unit : Monad.
Polarity : Isopolar.
Polar field index : Small, (0.13)-0.15-(0.18).
P/$\bar{E}$ ratio : (0.81)-0.89-(0.95).
Shape class : Spheroidal to suboblate.
Size class : Small, P = (32.00)- 20.00-(45.00) µm,
E = (19.00)- 22.65-(24.50) µm.
Outline : Polar view- circular, rather straight to distinctly convex sided. Equatorial view- circular to elliptic or poles are rather acute under SEM.
Exine : Semitectate, exine medium, (1.50)-1.81-(2.00) µm. Sexine thicker than the nexine.
Aperture : 7-10-zonodiploporate. Ectoapertures- colpi rather long, (16.00)-17.60-(18.00) µm in length, colpi narrow, ends acute or obtuse, margin distinct. Endoapertures- lalongate, pori circular to circular-elliptic, usually two pori per colpi, rarely with one pore. Costae present.
Sculpturing : Reticulate.
In LM: coarse reticulate. Columellae clearly seen in surface view. Muri simplicolumellate.
In SEM: lumina rounded or subrounded in shape, and vary in size, 1.00-2.00 µm in diameter, muri mostly narrower than the breadth of the lumina.
Species : *Breynia glauca* Craib(Plate 25 A-C, Plate 26 a-h); *Breynia fruticosa* Craib(Plate 27 E-F); *B. vitis-idaea* Fischer(Plate 25 D-F).

Note :

Breynia type is one of the easily recognised pollen type by its diploporate aperture, which has never been found in any other pollen type recognised in this study.

3.5 *Bridelia harmandii* type

Pollen class:	3-zonocolporate, Striato-reticulate.
Pollen unit :	Monad.
Polarity :	Isopolar.
Polar field index :	Medium to large, (0.31)-0.47-(0.71).
P/E ratio :	(0.86)-1.04-(1.25).
Shape class :	Oblate-spheroidal to subprolate.
Size class :	Small, P = (16.00)-18.45-(23.75) µm, E = (15.00)-18.11-(21.25) µm.
Outline :	Polar view- circular to triangular-obtuse with concave sides. Equatorial view- elliptic-obtuse.
Exine :	Semitectate, exine rather thin to rather thick, (0.75)-1.27-(2.00) µm, sexine as thick as or slightly thinner than nexine.
Aperture :	3-zonocolporate. Ectoapertures- colpi very long, slightly shorter than polar axis, (10.00)-13.24-(16.25) µ m in length, usually opened at the equator, ends acute or obtuse; colpus membrane with sparsely granules. Endoapertures- lalongate, pori circular or oblong-elliptic, costae persent.
Sculpturing :	Striato-reticulate. **In LM**: tectum with microreticulation, columellae visible, rather coarse clearly seen in surface view, muri simplicolumellate. **In SEM**: tectum with striato-reticulate, more often occurred in reticulate; lumina regular in shape and size; usually circular or oval, rarely in irregular elongate, 0.30-0.80 µm in diameter; the parallel or subparallel muri are cross-linked to form a reticulum. The connections between the muri lie on a single level or different levels; vallae (or muri) as broad as, or broader than the breadth of the lumina; granules presented in the lumina
Species :	*Bridelia harmandii* Gagnep. (Plate 21 A-C, Plate 22 a-e); *Bridelia ovata* Decne (Plate 21 D-F, Plate 22 f-j)

Note :

The sculpture of this pollen type is reticulate in LM, however, it is clearly striato-reticulate under SEM observation. The muri are mostly curved unevenly thickened and branched forming a continuous striate-network.

3.6 *Bridelia tomentosa* type

Pollen class:	3-zonocolporate, Striate.
Pollen unit :	Monad.
Polarity :	Isopolar.
Polar field index :	Medium, (0.38)-0.45-(0.48).
P/E ratio :	(1.06)-1.11-(1.17).
Shape class :	Oblate-spheroidal to subprolate.
Size class :	Small, (P = (16.00)-17.13-(18.00) µm, E = (14.50)-15.45-(17.00) µm.
Outline :	Polar view- circular. Equatorial view- circular elliptic
Exine :	Semitectate, exine thick, 1.50-2.00 µm, sexine as thick as, or slightly thinner than nexine.
Aperture :	3-zonocolporate. Ectoapertures- colpi very long, slightly shorter than polar axis, (10.00)-12.35-(15.00) µm in length, wide and opened or widened at the equator; colpus membrane granulate, vestibulum present or absent. Endoapertures- lalongate, pori elliptic to oblong-elliptic, costae present, distinct or indistinct.
Sculpturing :	Striate. **In LM**: striato-reticulate, columellae clearly seen in surface view and optical, muri simplicolumellate. **In SEM**: tectum with raised strips, curved and branched; striae or vallae rather long and narrow, running in the direction of pole to pole, becoming striate-reticulate in the mesocolpium; grooves irregular elongate shape.
Species :	*Bridelia tomentosa* Bl. (Plate 23 A-C, Plate 24 a-f); *Bridelia stipularis* (L.) Bl. (Plate 23 D-F, Plate 24 g-k)

Key to species :

1. a Ectocolpus with vestibulum, indistinct costae.....*B. tomentosa*
1. b Ectocolpus without vestibulum, distinct costae.....*B. stipularis*

Note :

This pollen type is closely related to the *Bridelia harmandii* type. The difference between these two pollen types is the distinct striate pattern of *Bridelia tomentosa* type and striato-reticulate pattern of *B. harmandii* type.

3.7 *Croton* type

Pollen class:	Inaperturate; Croton pattern.
Pollen unit :	Monad.
Polarity :	Apolar.
Polar field index :	Absent.
P/E ratio :	1.00
Shape class :	Spheroidal.
Size class :	Medium, E = (26.00)-32.25-(60.00) µm.
Outline :	Circular.
Exine :	Intectate, exine thick, vary in thickness, (2.00-5.28) µm. Sexine thicker than nexine.
Aperture :	Inaperturate.
Sculpturing :	Croton pattern. **In LM**: (5)-6-(7)-clavae elements arranged in ring around a circular area in which vary in size from very small to rather large, 2.00-5.00 µm in diameter; the clavae elements can be closely packed or arranged in more open configuratiion. **In SEM**: the outline of clavae are circular to triangular-circular, sometimes irregular in shapes and size apices obtuse or acute, smooth surface or deeply lobed, margin entire or distinctly undulate, approximately 1.00-2.50 µm in diameter. Within the circular area, beset with small irregular granules which are clearly seen in top view.
Species :	*Vernicia montana* (Lour.) Wils. (Plate 1 A-B, Plate 2 a-c); *Baliospermum effusum* Pax et Hoffm. (Plate 6 A, Plate 7 a-d); *B. micranthum* Muell. Arg.; (Plate 6 B, Plate 20 e-h) *B. montanum* Muell. Arg. (Plate 6 C-E, Plate 7 i-l); *B. siamense* Craib(Plate 6 F, Plate 4 g-i); *Croton bonplandianus* Baill. (Plate 3 A-B, Plate 4 d-f); *C. cascarilloides* Raeusch. (Plate 1 E-F, Plate 5 a-e); *C. crassifolius* Geisel. (Plate 1 C-D, Plate 11 d-f); *C. caudatus* Geisel (Plate 3 E-F, Plate 5 f-i); *C. hutchinsonianus* Hoss. (Plate 8 A-B, Plate 9 a-c); *C.*

kerrii Airy Shaw (Plate 8 C-D, Plate 9 d-f); *C. kongensis* Gagnep. (Plate 12 E-F, Plate 13 a-d); *C. oblongifolius* Roxb. (Plate 14 a-c); *C. robustus* Kurz (Plate 10 C-D, Plate 11 a-c); *C. roxburghii* Black. (Plate 10 E-F, Plate 16 e-g); *C. thorelii* Gagnep(Plate 12 C-D, Plate 16 k-m); *C. sublyratus* Kurz(Plate 12 A-B, Plate 14 d-f); *C. poilanei* Gagnep. (Plate 8 E-F, Plate 9 d-f); *C. tiglium* L. (Plate 10 A-B, Plate 16 h-j); *Ostodes paniculata* Bl. (Plate 3 C-D, Plate 2 d-f).

Key to subtypes of pollen:

1. a Clavae elements not beset on the circular ridge under SEM.....2
1. b Clavae elements distinctly beset on the circular ridge under SEM.....3
2. a Clavae head distinctly undulate .....***Croton sublyratus* subtype** (including; *C. caudatus* Geisel; *C. kongensis* Gagnep.;*C. poilanei* Gagnep.; *C. robustus* Kurz;*C. tiglium* L; *C. oblongifolius* Roxb.; *C. roxburghii* Black.)
2. b Clavae head entire margin.....***Vernicia montana* subtype** (including *Croton cascarilloides* Raeusch.; *C. kerrii* Airy Shaw)
3. a Clavae with distinctly acute apices, deeply lobedand undulate margin under SEM .....***Baliospermum micranthum* subtype** (including *B. effusum* Pax et Hoffm.; *B. montanum* Muell. Arg.; *B. siamense* Craib; *Croton bonplandianus* Baill; *Ostodes paniculata* Bl.)
3. b Clavae with rather smooth surface, entire margin under SEM..... .....***Croton thorelii* subtype**

Note :

The Croton type has inaperturate grain. The shape is fairly uniform, usually spheroidal. There are many genera which their pollen grains possess a croton pattern included in this pollen type. In Euphorbiaceae, this pollen type is only found in subfamily Crotonoideae (Punt, 1962). The differences between structural elements of those species, which included in Croton pattern, are their arrangement, surface and margin, so that it seems better to omit the formation of groups (subtypes).

3.8 *Glochidion* type

Pollen class: 4-zonocolporate, (4)-5-zonocolporate, or 4-(5)-zonocolporate, Reticulate

Pollen unit :	Monad.
Polarity :	Isopolar.
Polar field index :	Medium, (0.30)-0.39-(0.45).
P/E ratio :	(0.87)-1.13-(1.29).
Shape class :	prolate-spheroidal.
Size class :	Small, P = (16.00)-20.69-(25.00) µm, E = (15.00)-18.19-(22.00) µm.
Outline :	Polar view- circular. Equatorial view- circular or elliptic-obtuse.
Exine :	Semitectate, exine thick, (1.50-2.50) µm. Sexine thicker than the nexine.
Aperture :	4-(5)-zonocolporate, (4)-5-zonocolporate, or 4-(5)-zonocolporate. Ectoapertures-colpi rather long, (8.95)-12.81-(17.50) µm in length, narrow, ends acute and obtuse, with or without margo. Endoapertures-lalongate-pori circular or elliptic.
Sculpturing :	Reticulate. **In LM**: coarse reticulation. Columellae clearly seen in surface view and muri simplicolumellate. **In SEM**: lumina rounded to elongate, vary in shape, 1.00-2.50 µm in diameter, muri as broad as, or narrower than the breadth of the lumina.
Species:	*Glochidion acuminatum* Muell. Arg. var. *siamense* Airy Show.(Plate 44 A-C, Plate 45 a-e); *G. arborescens* Bl. (Plate 47 A-C, Plate 46 a-e); *G. assamicum* (Muell. Arg.) Hook. f. (Plate 44 D-F, Plate 46 g-j); *G. coccineum* (Buch-Ham.) Muell. Arg. (Plate 47 C, Plate 50 a-e); *G. eriocarpum* Champ. (Plate 48 A-C, Plate 50 f-i); *G. daltnii* (Muell. Arg.) Kurz(Plate 51 C-D); *G. glomerulatum* (Miq.) Boerl. (Plate 48 D, Plate 49 a-f); *G. hirsutum* (Roxb.) Voight(Plate 48 E-F); *G. hongkongene* Muell. Arg. (Plate 51 A-B, Plate 52 a-e); *G. kerrii* Craib(Plate 51 E-F, Plate 52 f-h); *G. lanceolarium* (Roxb.) Voight (Plate 48 D-F); *G. littorale* Bl. (Plate 56 A-C, Plate 57 a-f); *G. nubigenum* Hook. f. (Plate 54 A-C, Plate 53 a-d); *G. obscurum* (Roxb. ex Willd.) Bl. (Plate 53 e-i); *G. rubrum* Bl. (Plate 56 D-F, Plate 58 a-g); *G. sericeum* (Blume) Zoll et Marets(Plate 59 A-B; *G. sphaerogynum*

(Muell. Arg.) Kurz(Plate 54 D-F, Plate 55 a-d); *G. superbum* Baill. (Plate 59 C-D, Plate 61 a-g)

Note :

This pollen type has small pollen grains with lalongate, circular or broad elliptic endoporus. The reticum is distinct and usually fairly coarse.

3.9 *Hevea brasiliensis* type

Pollen class:	3-zonocolpate, Croton pattern (baculate).
Pollen unit :	Monad.
Polarity :	Isopolar.
Polar field index :	Small, (0.15)-0.17-(0.18).
P/E ratio :	(0.82)-0.91-(1.00).
Shape class :	Suboblate to oblate spheroidal.
Size class :	Medium, P = (25.00)-27.31-(27.50) µm, E = (27.50)-30.50-(32.50) µm.
Outline:	Polar view-circular. Equatorial view- elliptic-obtuse.
Exine :	Intectate, exine rather thick, (1.25)-1.52-(2.50) µm. Sexine much thicker than the nexine.
Aperture :	3-zonocolpate; colpi very long, (17.50)-18.56-(22.50) µm in length, narrow, and closed or widened at the equator, ends acute or obtuse.
Sculpturing :	Croton pattern. **In LM**: form the very small circular ring; the arrangement of the structure elements conformed the pattern of *Croton* spp. **In SEM**: the baculae are small and densely crowded, regularly scattering. In some area baculae elements seems to form a ring of croton pattern of (5)-6-(7)-baculae elements.
Species :	*Hevea brasiliensis* Muell. Arg. (Plate 37 A-D, Plate 36 f-j)

Note :

The distinguishing features of the *Hevea brasiliensis* type are that the ornamentation is croton pattern and the aperture is colpate. Among this pollen types found in this study, it is the only one that presented the colpate aperture.

3.10 *Macaranga* type

Pollen class :	3-colporate; Scabrate and perforate.

Pollen unit : Monad.

Polarity : Isopolar.

Polar field index : Medium, (0.32)-0.46-(0.66).

P/E ratio : (0.92)-1.03-(1.17).

Shape class : Suboblate to subprolate.

Size class : Small, P = (12.50)-12.66-(13.00) µm, E = (13.00)-13.33-(14.00) µm.

Outline : Polar view- circular to triangular-obtuse with convex sides or 3-lobed. Equatorial view- cicular to elliptic-obtuse or retecgular-obtuse with convex sided.

Exine : Tectate, exine medium, (1.25-1.31) µm. Sexine as thick as, or thicker than the nexine.

Aperture : 3-zonocolporate. Ectoapertures- colpi rather long, (8.01)-9.45-(11.60) µm in length, broad and opened or widened at the equator, ends acute or obtuse. Endoapertures- lalongate, circular or elliptic-obtuse, sometimes equatorial endocolpus were found, distinct costae.

Sculpturing : Scabrate and perforate (SEM) or psilate (LM).
In LM: tectum psilate, columellae rather coarse Clearly seen in surface view.
In SEM: tectum undulate surface with scabrate, spines smaller than 1.00 µm; the scabrae elements are uniformly orientated with minute perforation, the holes are less than 1.00 µm in diameter, irregularly arranged.

Species : *Macaranga denticulata* (Bl.) Muell. Arg. (Plate 29 A-C, Plate 32 h-k); *M. indica* Wight(Plate 27 C-D, Plate 31 d-g); *M. tanarius* (L.) Muell. Arg. (Plate 29 D-F, Plate 32 a-d)

Note :

This pollen type is related to the *Mallotus* type under LM, but differs by visible scabrate on tectum under SEM.

3.11 *Mallotus* type

Pollen class : 3-zonocolporate; Granulate(SEM) or psilate(LM) and perforate.

Pollen unit : Monad.

Polarity : Isopolar.

Polar field index : Small to very large, (0.24)-0.95-(1.11).

P/E ratio : (0.86)-0.95-(1.35).

Shape class : Subspheroidal, oblate to prolate.

Size class : Small, P = (10.00)-17.55-(22.00) µm, E = (9.50)-14.36-(22.00) µm

Amb : Polar view- circular to triangular-obtuse with concave sides. Equatorial view- circular to elliptic-obtuse or retecgular-obtuse with convex sided.

Exine : Tectate, exine medium, 0.97-1.58 µm. Sexine as thick as, or thicker than nexine.

Aperture : 3-zonocolporate. Ectoapertures- colpi very short to rather long, (7.40)-10.46-(18.56)µm in length, broad and opened or widened at the equator and tapering towards the poles, ends acute or obtuse. Endoapertures-lalongate, circular or elliptic-obtuse, sometimes equatorial endocolpus, distinct costae.

Sculpturing : Granulate and perforate or psilate (LM).

In LM: tectum psilate with perforation, columellae fine or visible.

In SEM: tectum surface seems rather rough, verucate or undulate with tiny pores less than 1.00 µm in diameter, uneven distantly orientated; the granule elements are short and broadened at the base, blunt, pointed, or uniformly orientated, or sometimes disorientated arrangment.

Species : *Macaranga heynei* I. M. Johnston (Plate 27 A-C, Plate 31 a-e); *M. kurzii* (Kuntze) Pax et Hoffm. (Plate 28 D-F, Plate 32 e-g); *M. laciniata* Whitm.et. Airy Shaw (Plate 30 A-C, Plate 31 h-k); *M. lowii* King ex Hook. f. (Plate 30 D-F, Plate 31 l-o); *M. pruinosa* (Miq.) Muell. Arg. (Plate 28 A-C, Plate 31 p-s g-k); *Mallotus barbatus* Muell. Arg. (Plate 33 A-C, Plate 35 e-g); *M. oblongifolius* (Miq.) Muell. Arg. (Plate 33 D-F); *M. paniculatus* (Lam.) Muell. Arg. (Plate 34 A-C, Plate 35 a-d); *Cleidion spiciflorum* (Burm. f.) Merr. (Plate 17 D-F, Plate 24 g-k); *Sampantaea amentiflora* Airy Shaw (Plate 37 E-F, Plate 40 a-c); *Trewia nudiflora* L. (Plate 38 D-F, Plate 36 a-e)

Note :

The *Mallotus* type is similar to the *Macaranga* type in being a 3-zonocolporate grain. However, there is a slightly difference in ornamentation which is granulate-perforate in the *Mallotus* type, but scabrate in the *Macaranga* type

3.12 *Microstachys chamaelea* type

Pollen class :	3-zonocolporate; Microreticulate
Pollen unit :	Monad.
Polarity :	Isopolar.
Polar field index :	Small, (0.15).
P/E ratio :	(1.25)-1.32-(1.50).
Shape class :	Suboblate to prolate.
Size class :	Small to medium, P = (25.00)-26.50-(30.00) µm. E = (19.00)-20.35-(22.00) µm.
Outline:	Polar view- circular to triangular-obtuse with convex sides. Equatorial view- elliptic-obtuse.
Exine :	Semitectate, exine medium, (1.00)-1.25-(1.50) µm. Sexine thicker than the nexine.
Aperture :	3-zonocolporate. Ectoapertures-colpi rather long, (18.00)-19.80-(20.00) µm in length, broad and opened or widened at the equator, ends acute; margo persent with psilate and broadened margin; colpus membrane granulate. Endoapertures- lalongate, pori circular or faintly elliptic-obtuse, costae distinct.
Sculpturing :	Microreticulate. **In LM**: tectum microreticulate, columellae rather coarse, clearly seen in surface view and in irregular arrangement. **In SEM**: lumina very small, less than 1.00 µm in diameter, circular or oval shape. Size of lumina are rather irregularly; muri as broad as, or broader than the breadth of the lumina.
Species :	*Microstachys chamaelea* (L.) Juss. (Plate 38 D-F, Plate 41 a-c, Plate 42 a)

Note :

The *Microstachys chamaelea* type differs from the *Baccaurea motleyana* type by its narrow margo which is usually narrower than the breadth of ectoaperture, and

the deep triangular-obtuse with convex sided or three lobed pollen grains in polar view.

3.13 *Suregada multiflora* type

Pollen class :	Polypantoporate, Croton pattern.
Pollen unit :	Monad.
Polarity :	Apolar.
Polar field index :	Absent.
P/E ratio :	1.00
Shape class :	Spheroidal.
Size class :	Medium, (25.00)-30.17-(38.00) µm.
Outline :	Circular.
Exine :	Intectate, exine thick, (3.00)-3.95-(5.00) µm. Sexine
Aperture :	Polypantoporate. Pori circular to slightly elliptic, with uneven, diameter varies in 2.50-9.25 µm; margo present under SEM.
Sculpturing :	Croton pattern. **In LM**: the clavate structure elements arranged in ring of (5)-6-(7)-clavae elements, 3.50 µm in diameter; the clavae elements arranged in an open configuration. **In SEM**: the heads of clavae are circular to triangular-circular, approximately 1.00-2.00 µm in diameter; 2.50 µm in height, obtuse apices, smooth surface with undulate margin. In the circular rings, forming by clavae, beset with very small irregularly granules, which are clearly seen in top view.
Species :	*Suregada multiflora* (A. Juss.) Baill.: (Plate 39 A-C, Plate 42 b-d)

Note:

The sculpturing of this pollen type conformed to the *Croton* type. The pollen grains have many large apertures with uneven rims. The size of pori are remarkably varies from one grain to another.

3.14 *Thyrsanthera suborbicularis* type

Pollen class :	3-zonocolporate; Reticulate.
Pollen unit :	Monad.
Polarity :	Isopolar.

Polar field index :	Medium, (0.30)-0.37-(0.50).
P/E ratio :	(1.09)-1.32-(1.52).
Shape class :	Prolate-spheroidal to prolate.
Size class :	Medium, P = (32.00)-39.15-(45.00) µm, E = (27.00)-29.60-(33.00) µm.
Outline :	Polar view- triangular-obtuse with concave sided. Equatorial view- elliptic with acute(LM) to elliptic-truncate (SEM).
Exine :	Semitectate, exine rather thick, approximately 1.50 µm. Sexine thicker than the nexine.
Aperture :	3-zonocolporate. Ectoapertures-colpi very long, as long as or slightly shorter than polar axis, (25.00)-30.40-(35.00) µm in length, narrow and opened or widened at the equator, ends acute or obtuse. Endoapertures-lalongate, pori elliptic or elongate, costae present.
Sculpturing :	Reticulate. **In LM**: reticulate, columellae clearly seen in surface view and muri simplicolumellate. **In SEM**: lumina, mostly are rounded in shapes, rarely irregular form elongate, 1.00-1.50 µm in diameter and vary in size and shape; muri as broad as, or narrower than the breadth of the lumina.
Species :	*Thyrsanthera suborbicularis* Pierre ex Gagnep. (Plate 39 D-F, Plate 43 a-g)

Note :

The *Thyrsanthera suborbicularis* type was represented by only one species, it is similar to the other pollen types which are 3-colporate-reticulate. The most clearly difference is its distinctly coarse reticulum.

3.15 *Trigonostemon reidioides* type

Pollen class :	Inaperturate; Croton pattern.
Pollen unit :	Monad.
Polarity :	Apolar.
Polar field Index :	Absent.
P/E ratio (x100):	1.00
Shape class :	Spheroidal.
Size class :	Medium, E (22.50)-28.25-(31.75)µm.

Outline : Circular.

Exine : Semitectate, exine thick, 2.00-3.00 µm. Sexine thicker than nexine.

Aperture : Inaperturate.

Sculpturing : Croton pattern.

In LM: the clavate structure elements arranged in ring of (4)-6-(7)-clavae elements, the circular rings is very small, 1.00-2.00 µm in diameter; the clavae elements seems to form a reticulum.

In SEM: the heads of clavae are circular-elliptic, irregular in shapes and size, less than 1.00 µm in diameter; the clavae elements raised up from the normal surface or beset on the ridge. In the circular rings, forming by clavae, occurred irregularly the very small granules which are clearly seen in top view.

Species : *Trigonostemon reidioides* (Kurz) Craib (Plate 15 C-D, Plate 16 a-c); *Blachia siamensis* Gagnep. (Plate 15 A-B, Plate 4 a-c)

Note:

The sculpturing of this pollen type is very similar to the *Croton* type. Under LM, the structure elements seems to form a reticulum of semitectum. Under SEM, the arrangement of the structure elements is the same as in *Croton* spp., but the head of clavae are much smaller. The clavae elements stand directly on the tectum. The reticulate pattern were then formed by the clavae ring around the partially absent tectum. In those circular ring, there are very small irregularly granules which are clearly seen under the SEM.

Table 4 Pollen morphological data of Euphorbiaceae in Thailand (PxE = polar grain size showing mean for polar axis (P) and equatorial diameter (E); P. I = polar field index; Pol. = polarity: A= apolar, I =Isopolar; Size class: S = small, M = medium, L = large; Amb: C = circular, Tbc = triangular-obtuse with convex sides, Tl = 3-lobed, Qbc = quadrangular-obtuse with convex sides; P:E = shape of pollen grains express as ratio; osp = oblate-spheroidal; p = prolate; psp = prolate-spheroidal; so = suboblate; sp = spheroidal; la = lalongate; ed = equatorial endocolpus; Sc = sculpturing at the SEM; croton. = croton pattern, perf. = perforate, fov.= foveolate, gran. = granulate, scabr. = scabrate, microret. = microreticulate; ret. = reticulate, str. = striate, striato. = striato- reticulate).

Species	Aperture	Sc	Pol.	P. I	Amb	P:E class	Shape (µm)	PxE class	Size (µm)	Exine thickness (µm)	Colpi/pori size (µm)	Colpi/pori membrane	Ora size	Ora shape	Others characters
BACCAUREA															
B. bracteata	3-colporate	perf.	I	0.33	Tbc	1.14-1.50	sp-p	17-19x12-14	S	1.0-1.8	11-13	-	1X3	la	tectum smooth; costae endoaperture
B. kunstleri	3-colporate	fov.	I	0.33	Tbc	1.26-1.44	sp-p	17-19x12-14	S	1.2-1.50	11-12	-	1X3	la	tectum smooth; costae endoaperture
B. lanceolata	3-colporate	fov.	I	0.49	Tbc	0.93-1.03	sp-p	13-15x13-14	S	1.0-1.5	8-10	-	1X3	la	tectum smooth; costae endoaperture
B. motleyana	3-colporate	microret.	I	0.26	Tbc	1.26-1.66	sp-p	14-16x 9-12	S	0.8-1.0	11-13	-	1X3	la	tectum smooth; costae endoaperture
B. ramiflora	3-colporate	microret.	I	0.33	Tbc	1.30-1.55	sp-p	17-18x11-13	S	1.3-1.5	14-16	-	1X3	la	tectum smooth; costae endoaperture
BALIOSPERMUM															
B. effusum	inaperturate	croton.	A	-	C	0.81-0.95	sp	22-27 (dia.)	M	2.5-3.0	-	-	-	-	clavae with undulate margin and deeply lobed ridge on tectum
B. micranthum	inaperturate	croton.	A	-	C	1.0	sp	28-39 (dia.)	M	3.0-3.0	-	-	-	-	clavae with undulate margin and deeply lobed ridge on tectum
B. montanum	inaperturate	croton.	A	-	C	1.0	sp	25-28 (dia.)	M	1.5-2.0	-	-	-	-	clavae with undulate margin and deeply lobed
B. siamense	inaperturate	croton.	A	-	C	1.0	sp	24-32 (dia.)	M	2.0-2.8	-	-	-	-	clavae with undulate margin and deeply lobed ridge on tectum
BLACHIA															
B siamensis	inaperturate	croton.	A	-	C	1.0	sp	23-32 (dia.)	M	2.0-25	-	-	-	-	clavae with undulate margin and deeply lobed ridge on tectum

Table 4 (continued).

Species	Aperture	Sc	Pol.	P. I	Amb	P:E class	Shape (µm)	PxE class	Size (µm)	Exine thickness (µm)	Colpi/pori size (µm)	Colpi/pori membrane	Ora size	Ora shape	Others characters
BREYNIA															
B. fruticosa	polydicolporate	ret.	I	0.16	C	0.90-1.06	sp-so	17-19x17-21	S	1.3-1.5	14-16	-	2X2	la	Colpi sometimes with two ora; Muri <0.5µm; Lumina >2.0µm
B. glauca	polydicolporate	ret.	I	0.15	C	0.81-0.95	sp-so	18-22x19-25	S	1.5-2.0	14-16	-	2X3	la	Colpi sometimes with two ora; Muri <0.5µm; Lumina >2.0µm
B. vitis-idaea	polydicolporate	ret.	I	0.15	C	0.9-1.00	sp-so	18-22x19-25	S	1.3-1.5	13-15	-	1.5X2	la	Colpi sometimes with two ora; Muri <0.5µm; Lumina >2.0µm
BRIDELIA															
B. harmandii	3-colporate	striato.	I	0.55	Tbc	0.94-1.25	so-sp	20-24x20-21	S	0.5-1.7	13-16	finely gran.	3x3	la	-
B. ovata	3-colporate	striato.	I	0.39	Tbc	0.86-1.06	osp-psh	16-18x15-19	S	1.5-2.0	10-12	finely gran.	2x4	la	-
B. stipularis	3-colporate	str.	I	0.44	Tbc	0.91-1.19	psh-sp	19-27x18-24	S	1.5-2.0	12-15	finely gran.	2x4	la	-
B. tomentosa	3-colporate	str.	I	0.45	Tbc	1.06-1.17	psh-sp	19-27x18-24	S	1.8-2.5	11-13	finely gran.	4x6	la	-
CLEIDION															
C. spiciflorum	3-colporate	gran. & perf.	I	0.34	C	0.97-1.18	so-psh	17-21x16-19	S	1.2-18	14-16	-	2x5	la	-
CROTON															
C. bonplandianus	inaperturate	croton.	A	-	C	1.0	sp	27-35 (dia.)	M	3.0-4.0	-	-	-	-	clavae with undulate margin and deeply lobed ; ridge on tectum
C. cascarilloides	inaperturate	croton.	A	-	C	1.0	sp	25-53 (dia.)	L	2.0-2.5	-	-	-	-	clavae with entire margin ; not ridge on tectum
C. caudatus	inaperturate	croton.	A	-	C	1.0	sp	37-50 (dia.)	L	4.0-4.5	-	-	-	-	clavae with undulate margin ; not ridge on tectum
C. crassifolius	inaperturate	croton.	A	-	C	1.0	sp	28-50 (dia.)	L	4.0-4.0	-	-	-	-	clavae with undulate margin ; not ridge on tectum
C. hutchinsonianus	inaperturate	croton.	A	-	C	1.0	sp	32-50 (dia.)	L	3.0-4.0	-	-	-	-	clavae with undulate margin ; not ridge on tectum
C. kerrii	inaperturate	croton.	A	-	C	1.0	sp	41-53 (dia.)	L	2.0-2.5	-	-	-	-	clavae with entire margin ; not ridge on tectum
C. kongensis	inaperturate	croton.	A	-	C	1.0	sp	34-51 (dia.)	L	3.0-4.0	-	-	-	-	clavae with undulate margin ; not ridge on tectum
C. oblongifolius	inaperturate	croton.	A	-	C	1.0	sp	37-53 (dia.)	L	2.0-25	-	-	-	-	clavae with undulate margin ; not ridge on tectum

Table 4 (continued).

Species	Aperture	Sc	Pol.	P. I	Amb	P:E class	Shape (µm)	PxE class	Size (µm)	Exine thickness (µm)	Colpi/pori size (µm)	Colpi/pori membrane	Ora size	Ora shape	Others characters
C. poilanei	inaperturate	croton.	A	-	C	1.0	sp	37-55 (dia.)	L	3.0-3.0	-	-	-	-	clavae with undulate margin ; not ridge on tectum
C. robustus	inaperturate	croton.	A	-	C	1.0	sp	35-48 (dia.)	M	3.5-4.0	-	-	-	-	clavae with undulate margin ; not ridge on tectum
C. roxburghii	inaperturate	croton.	A	-	C	1.0	sp	41-53 (dia.)	L	2.0-25	-	-	-	-	clavae with undulate; *not ridg o n tectum*
C. sublyratus	inaperturate	croton.	A	-	C	1.0	sp	26-40 (dia.)	M	3.5-3.5	-	-	-	-	clavae with undulate margin ; not ridge on tectum
C. tiglium	inaperturate	croton.	A	-	C	1.0	sp	28-43 (dia.)	M	3..0-4.0	-	-	-	-	clavae with undulate margin ; not ridge on tectum
C. thorelii	inaperturate	croton.	A	-	C	1.0	sp	30-36(dia.)	M	2.8-3.0	-	-	-	-	clavae with undulate margin ; not ridge on tectum
GLOCHIDION															
G. acuminatum var. *siamense*	4-(5)-colporate	ret.	I	0.43	C-Qbc	1.03-1.18	psp	20-22x18-23	S	2.0-2.5	12-15	-	1.5x2.0	la	Muri >0.5µm; Lumina >2.0µm
G. arborescens	4-colporate	ret.	I	0.41	C-Qbc	1.03-1.14	osp	16-18x15-17	S	1.5-2.0	9-10	-	1.0x2.0	la	Muri >0.5µm; Lumina <2.0µm
G. assamicum	4-colporate	ret.	I	0.33	C-Qbc	1.02-1.32	psp-sp	19-25x17-22	S	1.8-2.0	11-18	-	1.0X2.0	la	Muri < 0.5µm; Lumina >2.0µm
G. coccineum	4-colporate	ret.	I	0.31	C-Qbc	0.92-1.22	psp-sp	17-22x18-20	S	2.0-2.5	10-12	-	1.0x2.5	la	Muri >0.5µm; Lumina <2.0µm
G. daltonii	4-colporate	ret.	I	0.44	C-Qbc	1.5-2.0	sp-so	17-19x17-21	S	1.3-1.5	14-16	-	2.0X2.0	la	Muri < 0.5µm; Lumina >2.0µm
G. eriocarpum	4-colporate	ret.	I	0.42	C-Qbc	1.06-1.10	sp-so	20-26x10-13	S	1.8-2.0	14-17	-	1.5X2.0	la	Muri < 0.5µm; Lumina >2.0µm
G. glomerulatu	4-colporate	ret.	I	0.41	C-Qbc	0.90-1.14	so-osp	18-21x17-20	S	1.5-2.0	11.15	-	2.0X2.0	la	Muri < 0.5µm; Lumina >2.0µm
G. hirsutu	4-colporate	ret.	I	0.33	C-Qbc	1.16-1.50	sp-p	19-27x16-20	S-M	1.5-2.0	12-20	-	1.5x3.0	la	Muri < 0.5µm; Lumina >2.0µm
G. hongkongensis	4-colporate	ret.	I	0.41	C-Qbc	1.05-1.21	psp-so	19-27x16-20	S-M	1.5-2.5	12-17	-	2.0X3.0	la	Muri < 0.5µm; Lumina >2.0µm
G. kerrii	4-colporate	ret.	I	0.35	C-Qbc	0.98-1.27	osp-sp	21-27x19-26	S-M	1.8-2.0	13-18	-	2.5X3.0	la	Muri < 0.5µm; Lumina >2.0µm

Table 4 (continued).

Species	Aperture	Sc	Pol.	P. I	Amb	P:E class	Shape (µm)	PxE class	Size (µm)	Exine thickness (µm)	Colpi/pori size (µm)	Colpi/pori membrane	Ora size	Ora shape	Others characters
G. lanceolarium	4-colporate ret.	ret.	I	0.30	C-Qbc	0.87-1.05	so-osp	20-25x20-24	S	1.5-2.0	17-18	-	2.0X3.0	la	Muri < 0.5µm; Lumina >2.0µm
G. littorale	4-colporate	ret.	I	0.45	C-Qbc	0.94-1.19	psp-sp	20-23x18-22	S	1.8-2.0	10-15	-	1.0X2.5	la	Muri < 0.5µm; Lumina >2.0µm
G. nubigenum	4-colporate	ret.	I	0.35	C-Qbc	1.00-1.29	osp-sp	24-28x19-22	M	2.0-2.5	12-15	-	1.5X2.0	la	Muri >0.5µm; Lumina >2.0µm, with granules
G. obscurum	4-colporate	ret.	I	0.38	C-Qbc	1.00-1.21	sp-so	17-19x17-21	S	1.3-1.5	14-16	-	2.0X2.0	la	Muri < 0.5µm; Lumina >2.0µm
G. rubrum	(4)-5-colporate	ret.	I	0.41	C-Qbc	0.97-1.05	psp	18-21x18-22	S	2.0-2.0	10-13	-	1.0X2.0	la	Muri < 0.5µm; Lumina < 2.0µm
G. sericeum	4-colporate	ret.	I	0.39	C-Qbc	0.90-1.11	psp	17-19x17-21	S	1.5-2.0	12-15	-	2.0X2.5	la	Muri >0.5µm; Lumina >2.0µm
G. sphaerogynum	4-colporate	ret.	I	0.42	C-Qbc	1.11-1.29	sp	19-22x15-19	S	1.5-2.0	12-15	-	2.5X3.0	la	Muri >0.5µm; Lumina >2.0µm
G. superbum	4-colporate	ret.	I	0.36	C-Qbc	0.83-1.07	so-osp	15-16x14-18	S	1.8-2.5	12-16	-	2.0X2.0	la	Muri >0.5µm;
HEVEA															
H. brasiliensis	3-colpate	croton.	I	0.17	C-TI	0.82-1.00	so-osp	25-28x28-31	M	1.25-2.5	18-22	-	-		baculae are small and densely crowded, regularly scattering
HOMONOIA															
H. riparia	3-colporate	gran.	I	0.54	C-Tbc	1.00-1.35	psp-p	20-24x17-24	S	1.5-2.0	15-18	-	-	-	Lumina >2.0µm
MACARANGA															
M. denticulata	3-colporate	scabr.	I	0.32	C-Tbc	0.89-1.08	so-osp	13-14x13-15	S	1.2-1.5	10-12	-	2.5x4.0	ed	-
M. heynei	3-colporate	gran.	I	0.34	Tbc-TI	0.95-1.15	so-osp	10-12x10-12	S	1.0-1.2	7-9	-	2.5x4.0	ed	-
M. indica	3-colporate	scabr.	I	0.41	C-Tbc	0.92-1.04	so-osp	11-13x12-14	S	1.2-1.5	7-10	-	1.8x4.0	ed	-
M. kurzii	3-colporate	gran.	I	0.55	C-Tbc	0.90-1.05	so-osp	20-23x 18-21	S	1.0-1.5	9-12	-	4.0x6.0	ed	-
M. laciniata	3-colporate	gran.	I	0.44	C-Tbc	0.90-1.02	psp	9-11x9-11	S	0.5-1.0	6-7	-	1.0x3.0	ed	-
M. lowii	3-colporate	gran.	I	0.52	C-Tbc	0.81-1.00	so-osp	10-12x10-12	S	1.0-1.5	6-8	-	1.0x3.0	ed	-
M. pruinosa	3-colporate	gran.	I	045	C-Tbc	0.95-1.05	so-osp	11-12x10-12	S	1.0-1.5	6-8	-	1.0x3.0	ed	-
M. tanarius	3-colporate	scabr.	I	0.66	C-Tbc	0.91-1.11	so-osp	11-13x10-13	S	0.5-1.5	7-9	-	1.0x3.0	ed	-

Table 4 (continued).

Species	Aperture	Sc	Pol.	P. I	Amb	P:E class	Shape (µm)	PxE class	Size (µm)	Exine thickness (µm)	Colpi/pori size (µm)	Colpi/pori membrane	Ora size	Ora shape	Others characters
MALLOTUS															
M. barbatus	3-colporate	gran. & perf.	I	0.46	C-Tbc	0.86-1.08	sp-osp	17-21x18-22	S	1.5-2.0	11-15	-	1.0x3.0	ed	-
M. oblongifolius	3-colporate	gran. & perf.	I	0.45	C-Tbc	1.11-1.33	osp-sp	13-14x13-15	S	1.2-1.5	17-19	-	1.0x3.0	ed	-
M. paniculatus	3-colporate	gran. & perf.	I	0.39	C-Tbc	0.83-1.17	psp	12-20X18-20	S	0.8-1.5	11-13	-	1.0x3.0	ed	-
MICROSTACHYS															
M. chamaelea	3-colporate	microret.	I	0.15	C-Tbc	1.25-1.5	so-p	25-30x19-22	M	1.0-1.5	18-20	-	3.0x4.0	la	margo distinct
OSTODES															
O. paniculata	inaperturate	croton.	A	-	C	1.00	sp	36-45 (dia.)	M	3.0-5.0	-	-	-	-	clavae with undulate margin and deeply lobed ; ridge on tectum
SAMPANTAEA															
S. amentiflora	3-colporate	gran.	I	0.34	C-Tbc	0.94-1.11	so-psp	17-20x18-19	S	0.94-1.11	10-11		-	la	-
SUREGADA															
S. multiflora	polyporate	croton.	A	-	C	1.00	sh	25-38 (dia.)	M	1.0-1.5	3-9	-	-	-	-
THYRSANTHERA															
T. suborbicularis	3-colporate	ret.	I	0.37	C	1.09-1.52	psp-p	32-45x27-33	M	1.5-2.0	28-35	-	-	la	-
TREWIA															
T. nudiflora L.	3-colporate	gran.	I	0.60	Tbc	0.94-0.95	so	18-22x20-24	S	1.0-1.3	7-10	-	-	la	-
TRIGONOSTEMON															
T. reidioides	inaperturate	croton.	A	-	C	1.00	sh	32-45 (dia.)	M	1.5-2.0	-	-	-	-	clavae with undulate margin and irregular in shape; distinct ridge on
VERNICIA															
V. montana	inaperturate	croton.	A	-	C	1.0	sp	42-60 (dia.)	L	4.5-6.0	-	-	-	-	clavae with entire margin ; not ridge on tectum

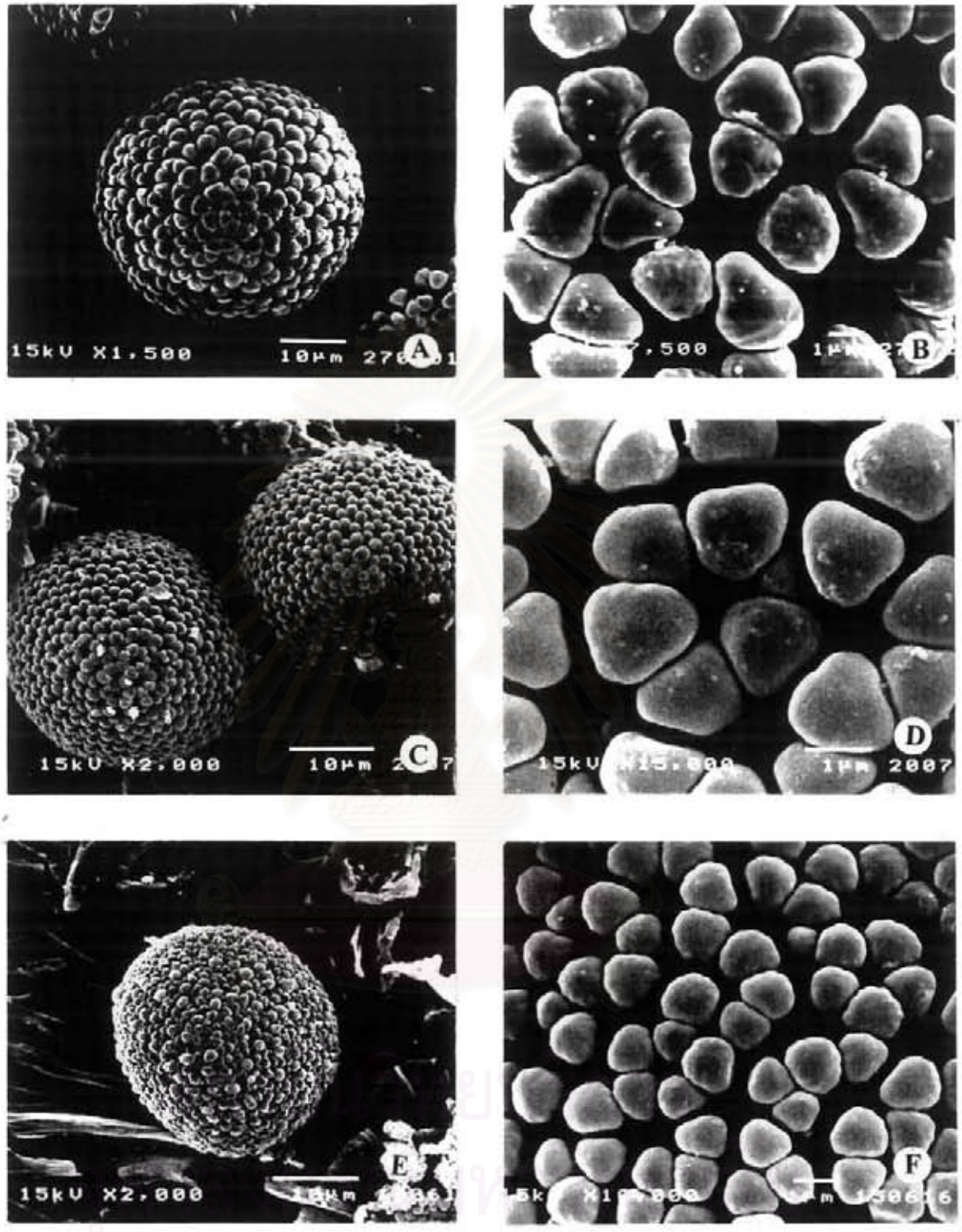


Plate 1. SEM micrographs: A-B. ***Vernicia montana*** **Lour.** (A) Whole grain. (B) culpturing. C-D. ***Croton crassifolius*** **Geisel.** (C) Whole grain. (D) Sculpturing. E-F. ***Croton cascarilloides*** **Raeusch.** (E) Whole grain. (F) Sculpturing.

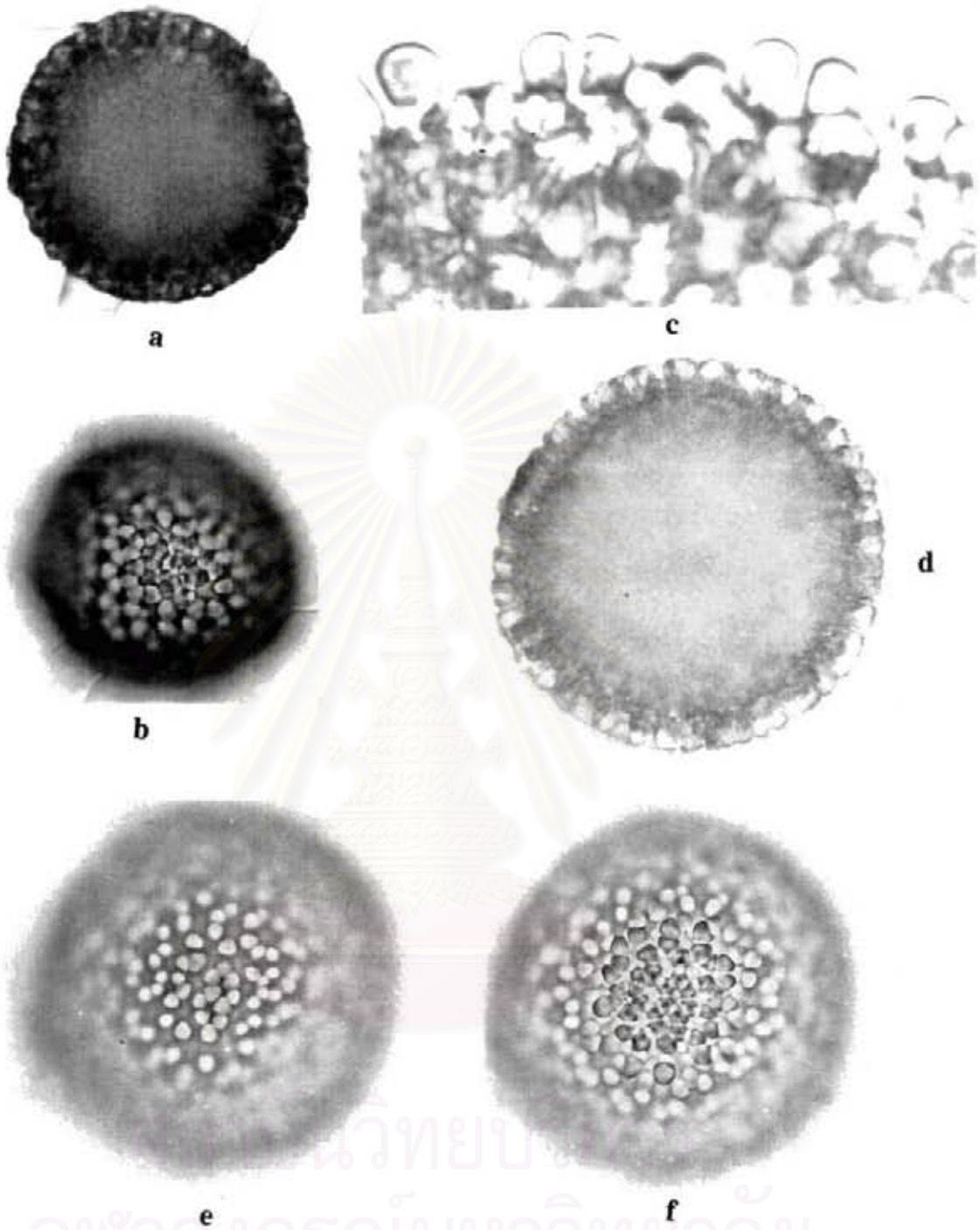


Plate 2. LM micrographs: a-c. ***Vernicia. montana* Lour**. (a) Equatorial plane of grain. (b) Top view of structure elements (c) Clavae elements. d-f. ***Ostodes paniculata* Bl.** (d) Equatorial plane of grain. (e-f) The top of structure elements. All Micrographs × 875.

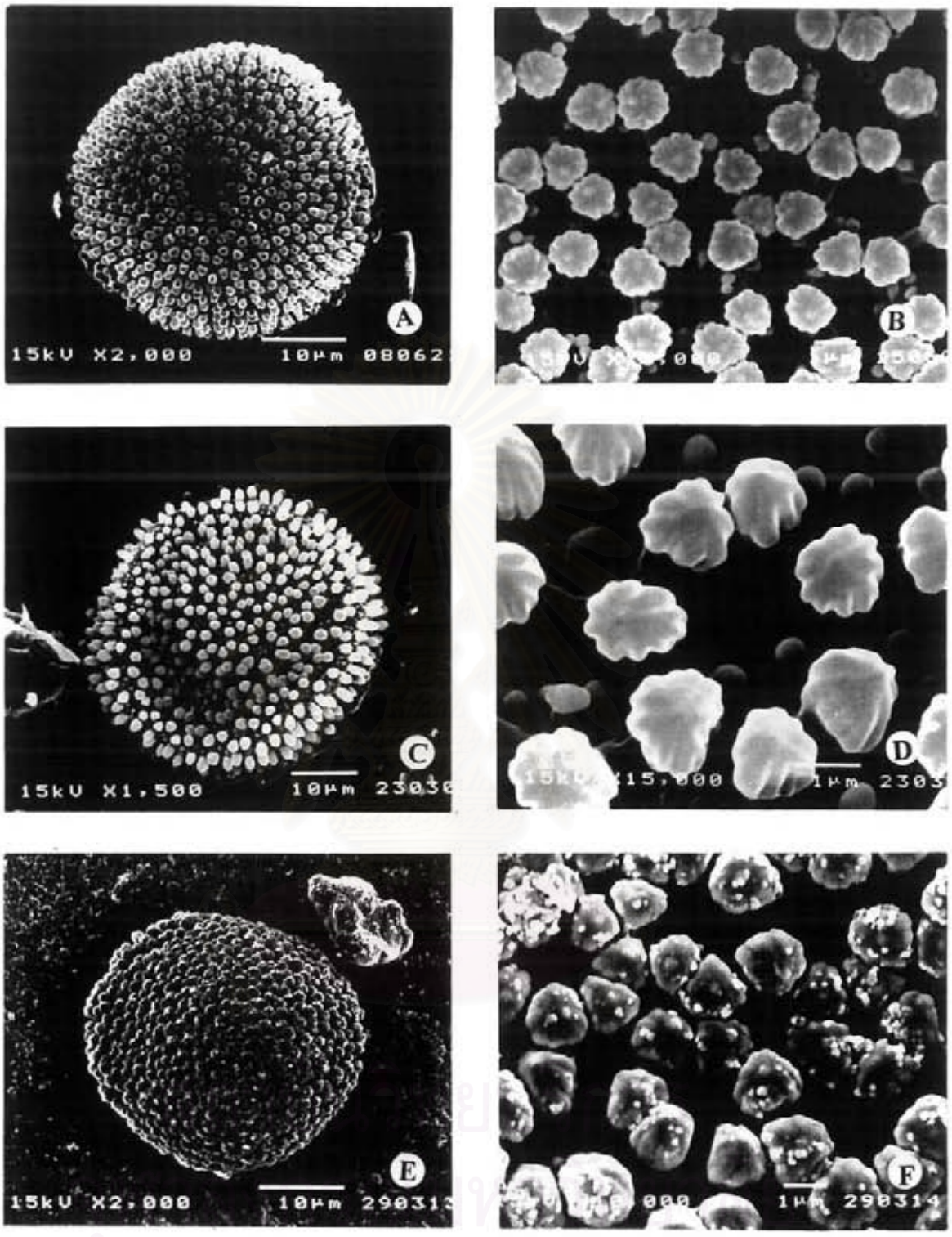


Plate 3. SEM micrographs: A-B. ***Croton bonplandianus*** **Baill.** (A) Whole grain. (B) Sculpturing. C-D. ***Ostodes paniculata*** **Bl.** (C) Whole grain. (D) Sculpturing. E-F. ***Croton caudatus*** **Geisel** (E) Whole grain. (F) Sculpturing.

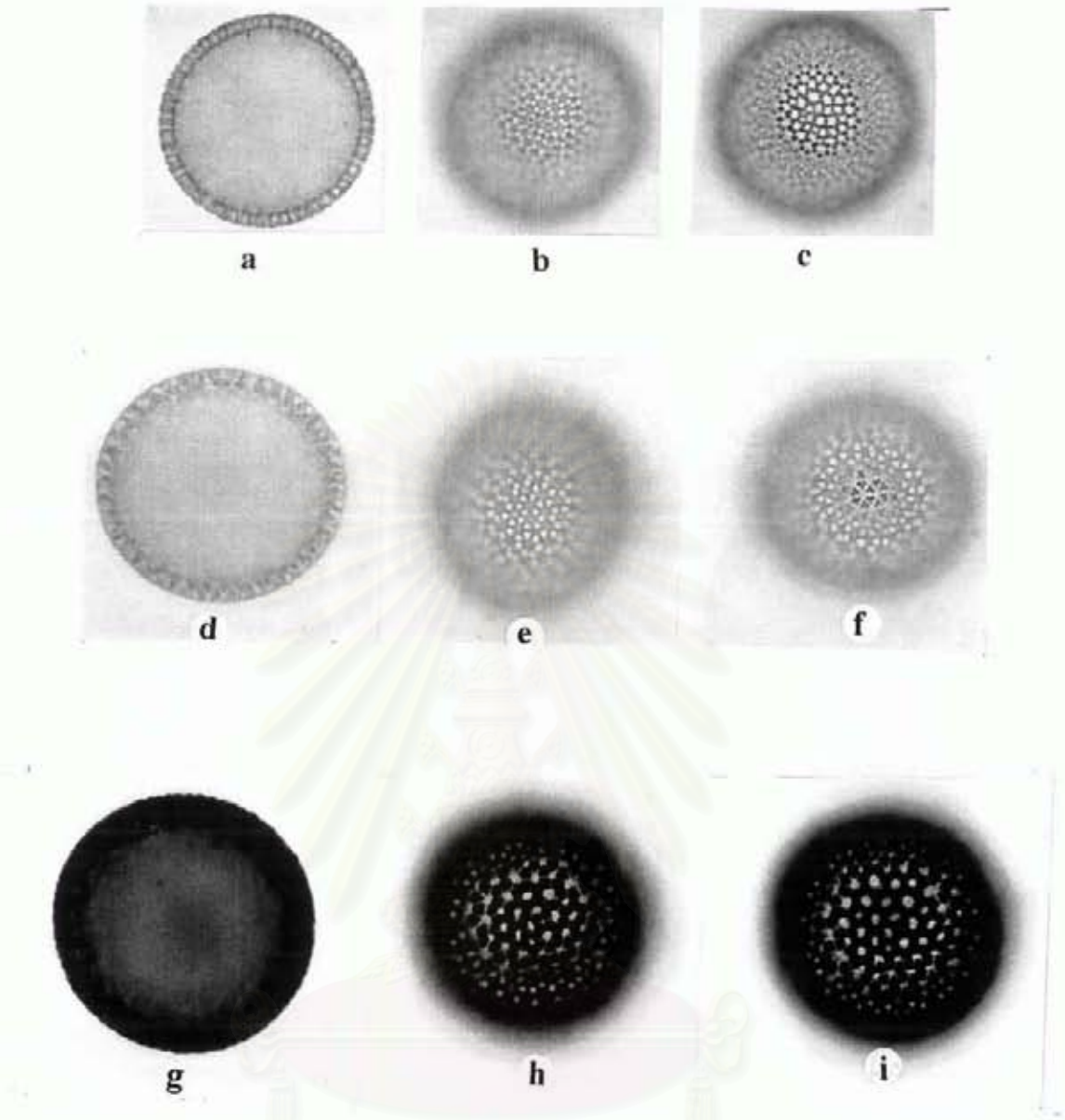


Plate 4. LM micrographs: a-c. ***Blachia siamensis*** **Gagnep.** (a) Equatorial plane of grain. (b-c) Top view of structure elements. d-f. ***Croton bonplandianus*** **Baill.** (d) Equatorial plane of grain. (e-f) Top view of structure elements. g-i. ***Baliospermum siamense*** **Craib.** (g) Equatorial plane of grain. (h-i) Top view of structure elements. All Micrographs ×875.

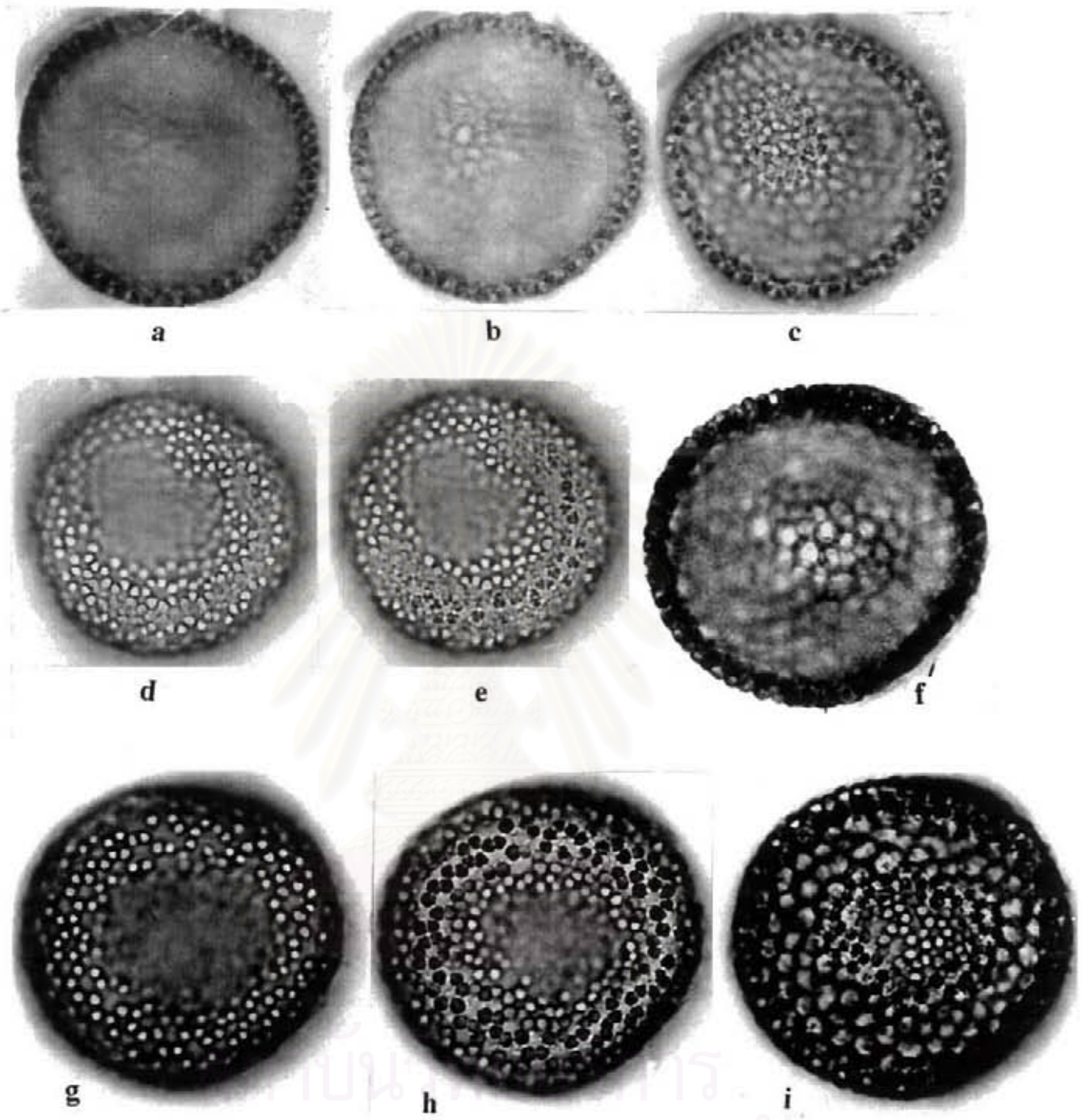


Plate 5. LM micrographs: a-e. ***Croton cascarilloides*** **Raeusch.** (a-b) Equatorial plane of grain. (d-e) Top view of structure elements. f-i. ***Croton caudatus*** **Geisel** (f) The equatorial plane of grain. (g-i) Top view of structure elements. All icrographs ×875.

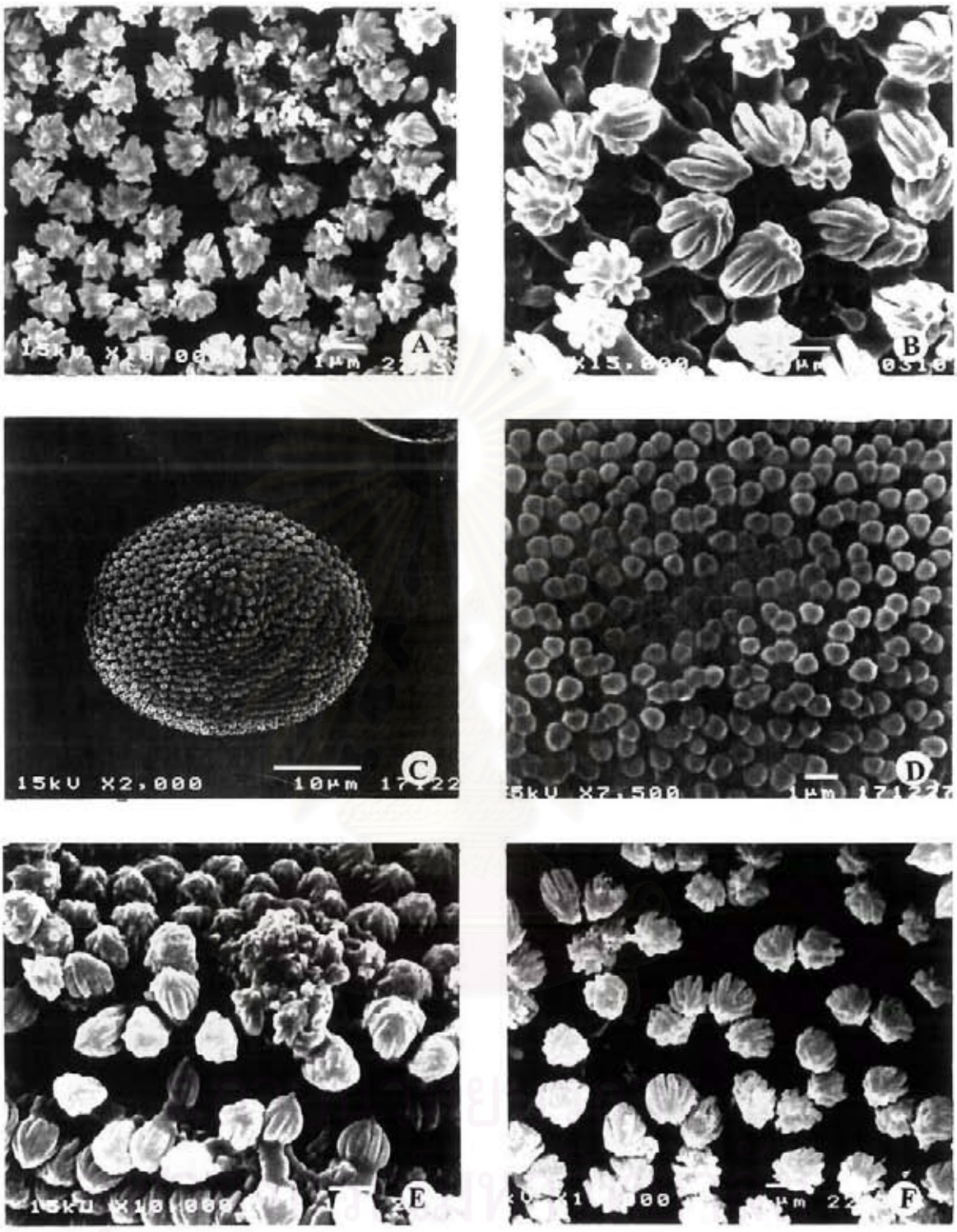


Plate 6. SEM micrographs: A ***Baliospermum effusum*** **Pax et Hoffm.** (A) Sculpturing. B. ***Baliospermum micranthum*** **Muell. Arg.** (B) Sculpturing. C-E. ***Baliospermum montanum*** **Muell. Arg.** (C) Whole grain. (D-E) Sculpturing. F. ***Baliospermum siamense*** **Craib.** (F) Sculpturing.

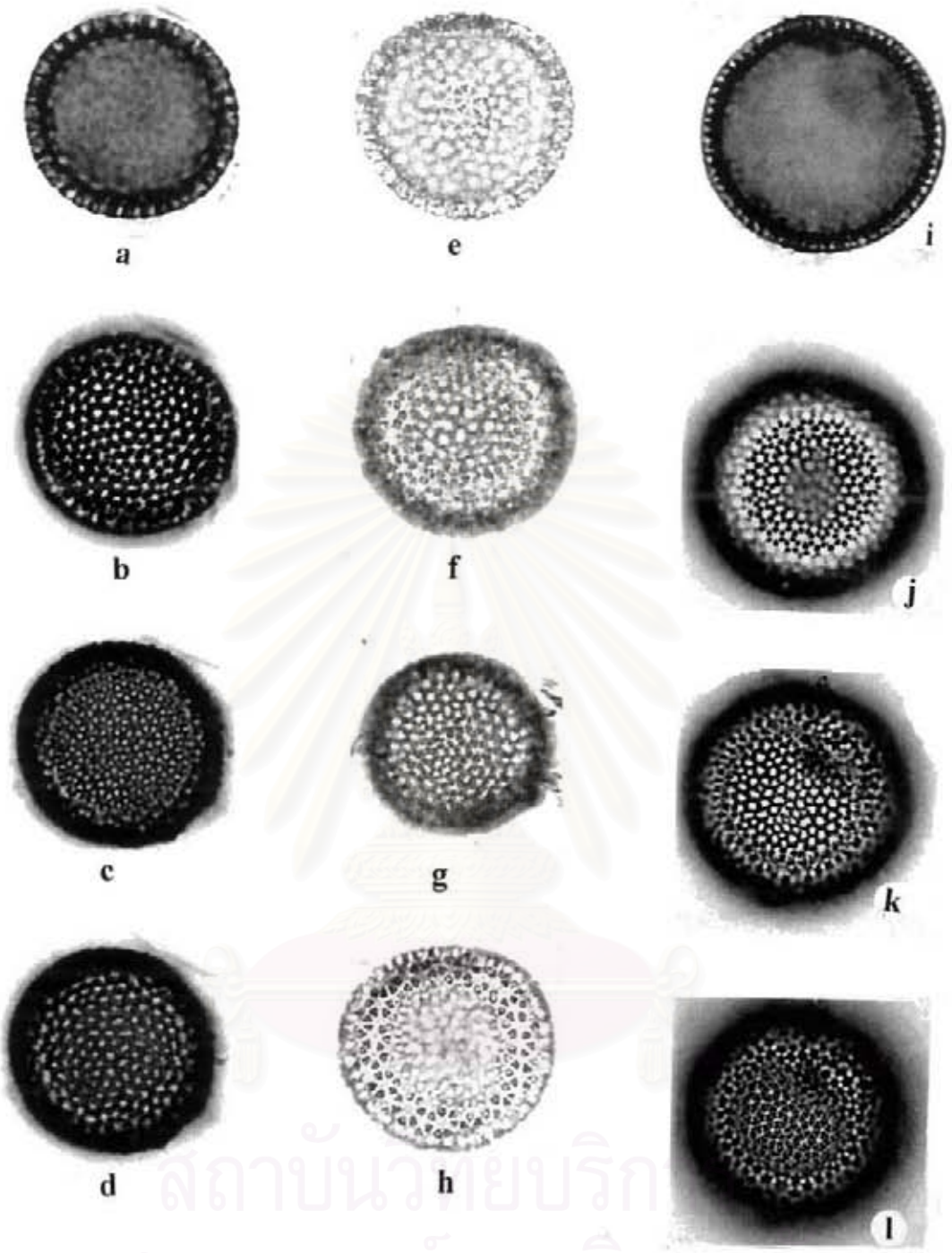


Plate 7. LM micrographs: a-d. ***Baliospermum effusum*** **Pax et Hoffm.** (a) Equatorial plane of grain. (b-d) Top view of structure elements. e-h. ***Baliospermum micranthum*** **Muell. Arg.** (e) The equatorial plane of grain. (f-h) Top view of structure elements. i-l. ***Baliospermum montanum*** **Muell. Arg.** (i) Equatorial plane of grain. (j-l) Top view of structure elements. All Micrographs ×875.

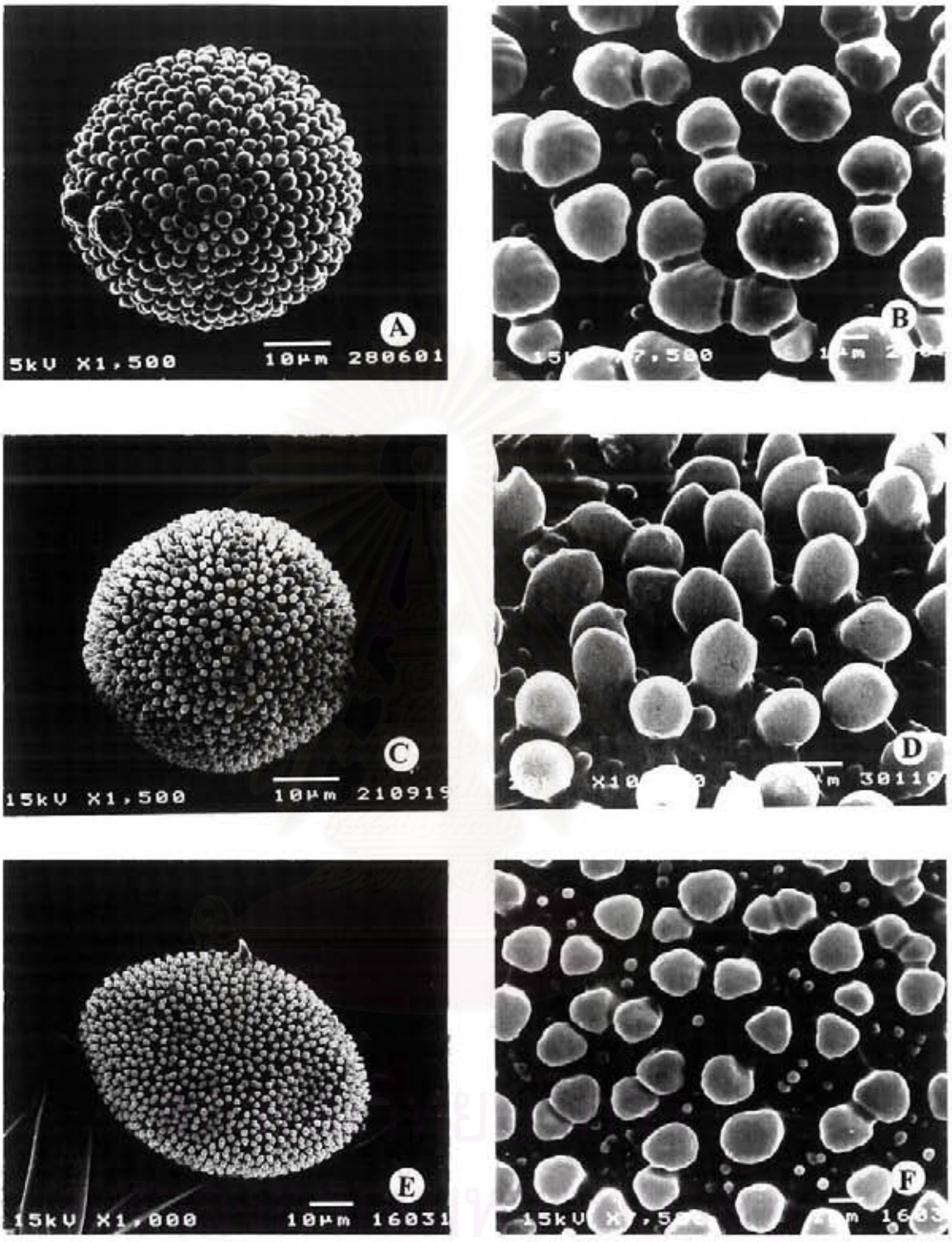


Plate 8. SEM micrographs: A-B. ***Croton hutchinsonianus* Hoss.** (A) Whole grain. (B) Sculpturing. C-D. ***Croton kerrii* Airy Shaw** (C) Whole grain. (D) Sculpturing. E-F. ***Croton poilanei* Gagnep.** (E) Whole grain. (F) Sculpturing.

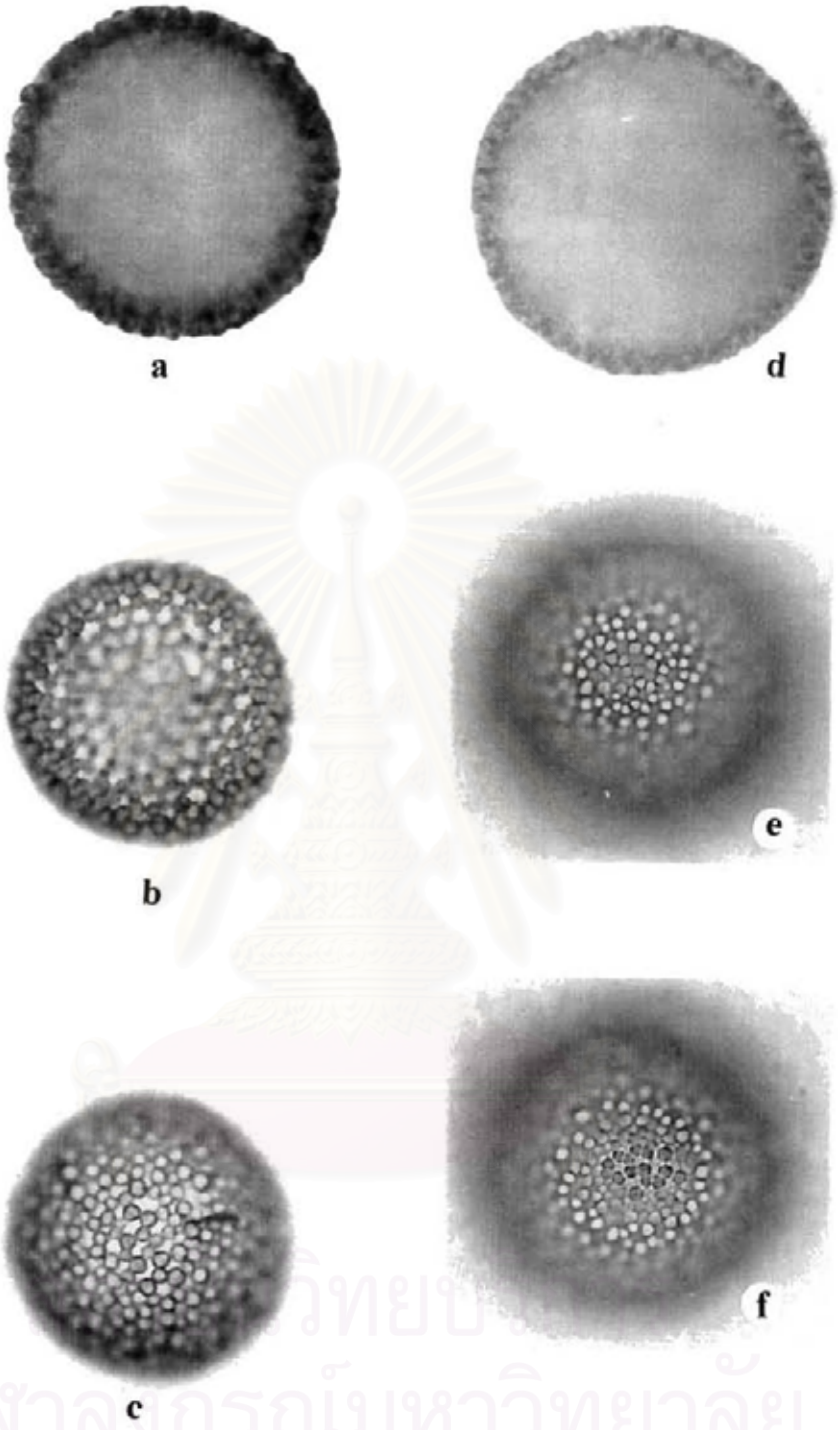


Plate 9. LM micrographs: a-c. ***Croton hutchinsonianus*** **Hoss.** (a) Equatorial plane of grain. (b-c) Top view of structure elements. d-f. ***Croton kerrii*** **Airy Shaw** (d) Equatorial plane of grain. (e-f) Top view of structure elements. All Micrographs ×875.

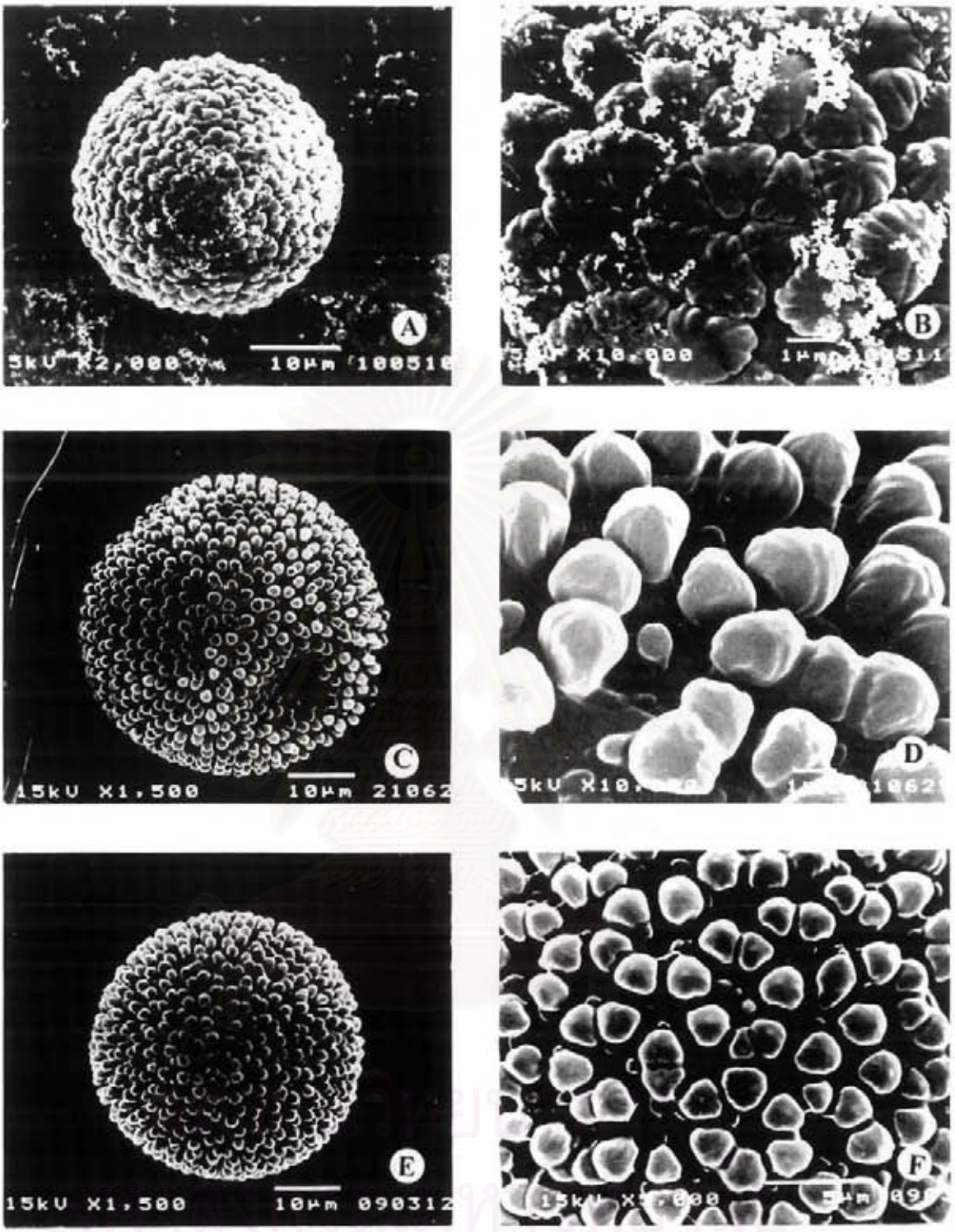


Plate 10. SEM micrographs: A-B. ***Croton tiglium* L.** (A) Whole grain. (B) Sculpturing. C-D. ***Croton robustus* Kurz** (C) Whole grain. (D) Sculpturing. E-F. ***Croton roxburghii* Black.** (E) Whole grain. (F) Sculpturing.

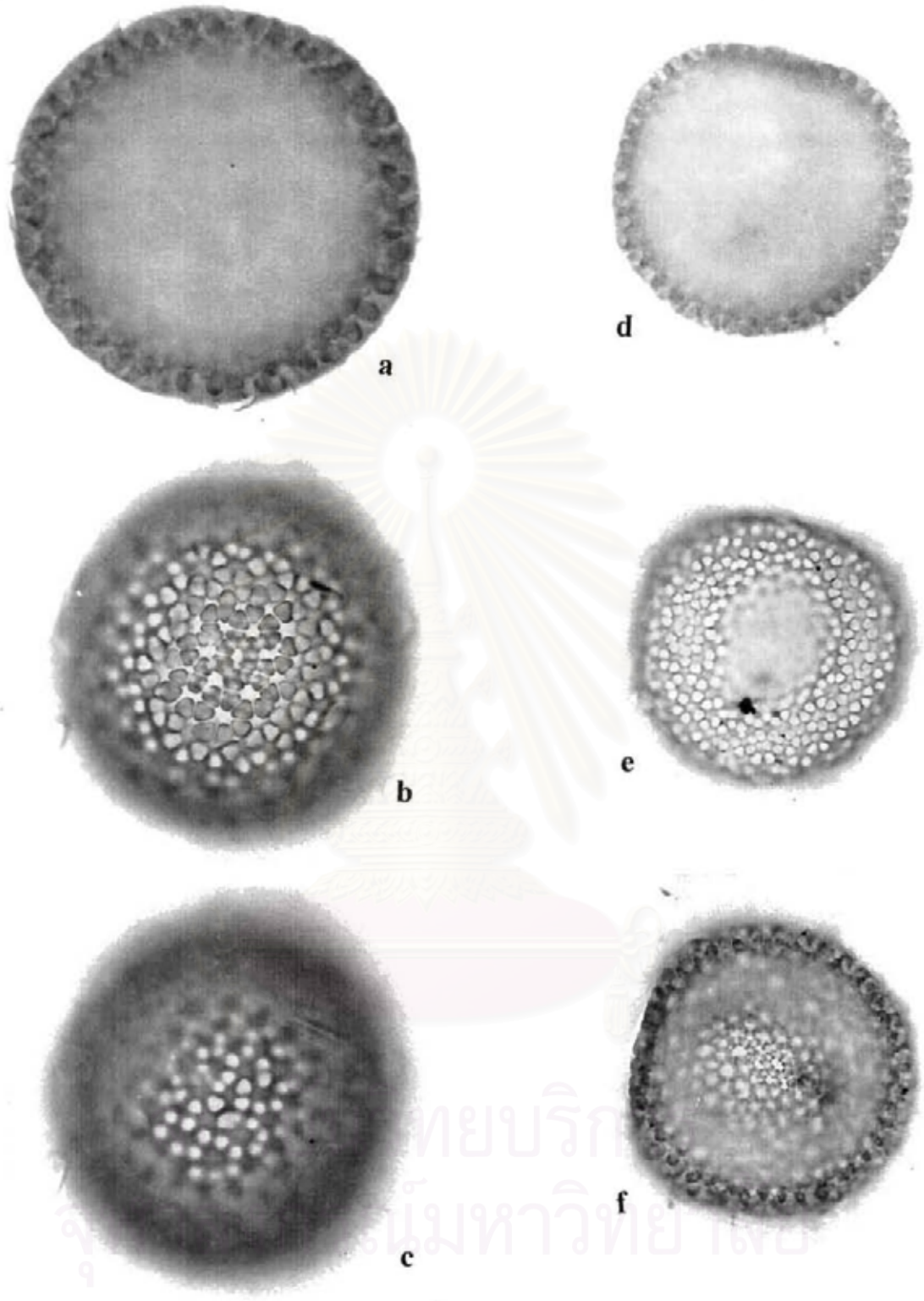


Plate 11. LM micrographs: a-c. ***Croton robustus*** **Kurz** (a) The equatorial plane of grain. (b-c) Top view of structure elements. d-f. ***Croton crassifolius*** **Geisel.** (d) Eequatorial plane of grain. (e-f) Top view of structure elements. All Micrographs × 875.

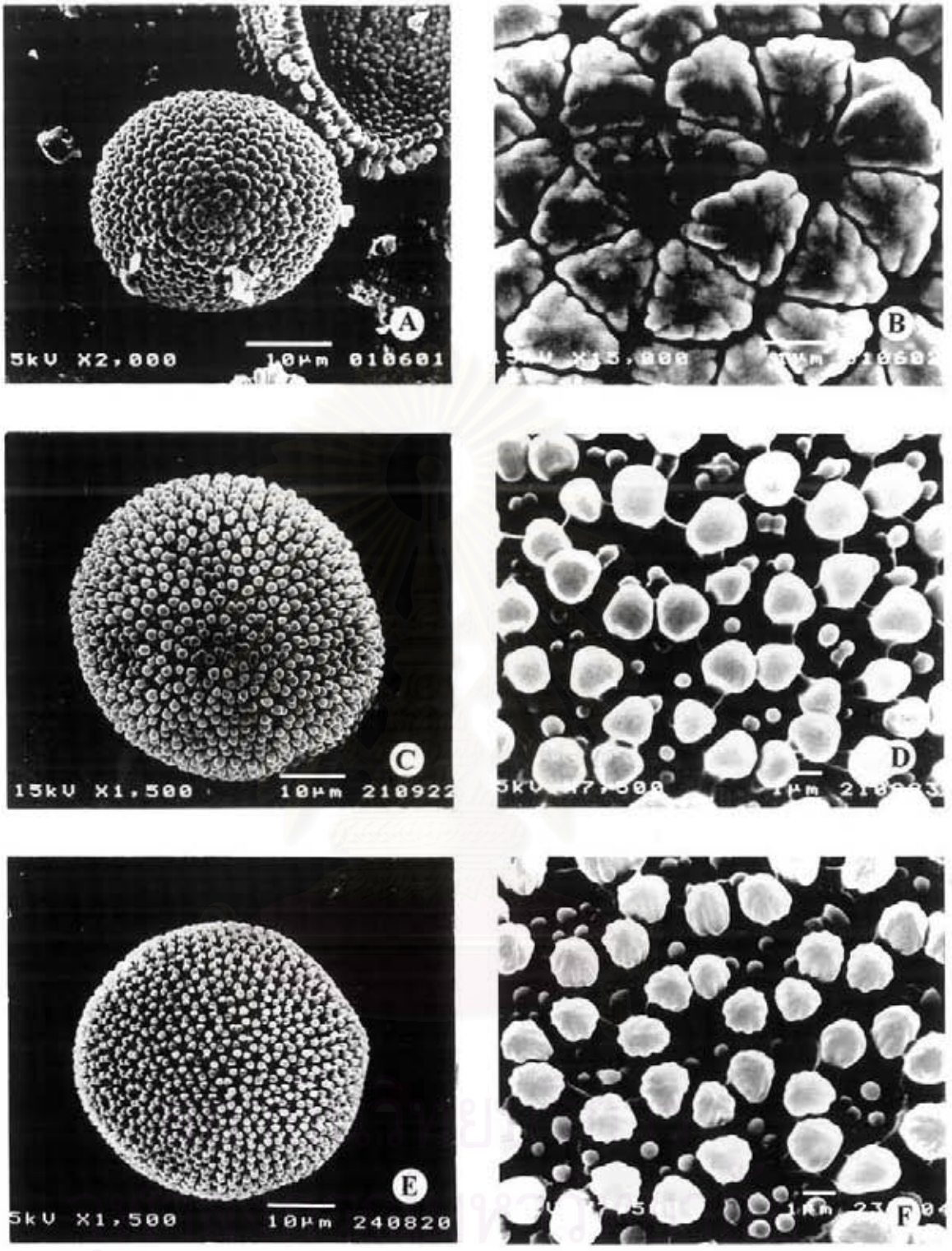


Plate 12. SEM micrographs: A-B. ***Croton sublyratus* Kurz** (A) Whole grain. (B) Sculpturing. C-D. *Croton thorelii* Gagnep. (C) Whole grain. (D) Sculpturing. E. *Croton kongensis* Gagnep. (E) Whole grain.

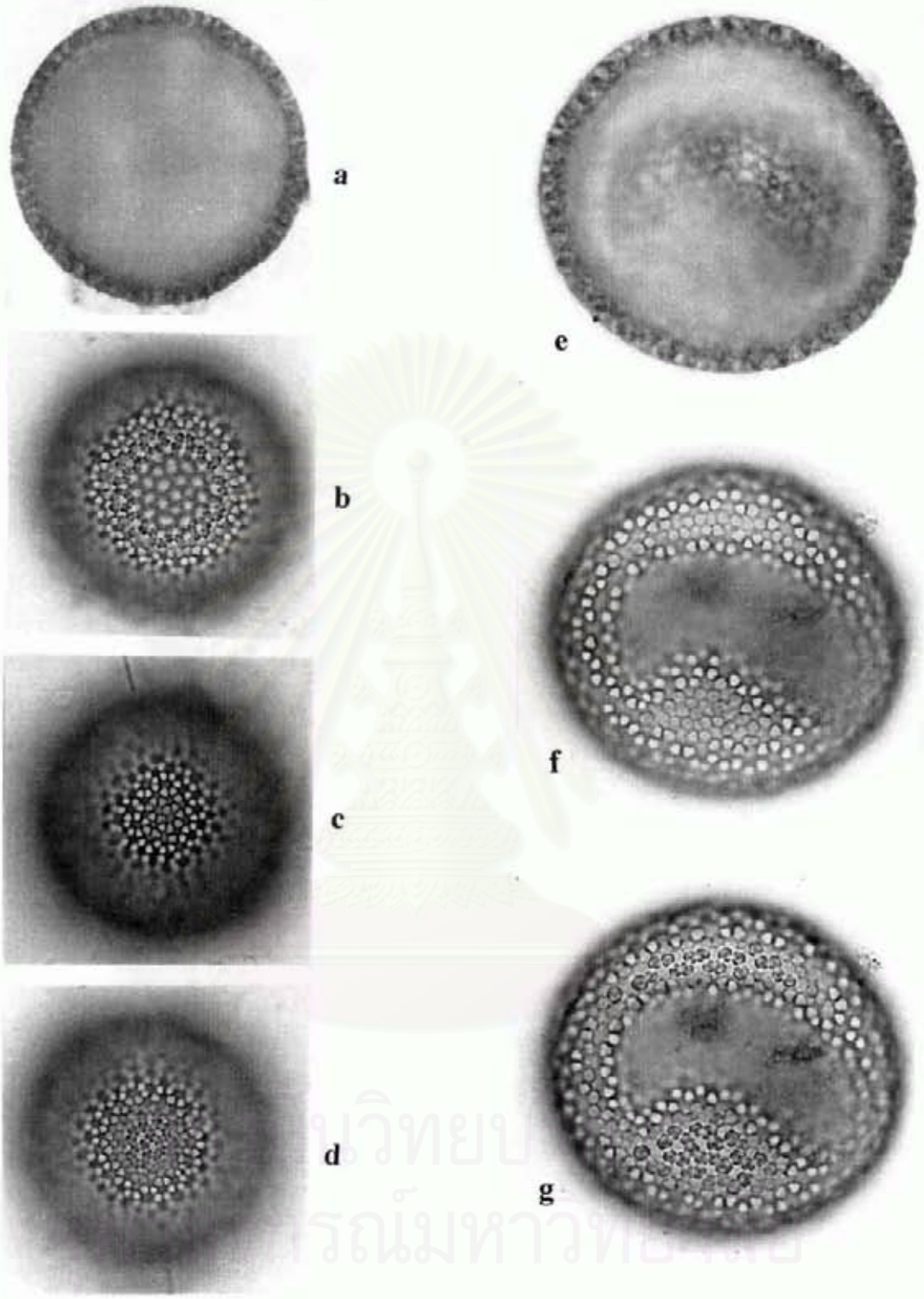


Plate 13. LM micrographs: a-d. ***Croton kongensis*** **Gagnep.** (a) Equatorial plane of grain. (b-d) Top view of structure elements. e-g. ***Croton poilanei*** **Gagnep.** (e) Equatorial plane of grain. (f-g) Top view of structure elements. All Micrographs ×875.

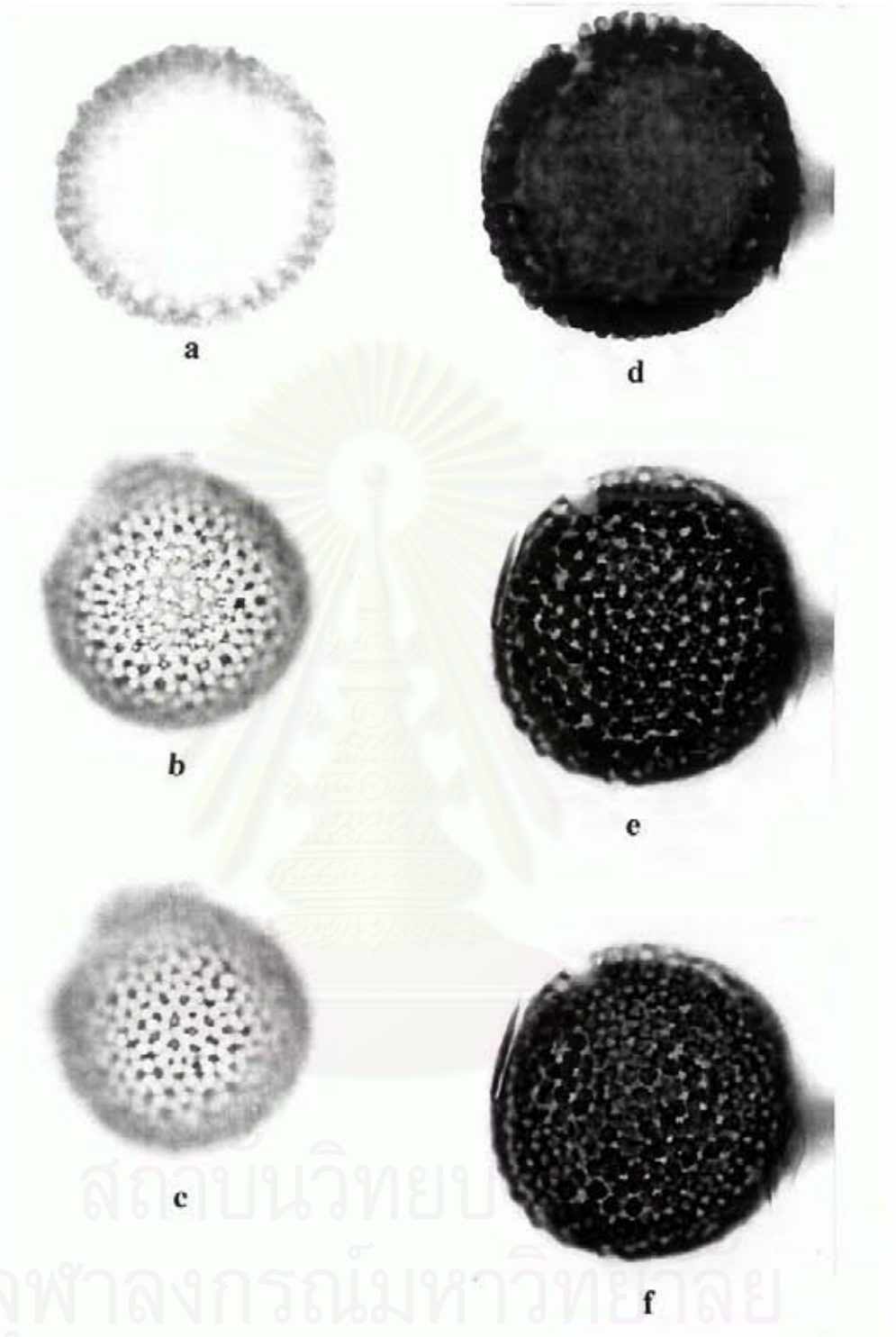


Plate 14. LM micrographs: a-c. ***Croton oblongifolius*** **Roxb.** (a) Equatorial plane of grain. (b-c) Top view of structure elements. d-f. ***Croton sublyratus*** **Kurz** (d) Equatorial plane of grain. (e-f) Top view of structure elements. All Micrographs ×875.

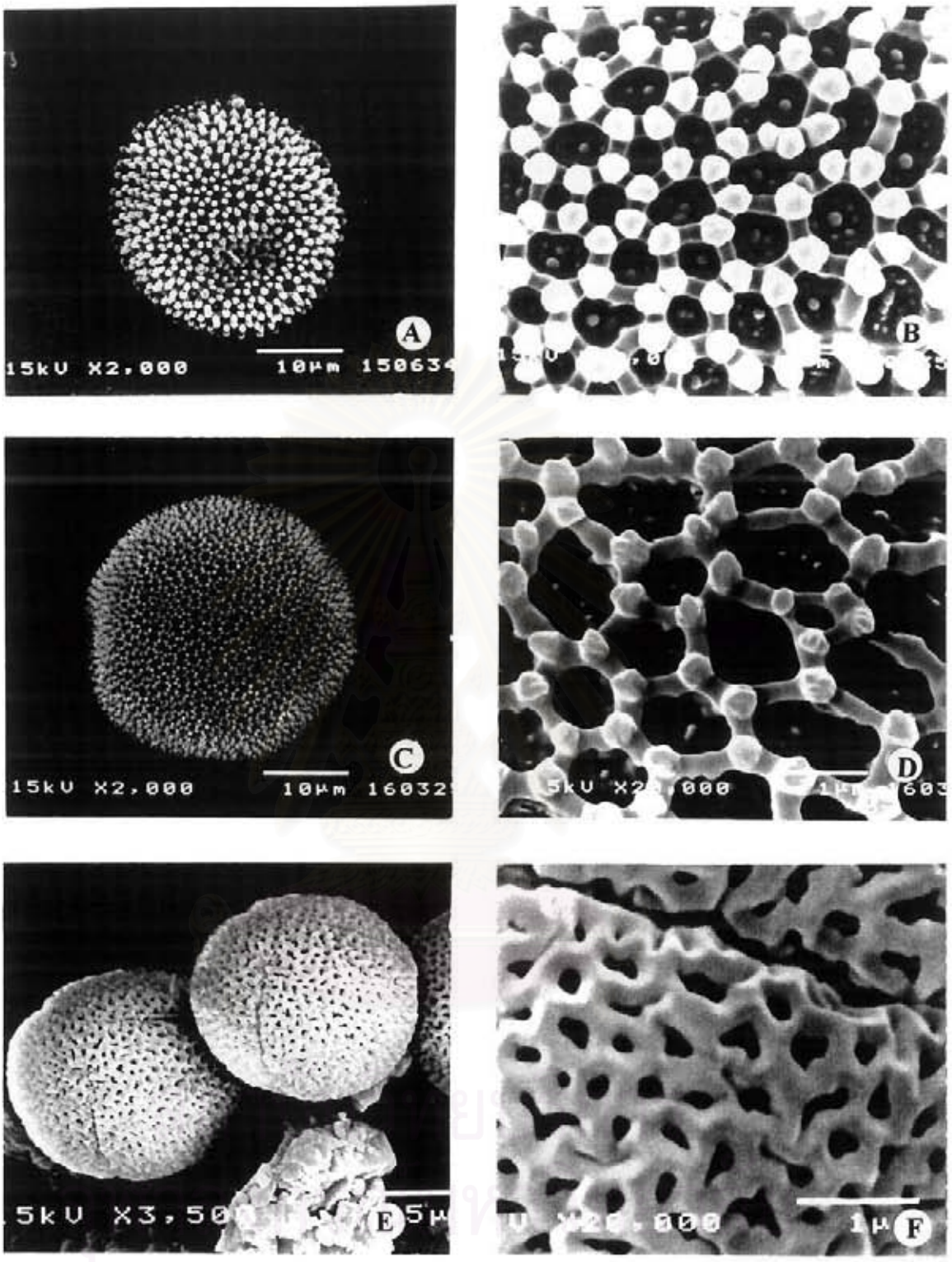


Plate 15. SEM micrographs: A-B. ***Blachia siamensis*** **Gagnep.** (A) Whole grain. (B) Sculpturing. C-D. ***Trigonostemon reidioides*** **(Kurz) Craib** (C) Whole grain. (D) Sculpturing. E-F. ***Baccaurea lanceolata*** **Muell. Arg.** (E) Equatorial view and Polar view. (F) sculpturing.

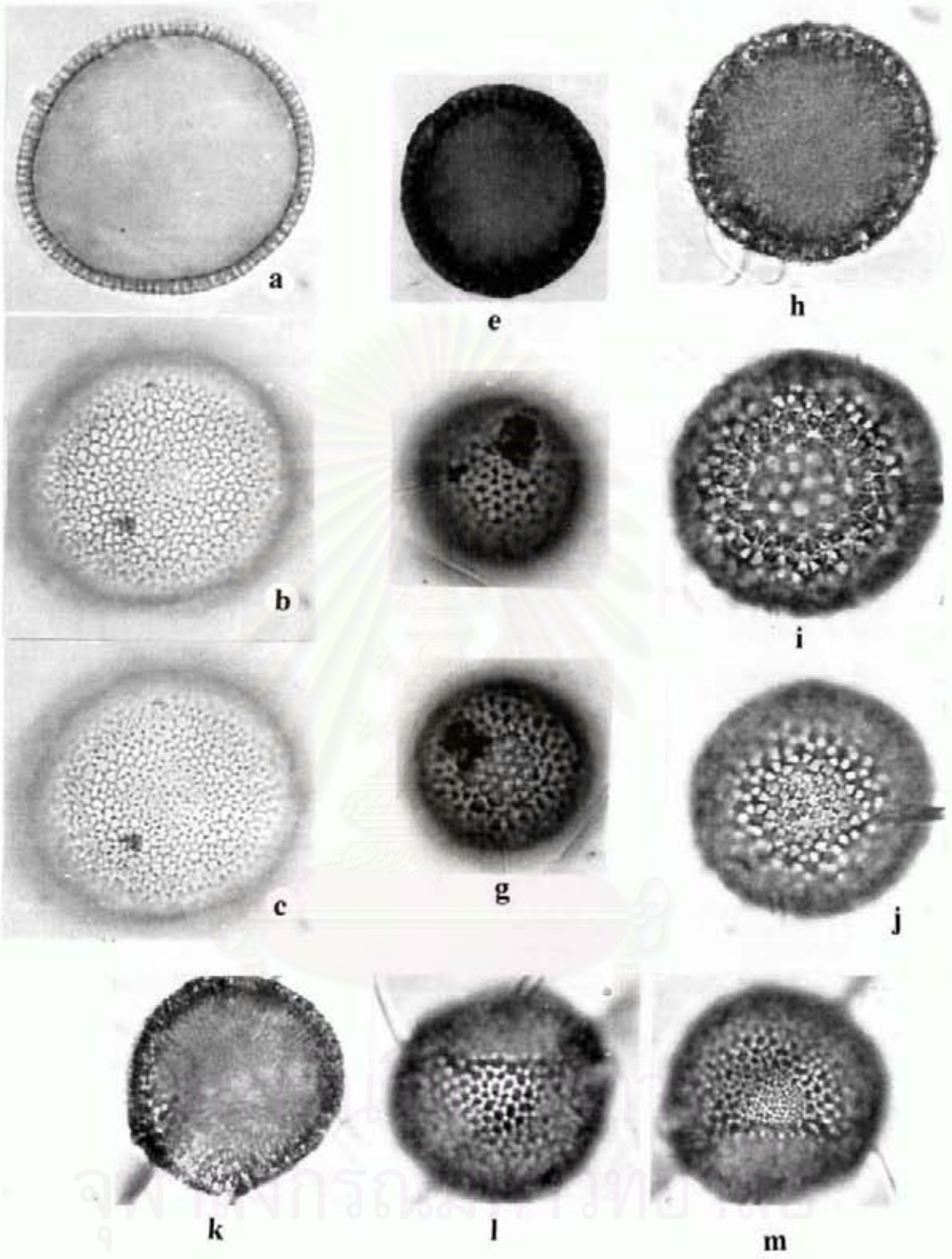


Plate 16. LM micrographs: a-c. ***Trigonostemon reidioides*** **(Kurz) Craib** (a) Equatorial plane of grain. (b-c) (A) Whole grain. (B) Sculpturing. e-g. ***Croton roxburghii*** **Black.** (e) The equatorial plane of grain. (f-g) Top view of structure elements. h-j. ***Croton tiglium*** **L.** (h) Equatorial plane of grain. (i-j) Top view of structure elements. k-m. ***Croton thorelii*** **Gagnep.** (k) Equatorial plane of grain. (l-m) Top view of structure elements. All Micrographs ×875.

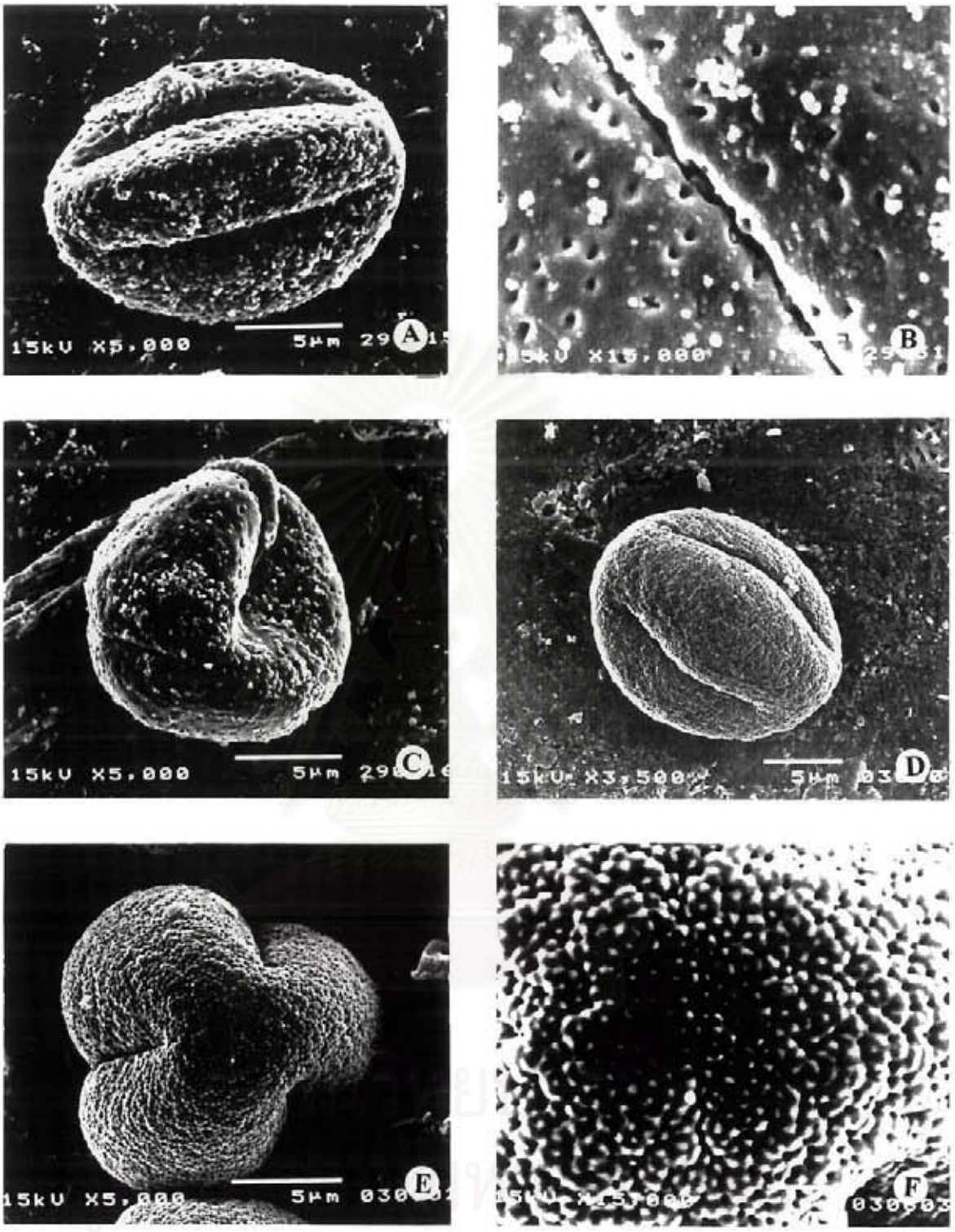


Plate 17. SEM micrographs: A-C. ***Baccaurea bracteata*** **Muell. Arg.** (A) Equatorial view. (B) Sculpturing. (C) Polar view. D-F. ***Cleidion spiciflorum*** **(Burm. f.) Merr.** (D) Equatorial view. (E) Polar view. (F) Sculpturing.

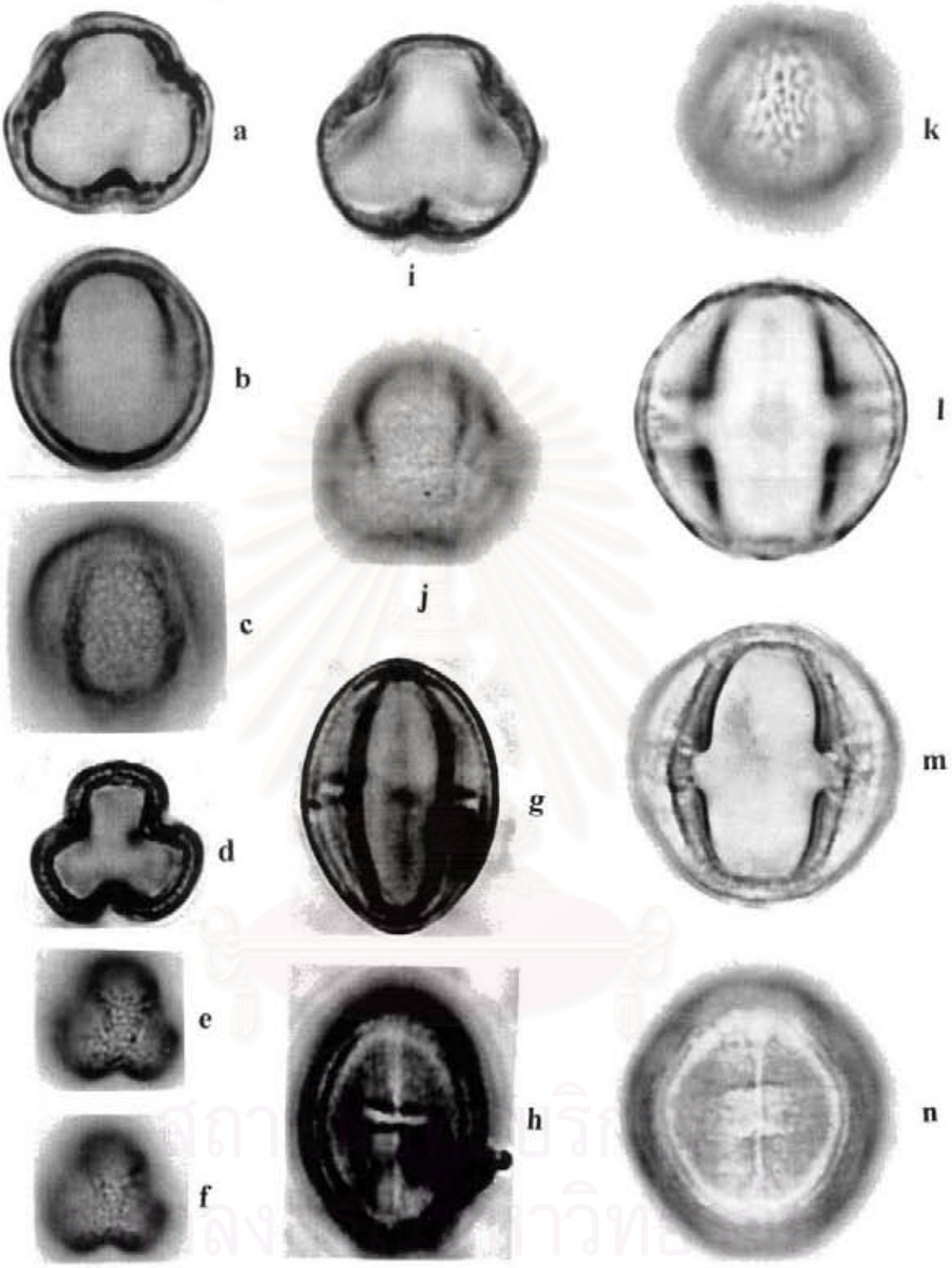


Plate 18. LM micrographs: a-c. ***Baccaurea bracteata*** **Muell. Arg.** (a) Polar view. (b) Equatorial view. (c) Sculpturing. d-h. ***Baccaurea ramiflora*** **Lour.** (d) Polar view. (e-f) Sculpturing. (g-h) Equatorial view. i-n. ***Cleidion spiciflorum*** **(Burm. f.) Merr.** (i-k) Polar view. (l-n) Equatorial view. All Micrographs ×1,750.

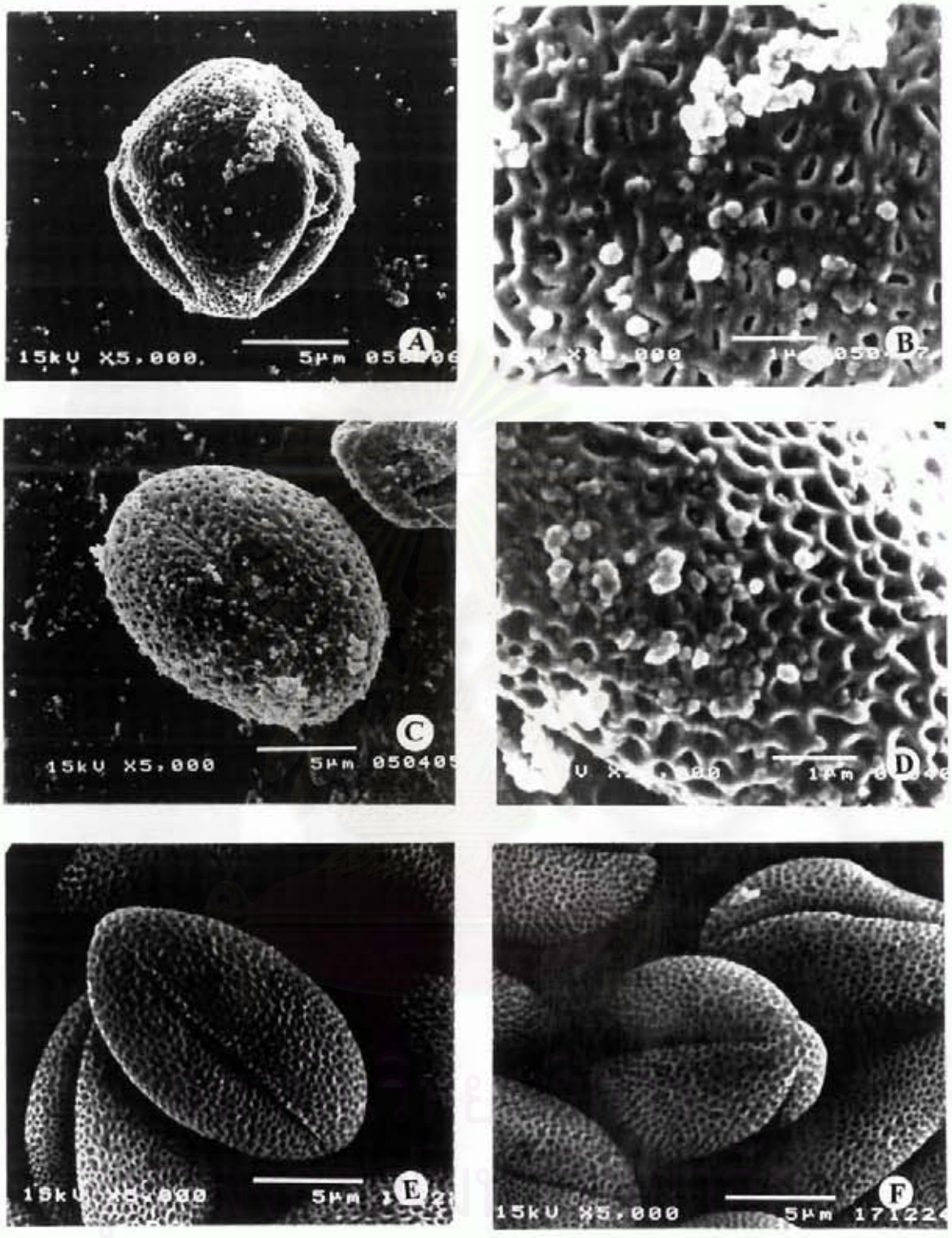


Plate 19. SEM micrographs: A-B. ***Baccaurea kunstleri*** **King ex Gage** (a) Polar view. (b) Equatorial view. (c) Sculpturing. C-D. ***Baccaurea motleyana*** **(Muell. Arg.) Muell. Arg.** (C) Equatorial view. (D) Sculpturing. E-F. ***Baccaurea ramiflora*** **Lour.** (E) Polar view. (F) Equatorial view.

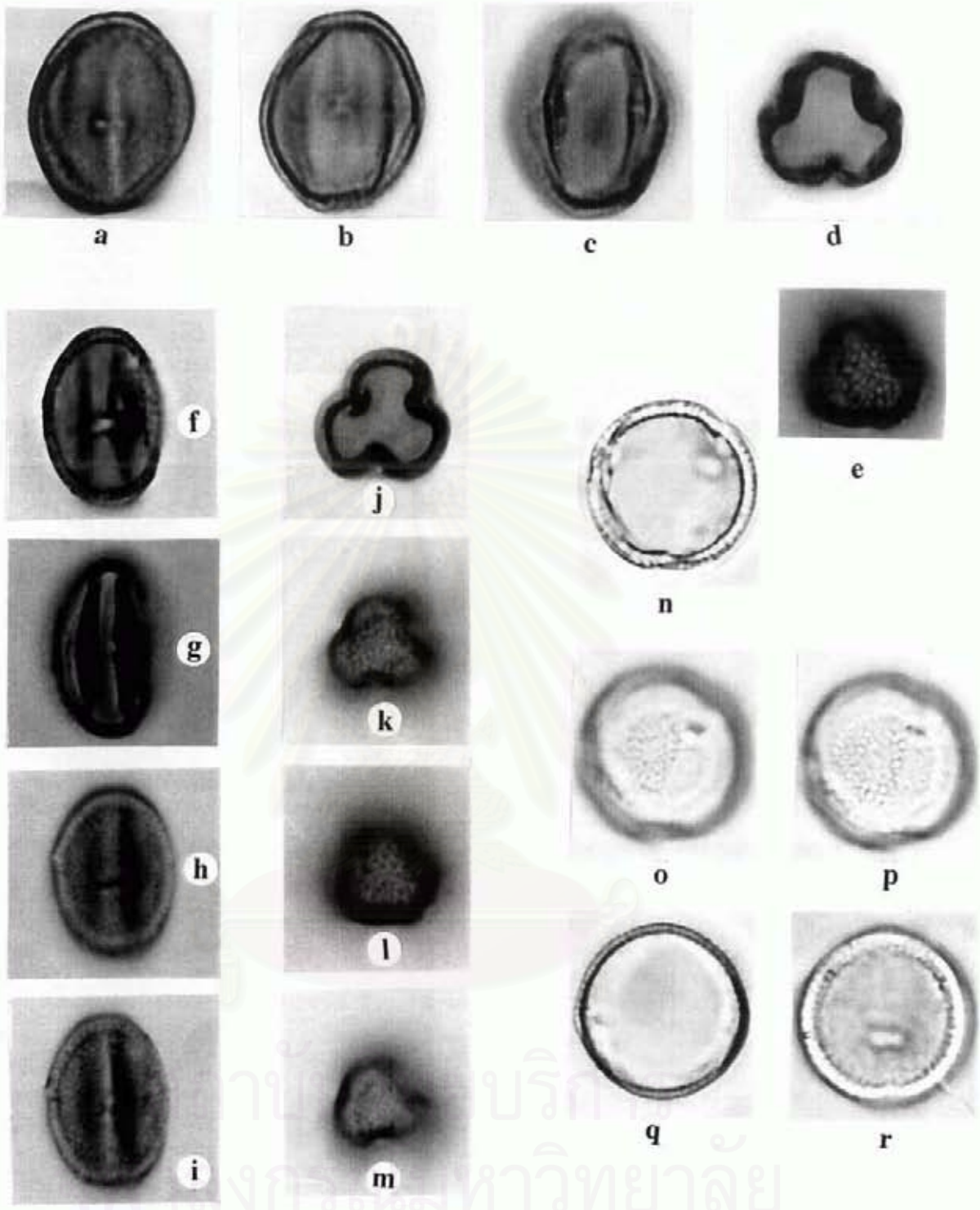


Plate 20. LM micrographs: a-e. ***Baccaurea kunstleri*** **King ex Gage.** (a-c) Equatorial view. (c) Polar view. (e) Sculpturing. f-m. ***Baccaurea motleyana*** **(Muell. Arg.) Muell. Arg.** (f-i) Equatorial view. (j) Polar view. (k-m) Sculpturing. n-r. ***Baccaurea lanceolata*** **Muell. Arg.** (n) Polar view oblique. (o-p) Sculpturing. (q-r) Equatorial view. All Micrographs ×1,750.

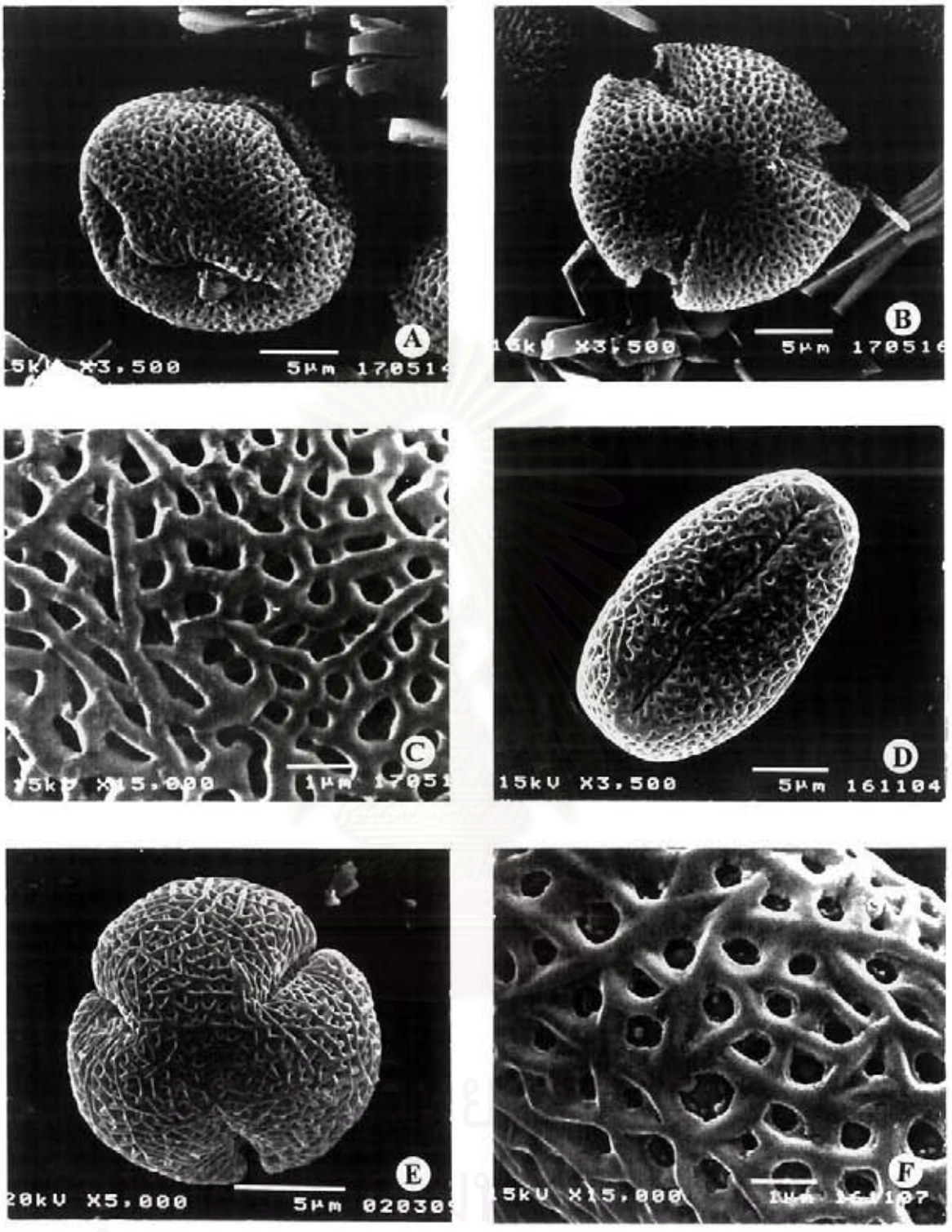


Plate 21. SEM micrographs: A-C. ***Bridelia harmandii*** **Gagnep.** (A) Equatorial view. (B) Polar view. (C) Sculpturing. D-F. ***Bridelia ovata*** **Decne** (D) Equatorial view. (E) Polar view. (F) Sculpturing.

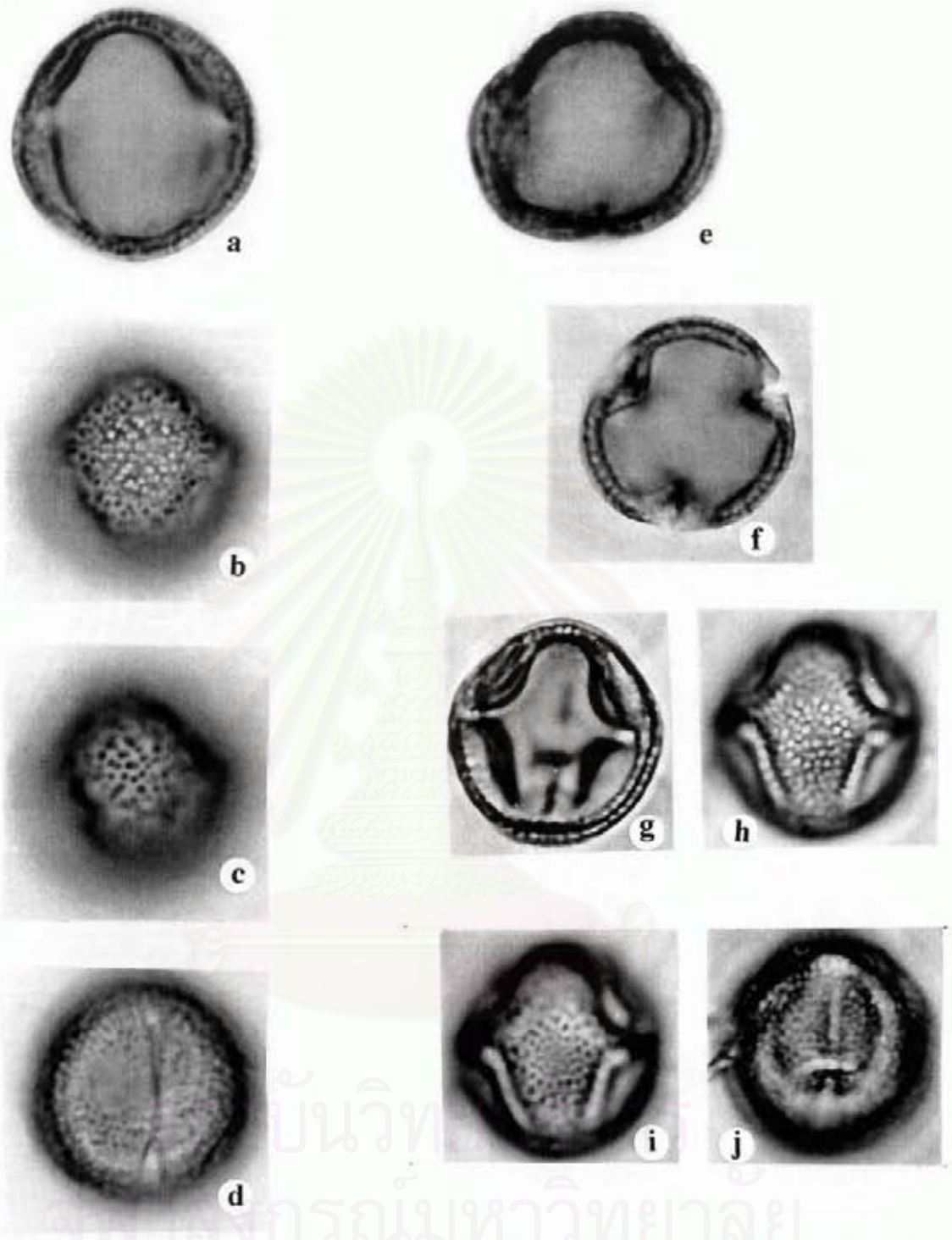


Plate 22. LM micrographs: a-e. ***Bridelia harmandii*** **Gagnep.** (a,d) Equatorial view. (b) Sculpturing.(e-) Polar view. f-j. ***Bridelia ovata*** **Decne** (f) Polar view. (g-j) Equatorial view. All Micrographs ×1,750.

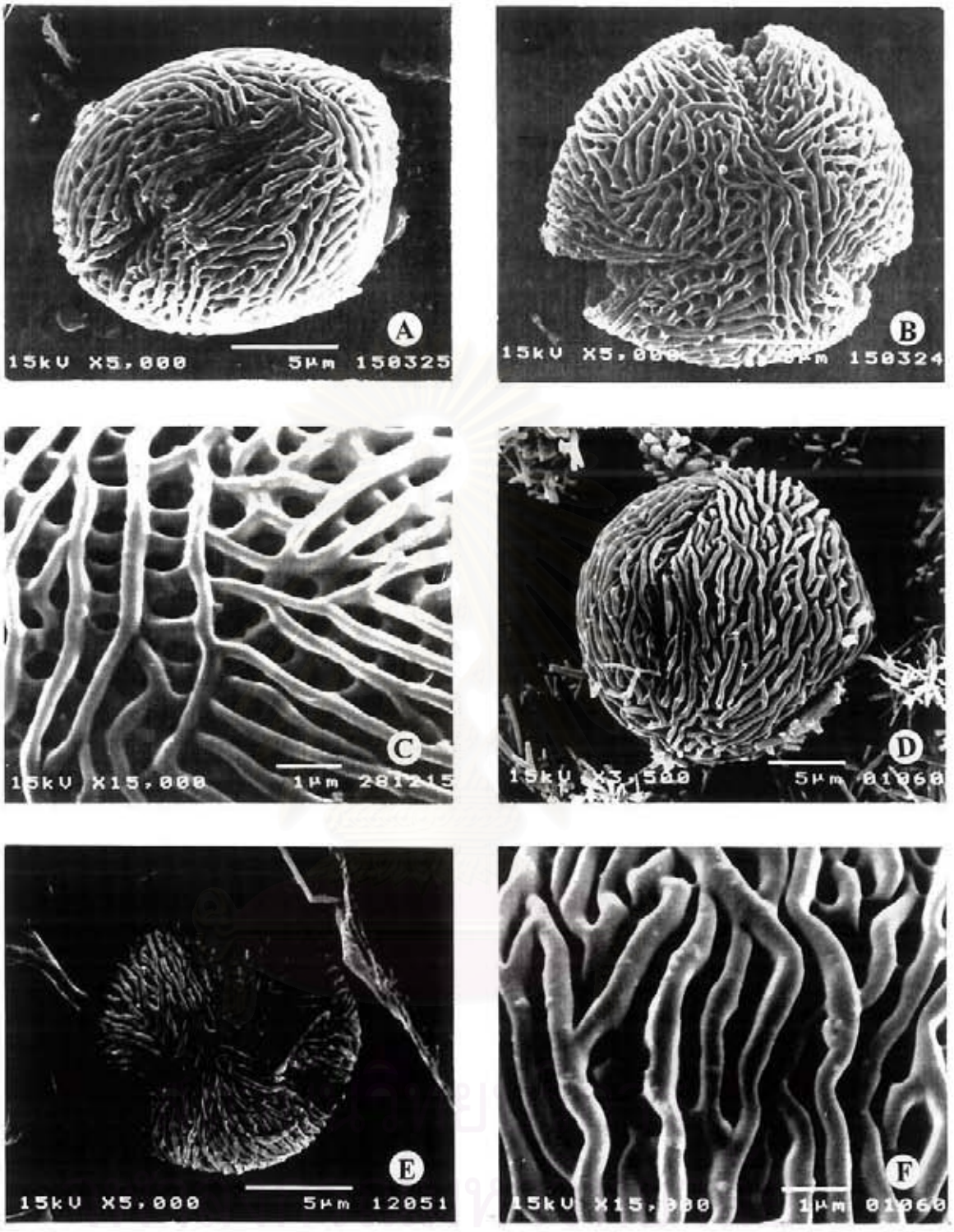


Plate 23. SEM micrographs: A-C. ***Bridelia tomentosa*** **Bl.** (A) Equatorial view. (B) Polar view. (C) Sculpturing. D-F. ***Bridelia stipularis*** **(L.) Bl.** (D) Equatorial view. (E) Polar view. (F) Sculpturing.

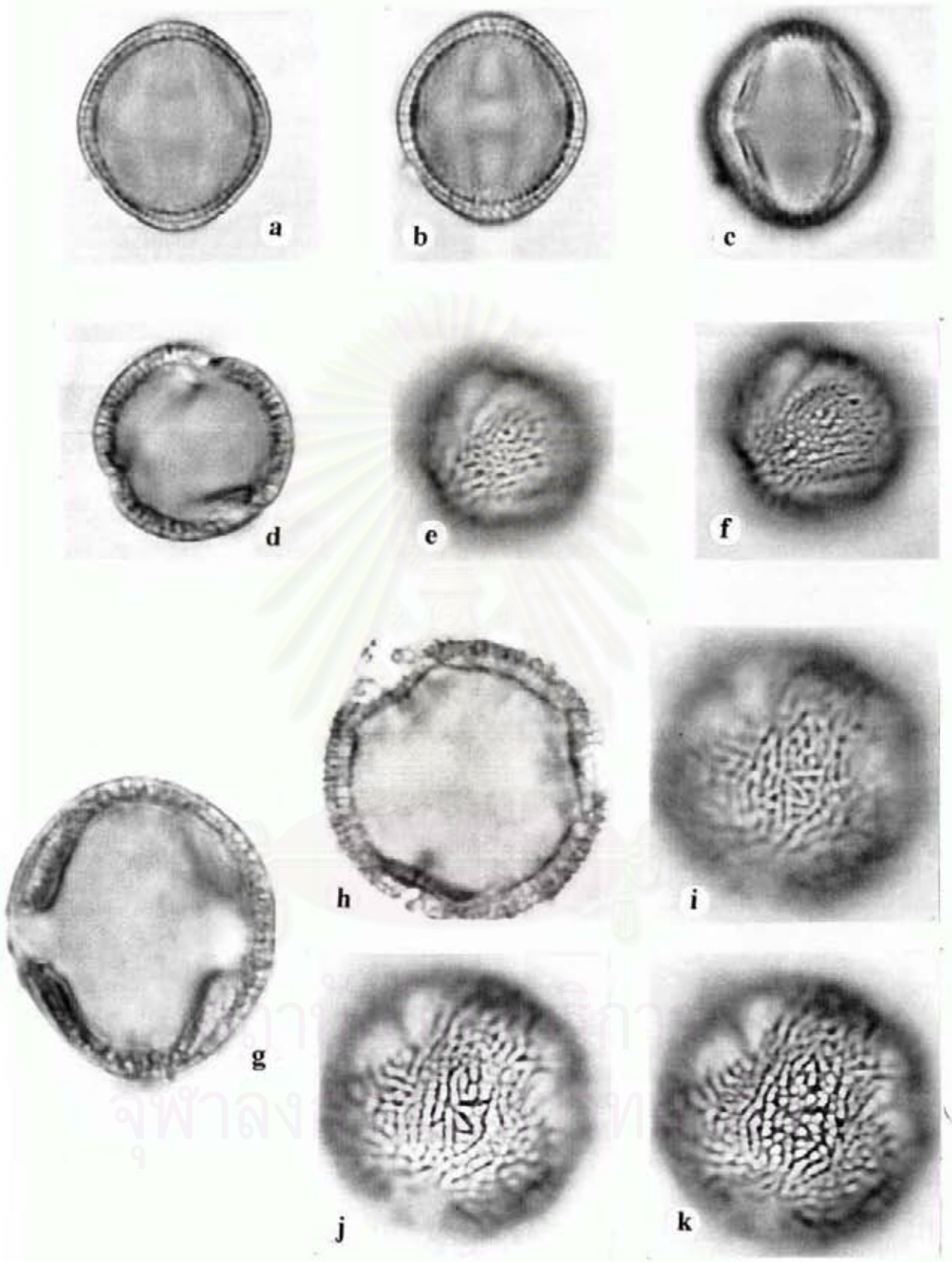


Plate 24. LM micrographs: a-f. ***Bridelia tomentosa*** **Bl.** (a-c) Equatorial view. (d) Polar view. (e-f) Sculpturing. g-k. ***Bridelia stipularis (L.)*** **Bl.** (g) Equatorial view. (h) Polar view. (i-k) Sculpturing. All Micrographs x1,750.

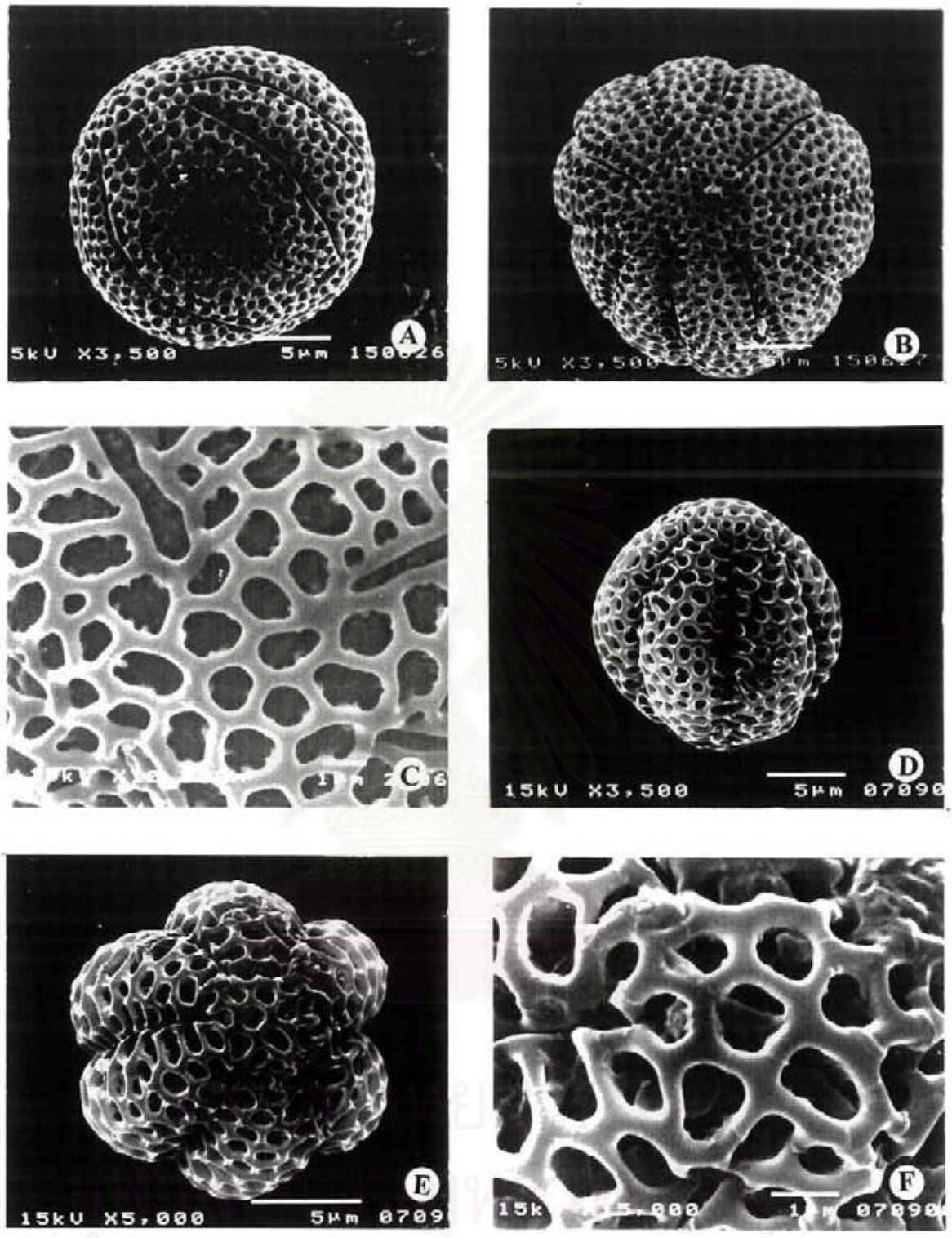


Plate 25. SEM micrographs: A-C. ***Breynia glauca*** **Craib** (A) Equatorial view. (B) Polar view. (C) Sculpturing. D-F. ***Breynia vitis-idaea*** **Fischer** (D) Equatorial view. (E) Polar view. (F) Sculpturing.

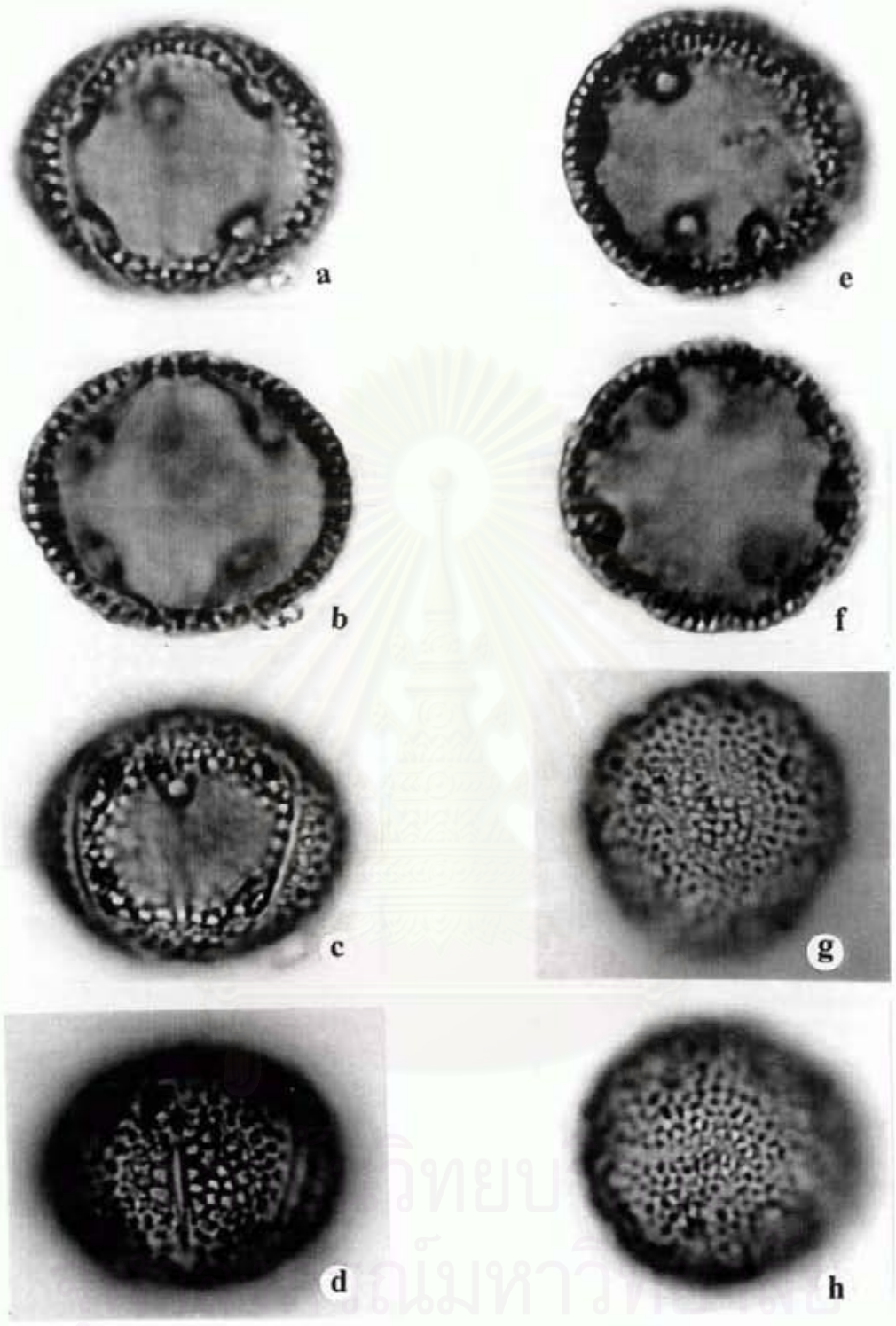


Plate 26. LM micrographs: a-h. ***Breynia glauca*** **Craib** (a-d) Equatorial view. (e-f) Polar view. (g-h) Sculpturing. All Micrographs x1,750.

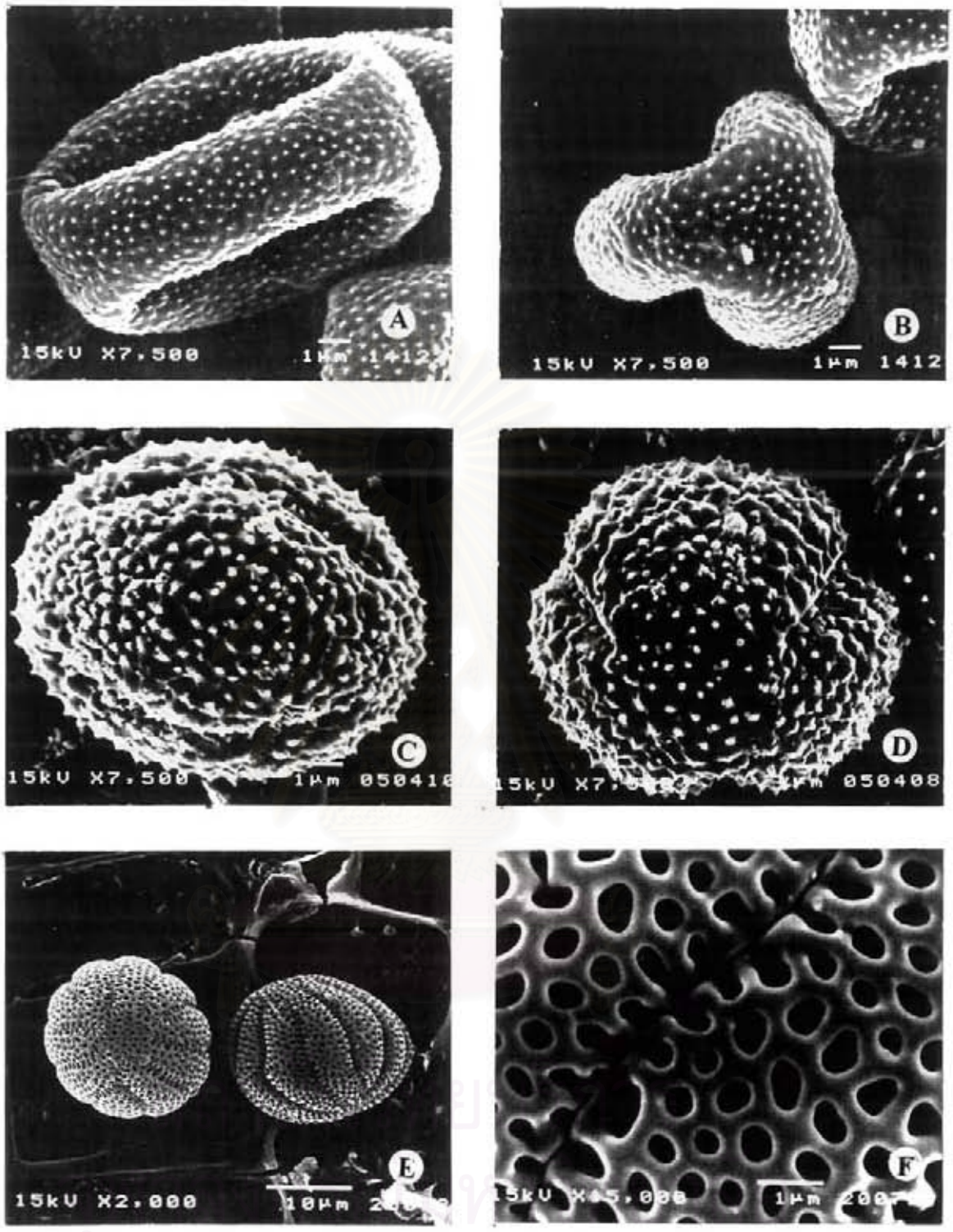


Plate 27. SEM micrographs: A-C. ***Macaranga heynei* I. M. Johnston** (A) Equatorial view. (B) Polar view. C-D. ***Macaranga indica* Wight** (C) Equatorial view. (D) Polar view. E-F. ***Breynia fruticosa* Craib** (E) Equatorial view and Polar view. (F) Detail of exine sculpturing on mesocolpium.

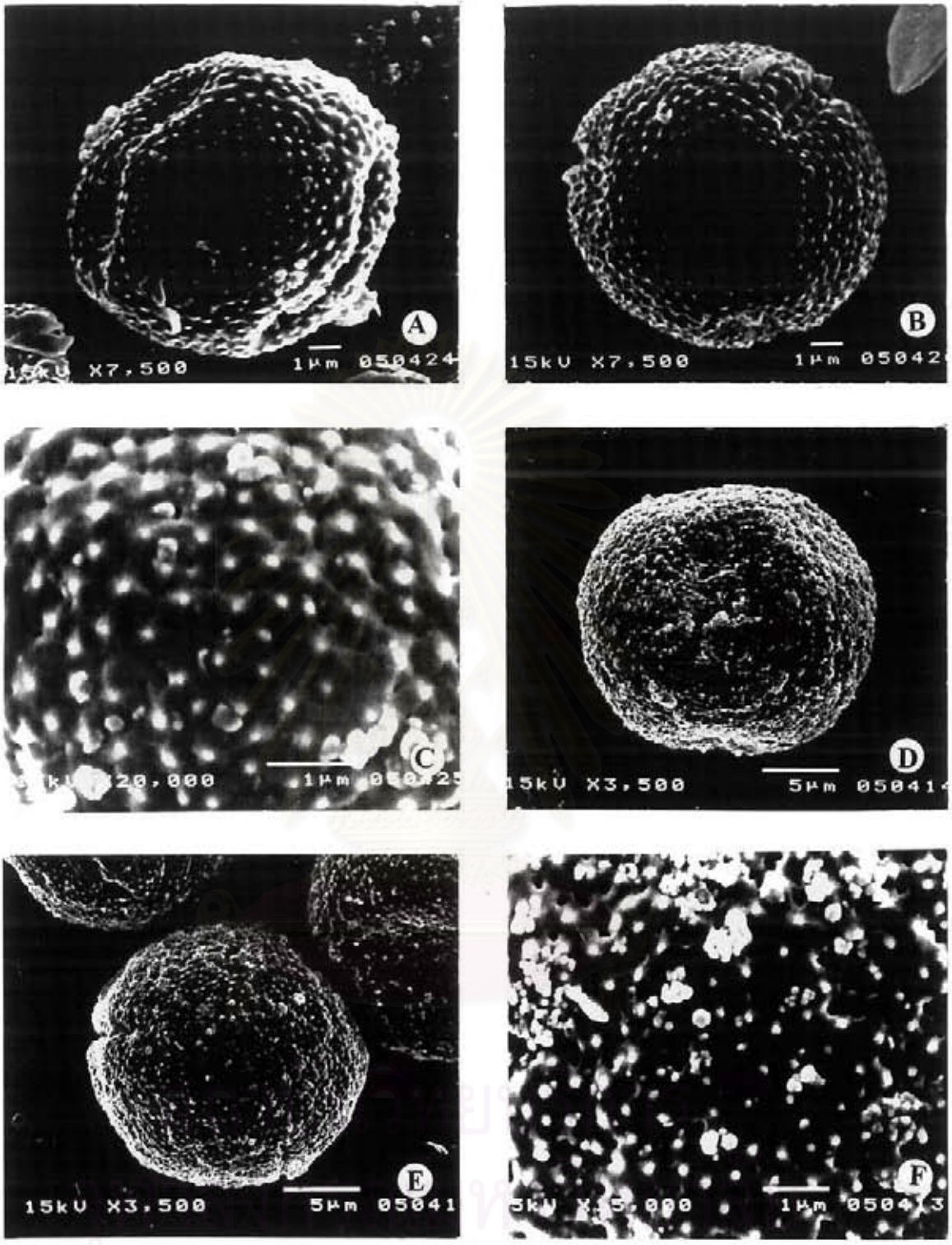


Plate 28. SEM micrographs: A-C. ***Macaranga pruinosa*** **(Miq.) Muell. Arg.** (A) Equatorial view. (B) Polar view. (C) Sculpturing. D-F. ***Macaranga kurzii*** **(Kuntze) Pax et Hoffm.** (D) Equatorial view. (E) Polar view. (F) Sculpturing.

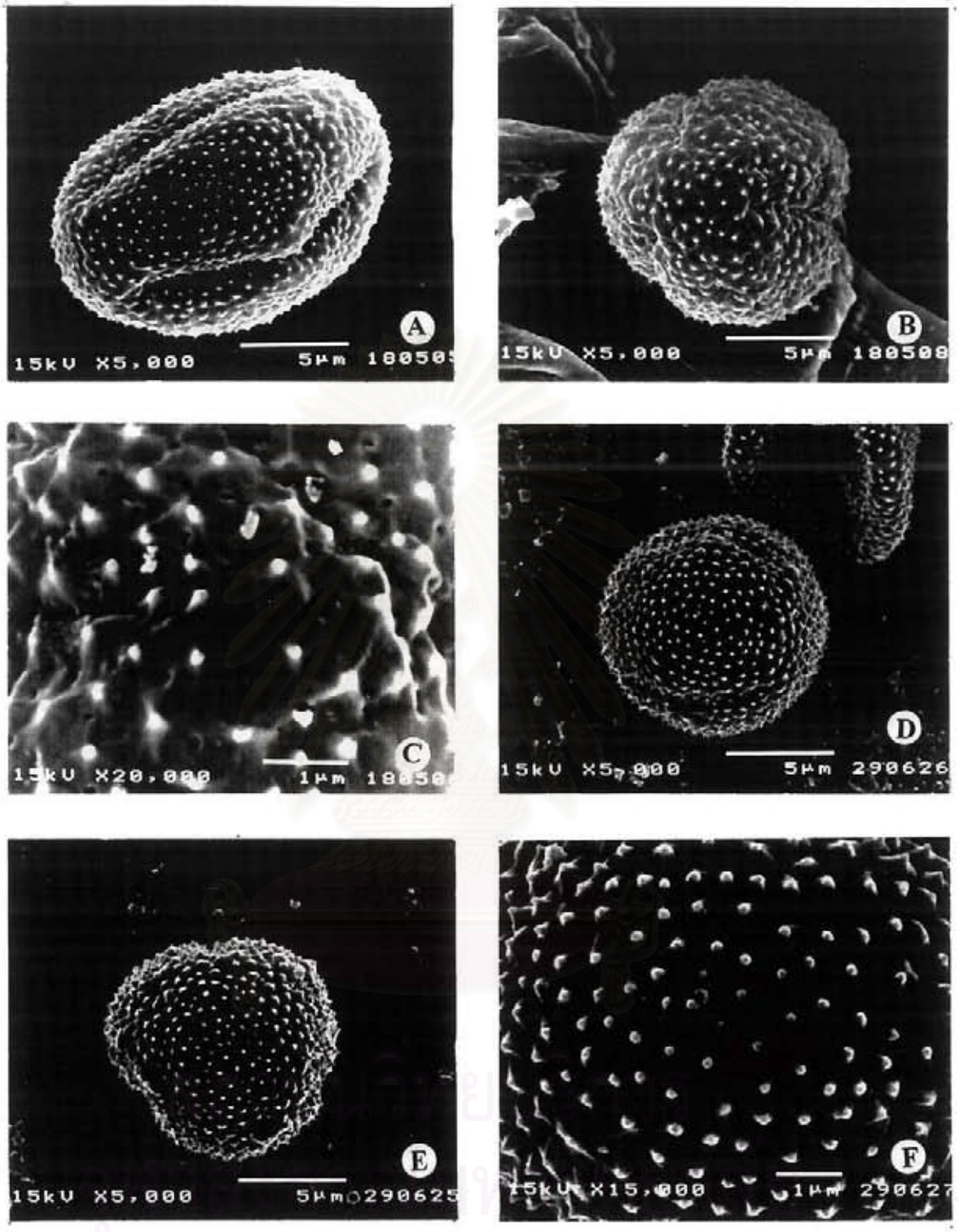


Plate 29. SEM micrographs: A-C. ***Macaranga denticulata*** **(Bl.) Muell. Arg.** (A) Equatorial view. (B) Polar view. (C) Sculpturing. D-F. ***Macaranga tanarius*** **(L.) Muell. Arg.** (D) Equatorial view. (E) Polar view. (F) Sculpturing

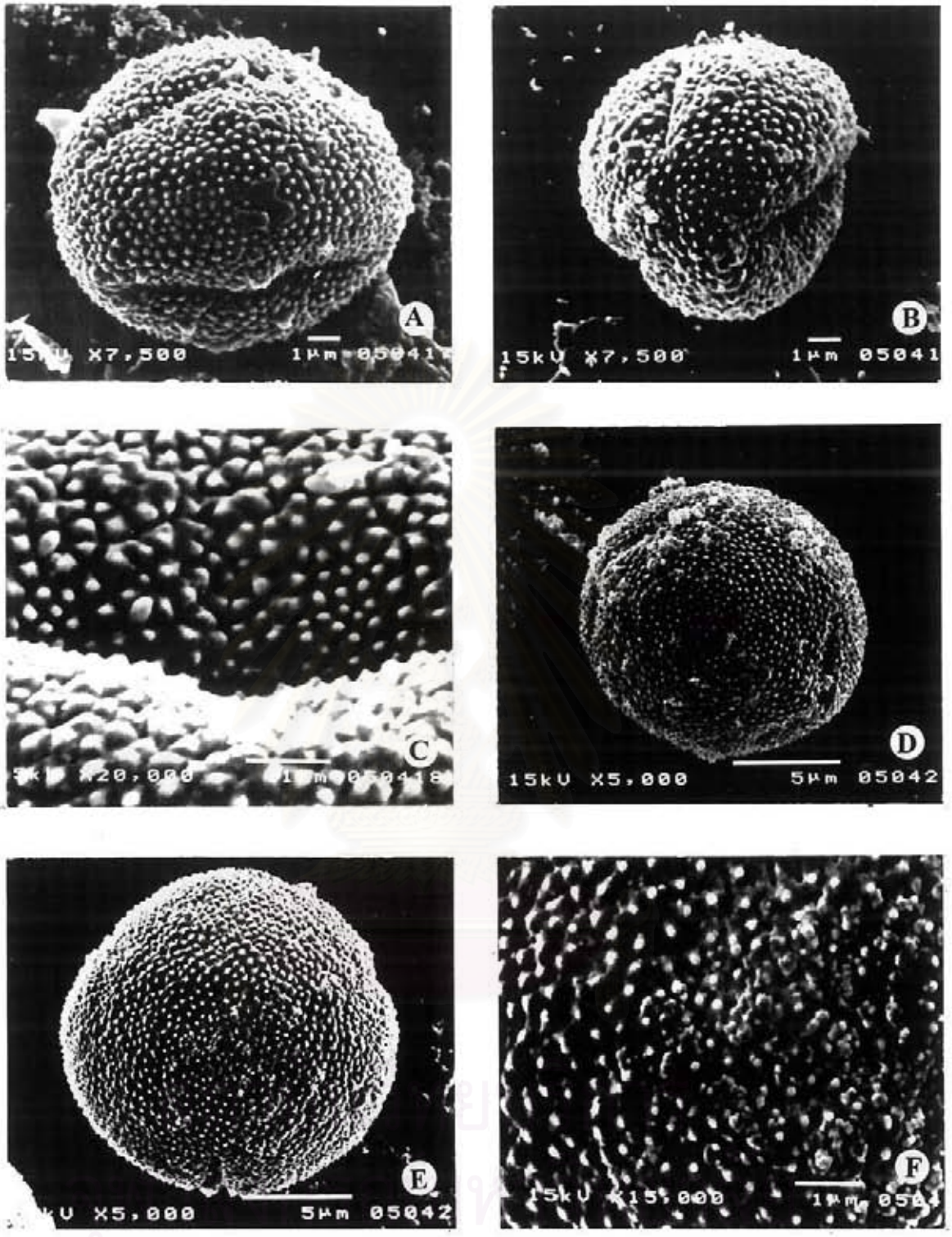


Plate 30. SEM micrographs: A-C. ***Macaranga laciniata*** **Whitm.et. Airy Shaw** (A) Equatorial view. (B) Polar view. (C) Sculpturing. D-F. ***Macaranga lowii*** **King ex Hook. f.** (D) Equatorial view. (E) Polar view. (F) Sculpturing.

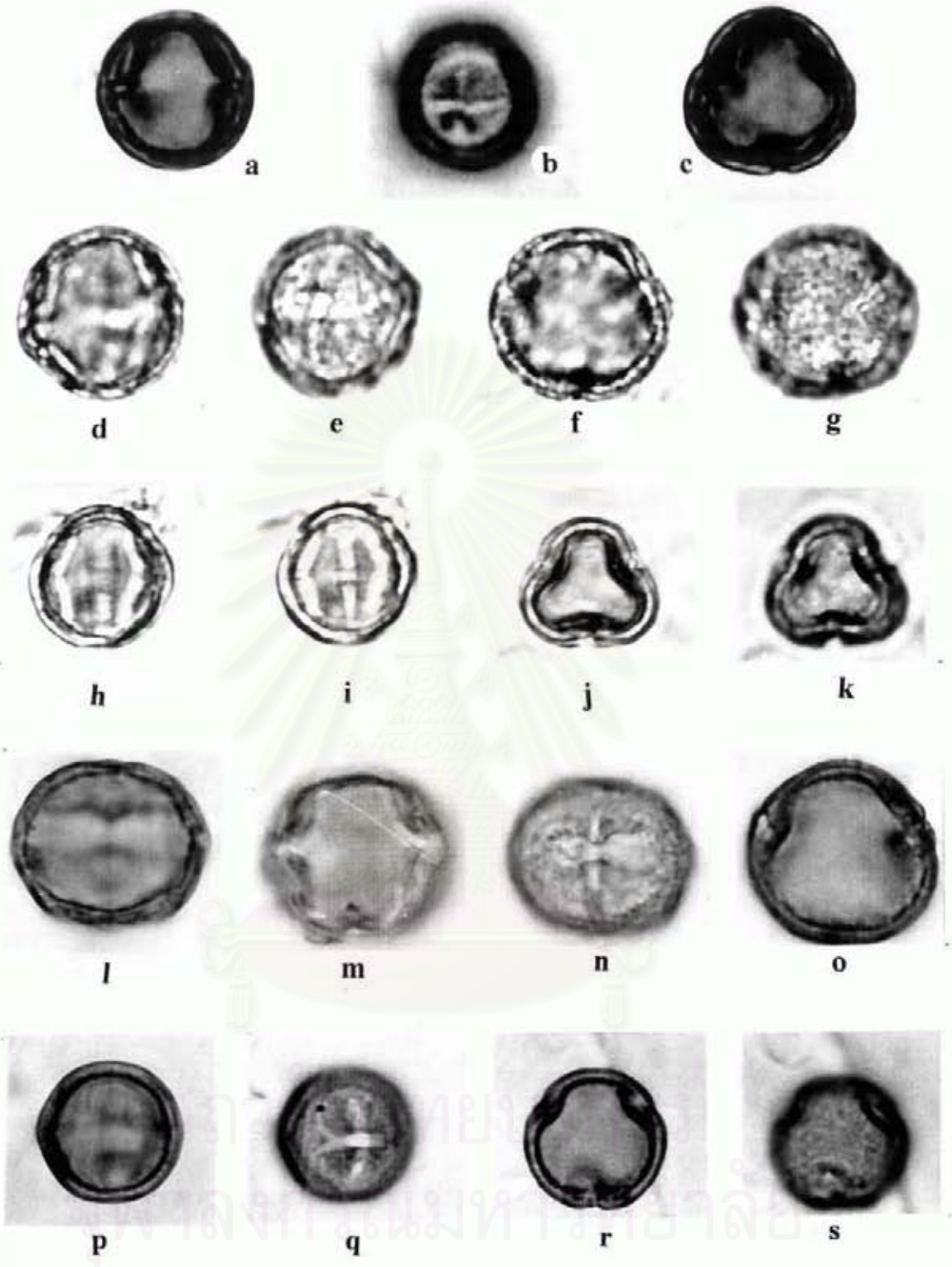


Plate 31. LM micrographs: a-e. ***Macaranga heynei* I. M. Johnston** (a-b) Equatorial view. (c) Polar view. d-g. ***Macaranga indica* Wight** (d-e) Equatorial view. (f) Polar view. (g) Sculpturing. h-k. ***Macaranga laciniata* Whitm.et. Airy Shaw** (h-i) Equatorial view. (j-k) Polar view. l-o. ***Macaranga lowii* King ex Hook. f.** (l-m) Equatorial view. (n-o) Polar view. p-s. ***Macaranga pruinosa* (Miq.) Muell. Arg.** (p-q) Equatorial view. (r-s) Polar view. All Micrographs ×1,750.

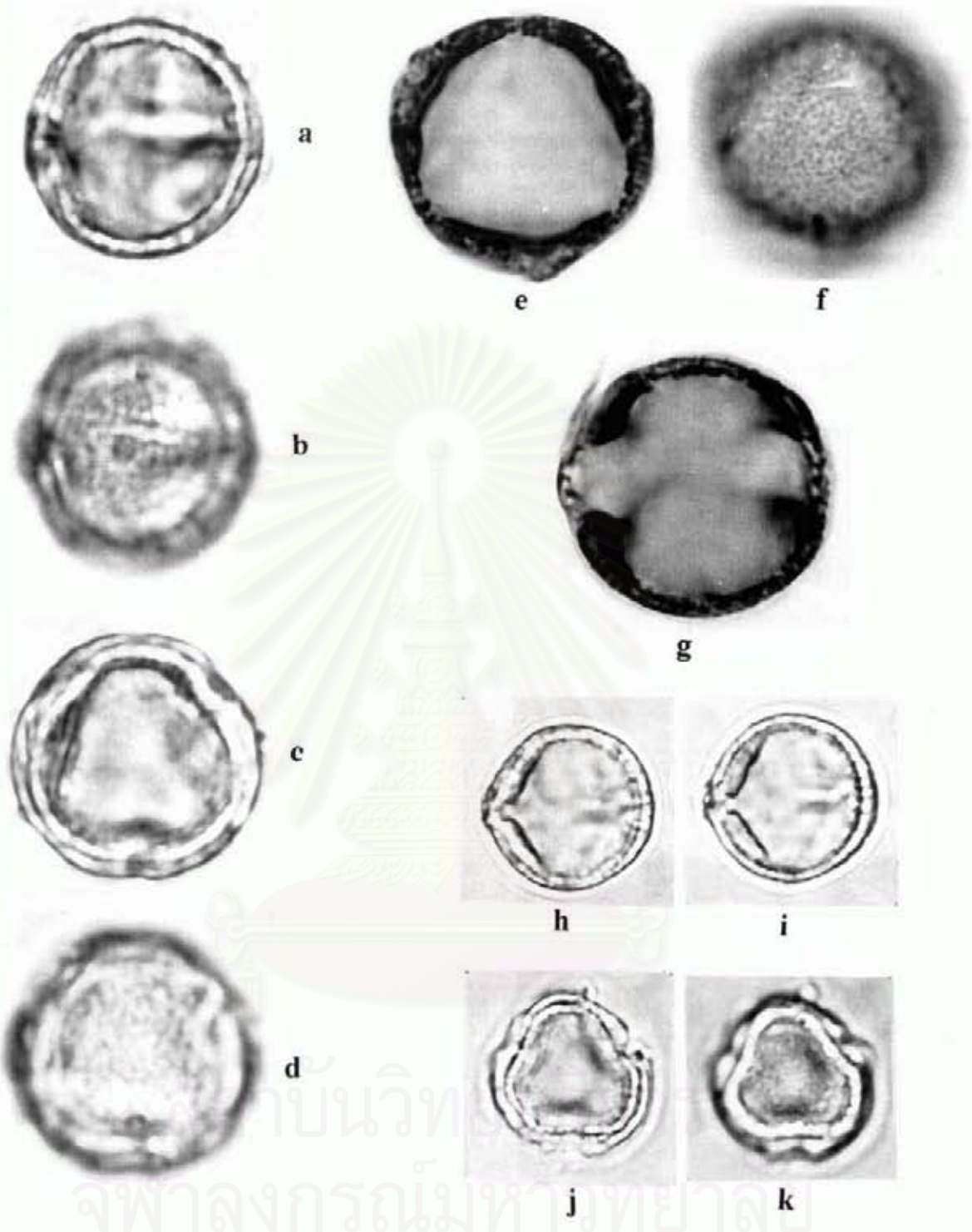


Plate 32. LM micrographs: a-d. ***Macaranga tanarius* (L.) Muell. Arg.** (a-b) Equatorial view. (c-d) Polar view. e-g. ***Macaranga kurzii* (Kuntze) Pax et Hoffm.** (e) Polar view. (f) Sculpturing. (g) Equatorial view. h-k. ***Macaranga denticulata* (Bl.) Muell. Arg.** (h-i) Equatorial view. (j-k) Polar view. All Micrographs ×1,750.

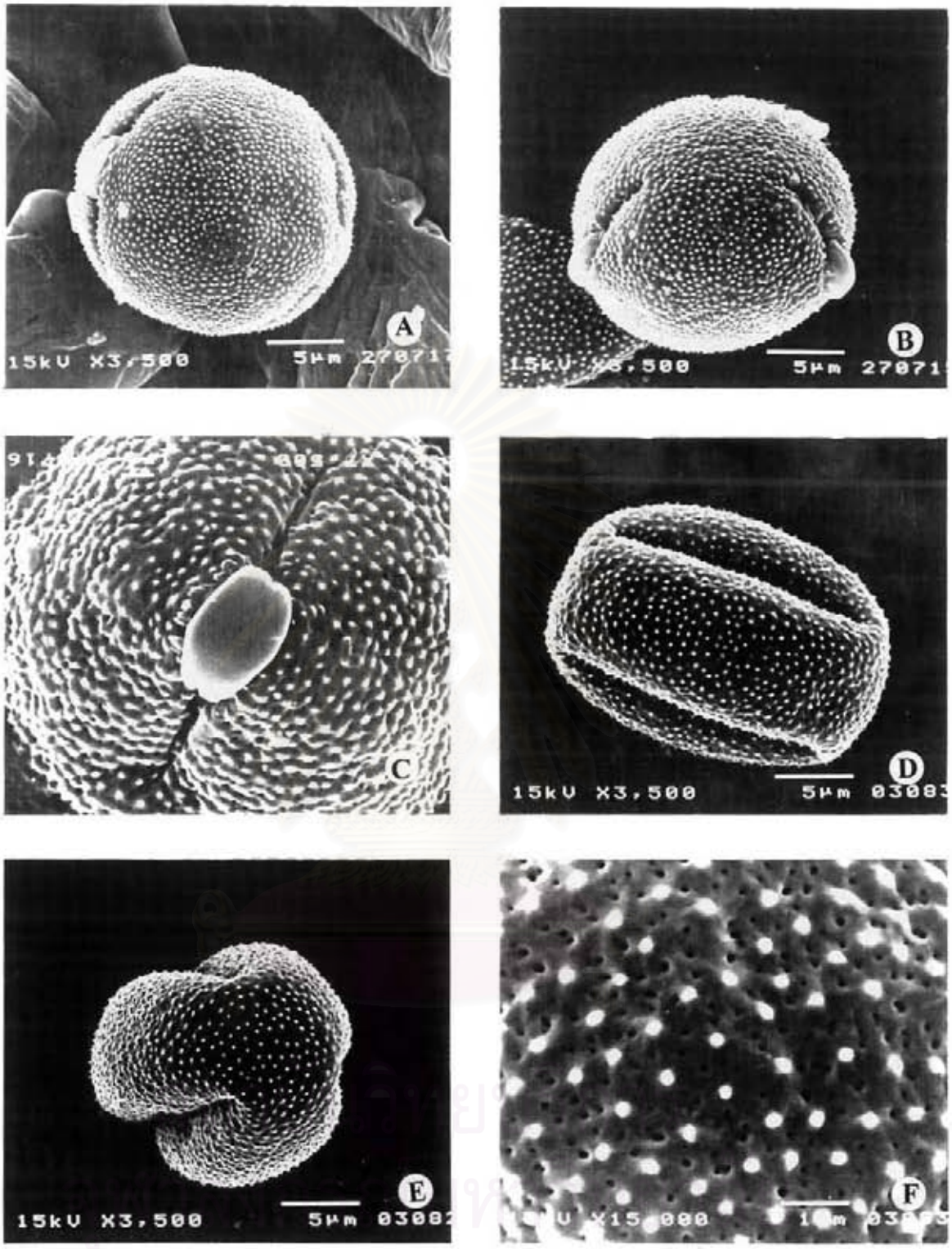


Plate 33. SEM micrographs: A-C. ***Mallotus barbatus*** **Muell. Arg.** (A) Equatorial view. (B) Polar view. (C) Sculpturing. D-F. ***Mallotus oblongifolius*** **(Miq.) Muell. Arg.** (D) Equatorial view. (E) Polar view. (F) Sculpturing.

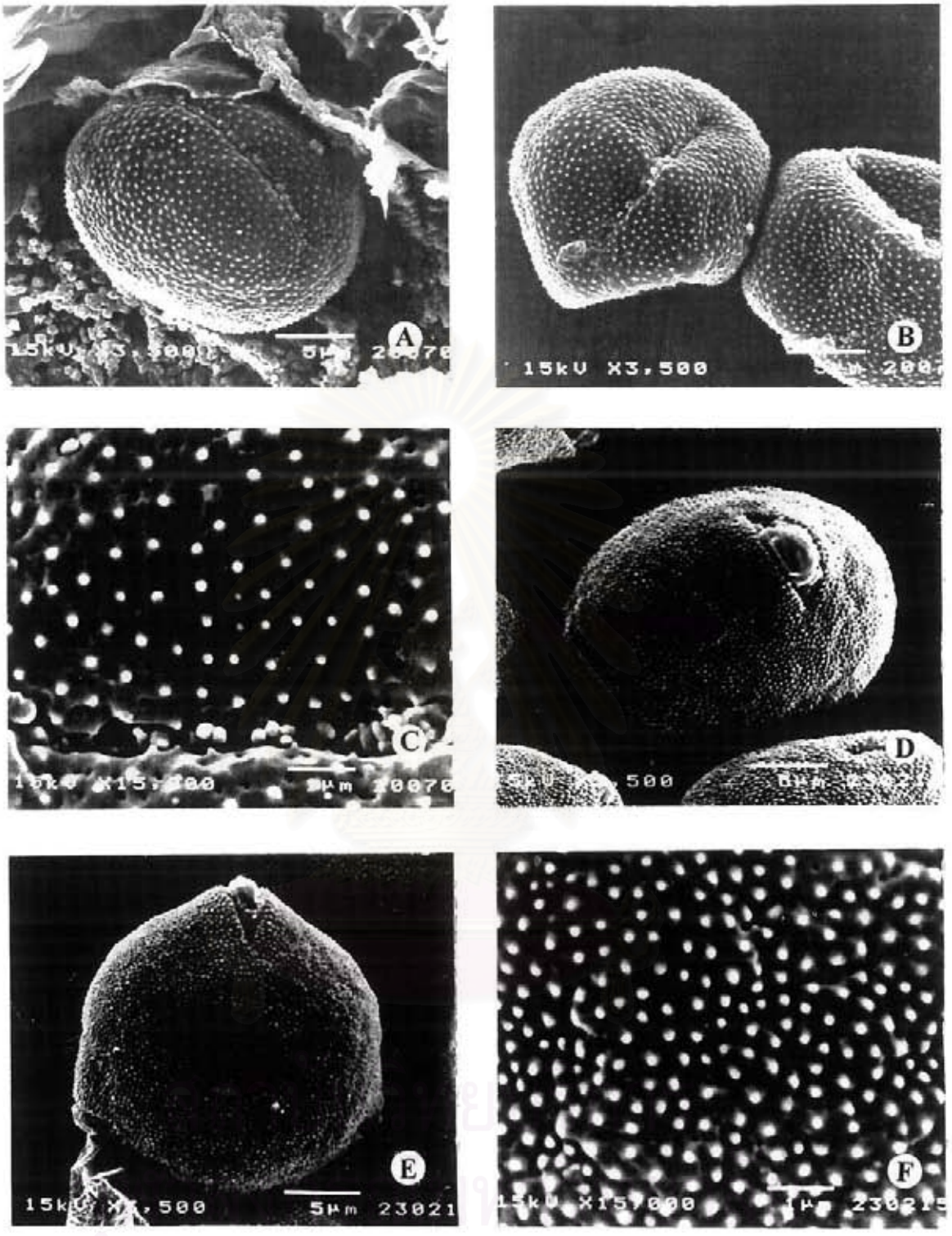


Plate 34. SEM micrographs: A-C. ***Mallotus paniculatus*** **(Lam.) Muell. Arg.** (A) Equatorial view. (B) Polar view. (C) Sculpturing. D-F. ***Trewia nudiflora*** **L.(Miq.) Muell. Arg.** (D) Equatorial view. (E) Polar view. (F) Sculpturing.

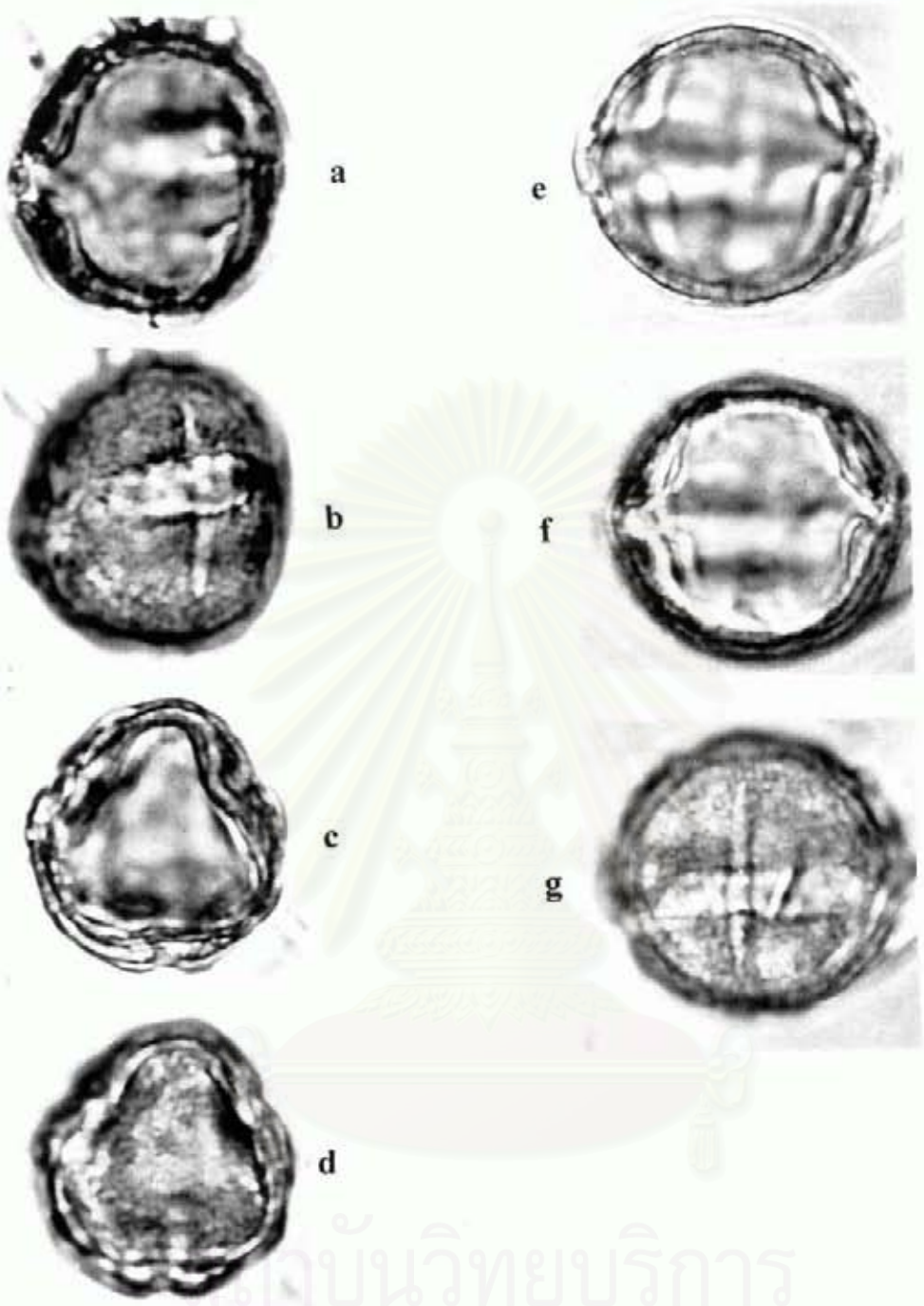


Plate 35. LM micrographs: a-d. ***Mallotus paniculatus* (Lam.) Muell. Arg.** (a-b) Equatorial view. (c-d) Polar view. e-g. ***Mallotus barbatus* Muell. Arg.** (e-f) Equatorial view. All Micrographs ×1,750.

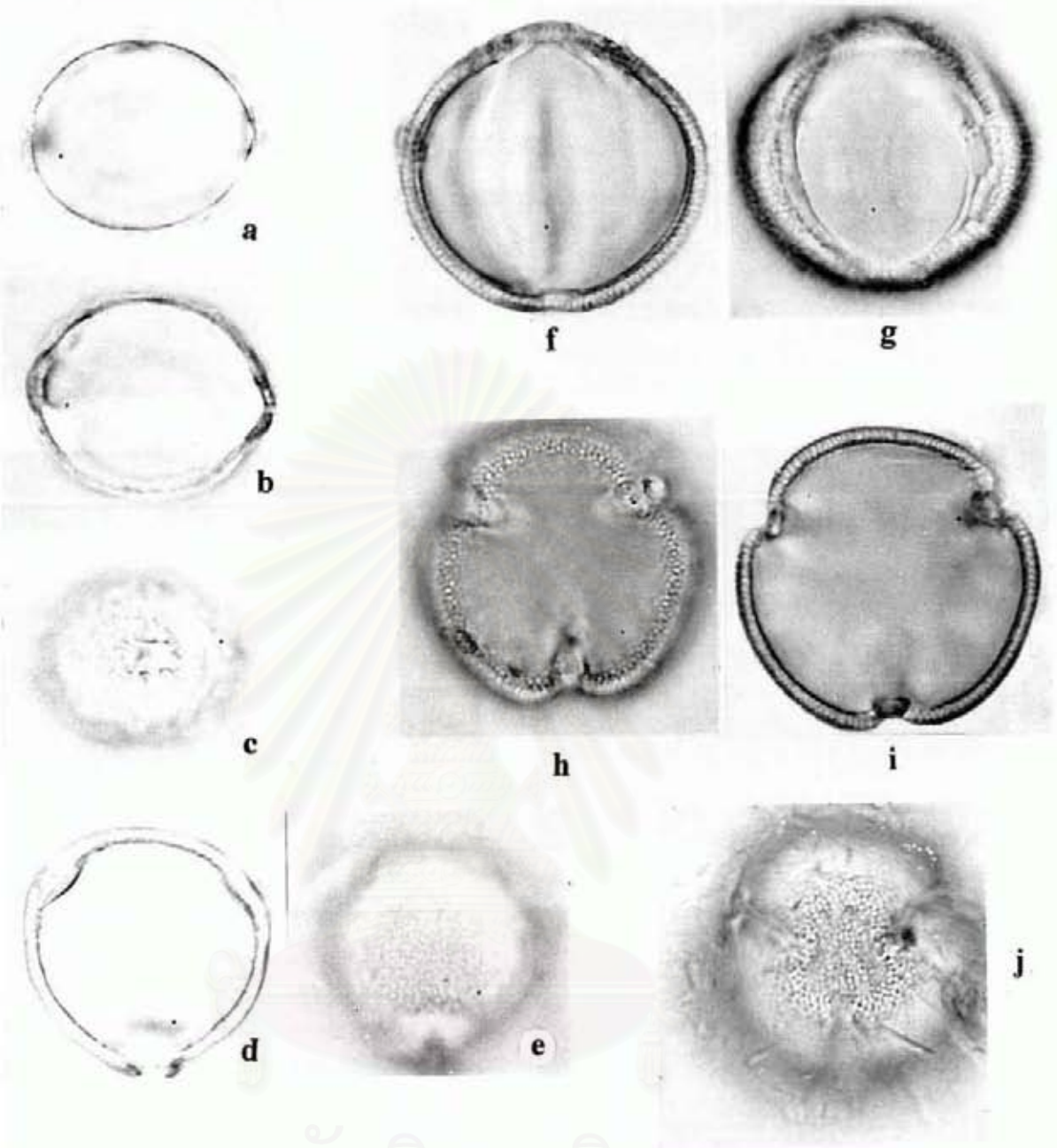


Plate 36. LM micrographs: a-e. ***Trewia nudiflora* L.** (a-c) Equatorial view. (d) Polar view. (e)Sculpturing. f-j. ***Hevea brasiliensis* Muell. Arg.** (f-g) Equatorial view (h-i) Polar view. (e-j) Sculpturing. All Micrographs ×875.

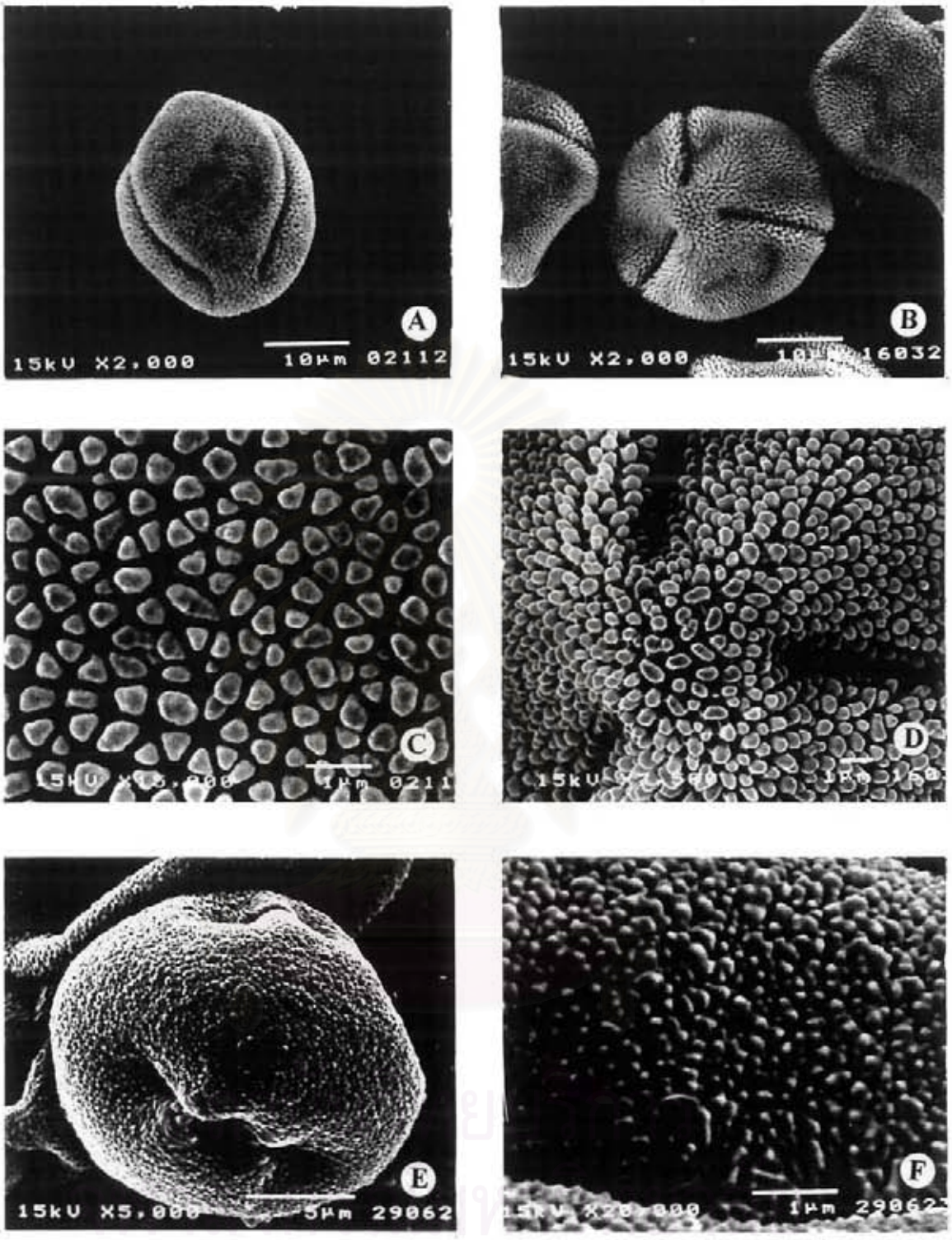


Plate 37. SEM micrographs: A-D. ***Hevea brasiliensis*** **Muell. Arg.** (A) Equatorial view. (B) Polar view. (C) Detail of apocolpium. E-F. ***Sampantaea amentiflora*** **Airy Shaw** (F) Equatorial view. (F) Sculpturing.

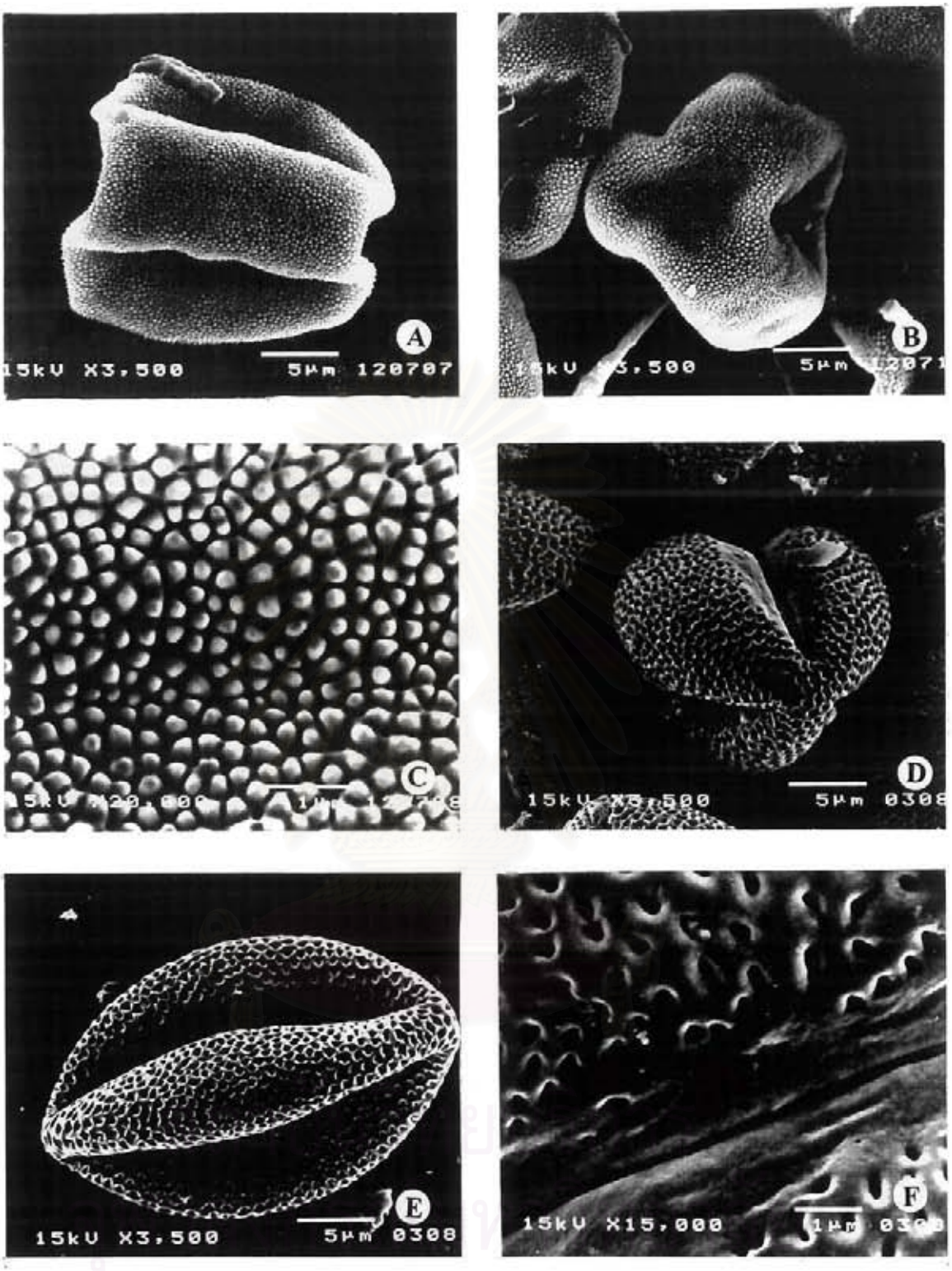


Plate 38. SEM micrographs: A-C. ***Homonoia riparia*** **Lour.** (A) Equatorial view. (B) Polar view. (C) Sculpturing. D-F. ***Trewia nudiflora*** **L.(Miq.) Muell. Arg.** (D) Equatorial view. (E) Polar view. (F) Sculpturing.

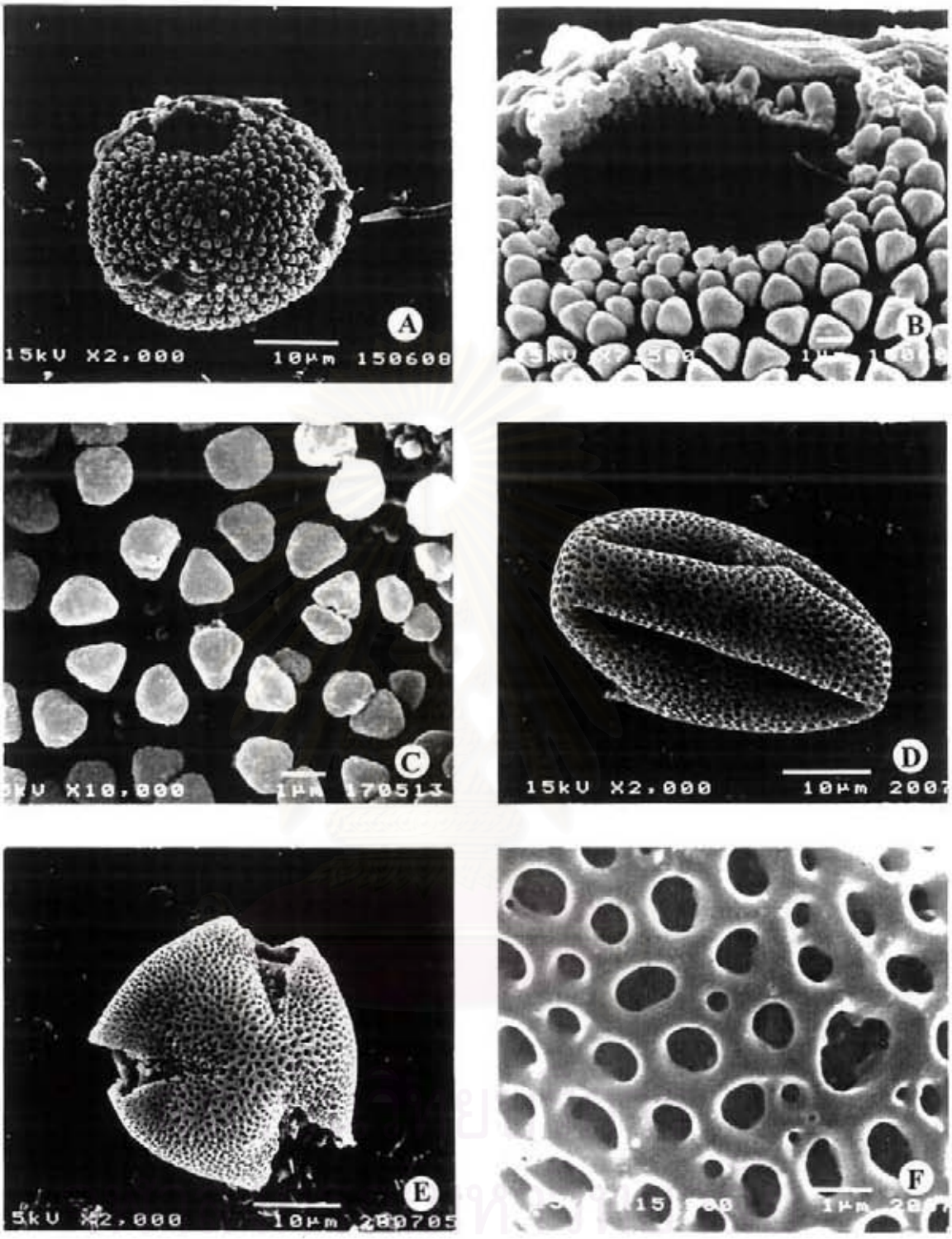


Plate 39. SEM micrographs: A-C. ***Suregada multiflora*** **(Juss.) Baill.** (A) Equatorial view. (B) Polar view. (C) Sculpturing. D-F. ***Thyrsanthera suborbicularis*** **Pierre ex Gagnep.** (D) Equatorial view. (E) Polar view. (F) Sculpturing.

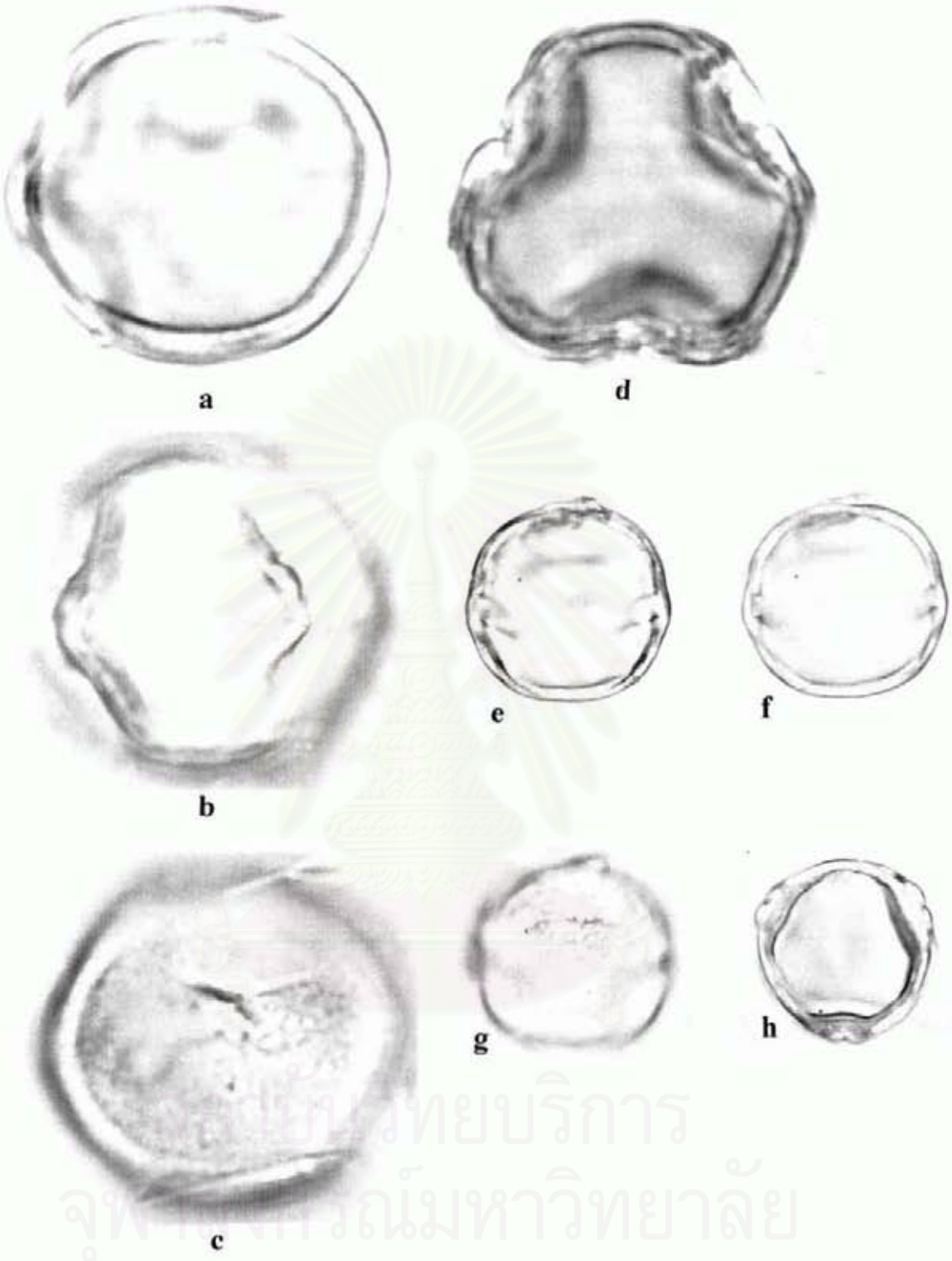


Plate 40. LM micrographs: a-c. ***Sampantaea amentiflora*** **Airy Shaw** (a-c) Equatorial view. (c-d) Polar view. (e) Sculpturing. All Micrographs ×875. e-h. ***Homonoia riparia*** **Lour.** (e-g) Equatorial view. (h) Polar view. All Micrographs ×1,750.

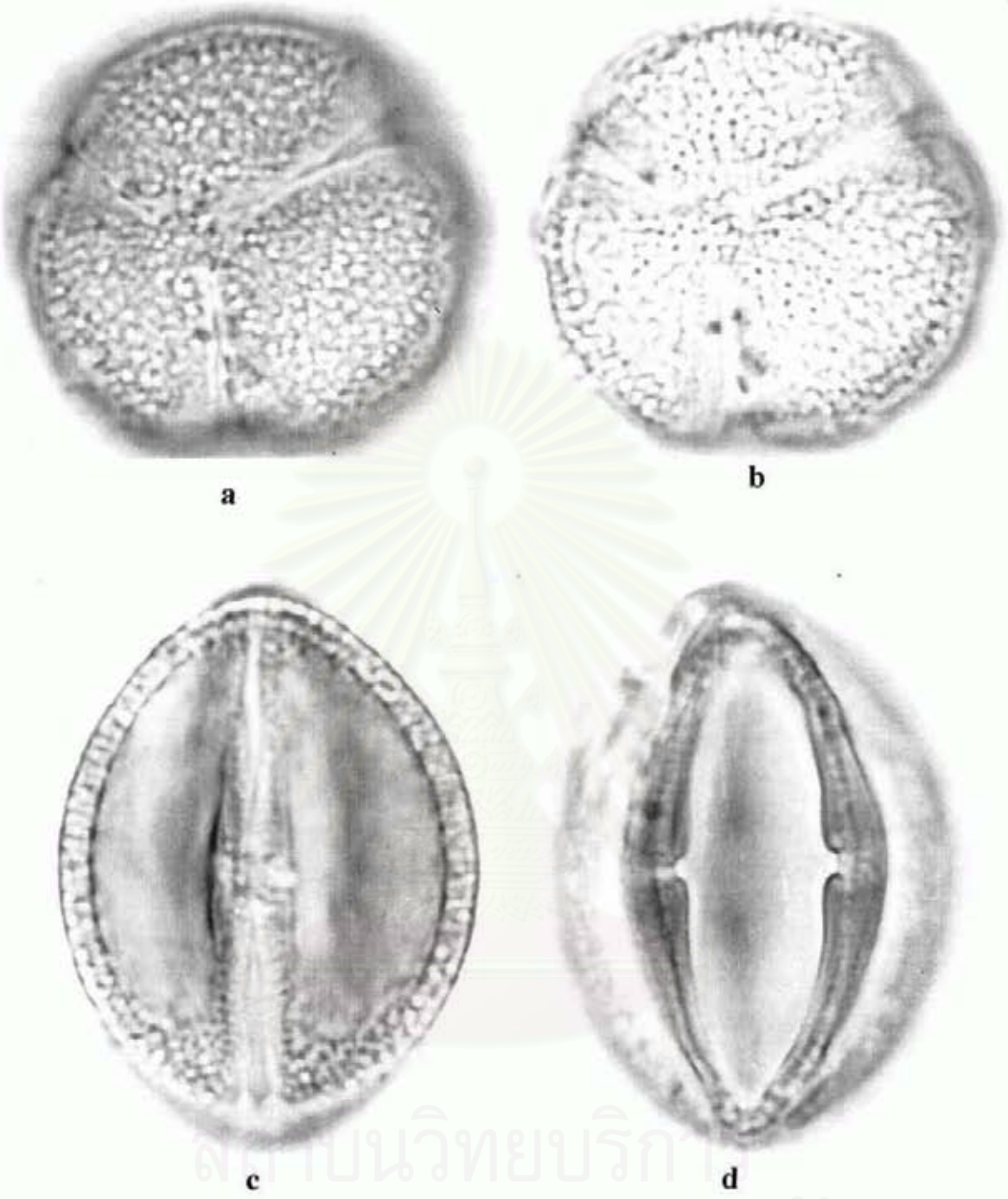


Plate 41. LM micrographs: a-d. ***Microstachys chamaelea* (L.) Juss.** (a-b) Polar view. (c-d) Equatorial view. All Micrographs ×1,750.

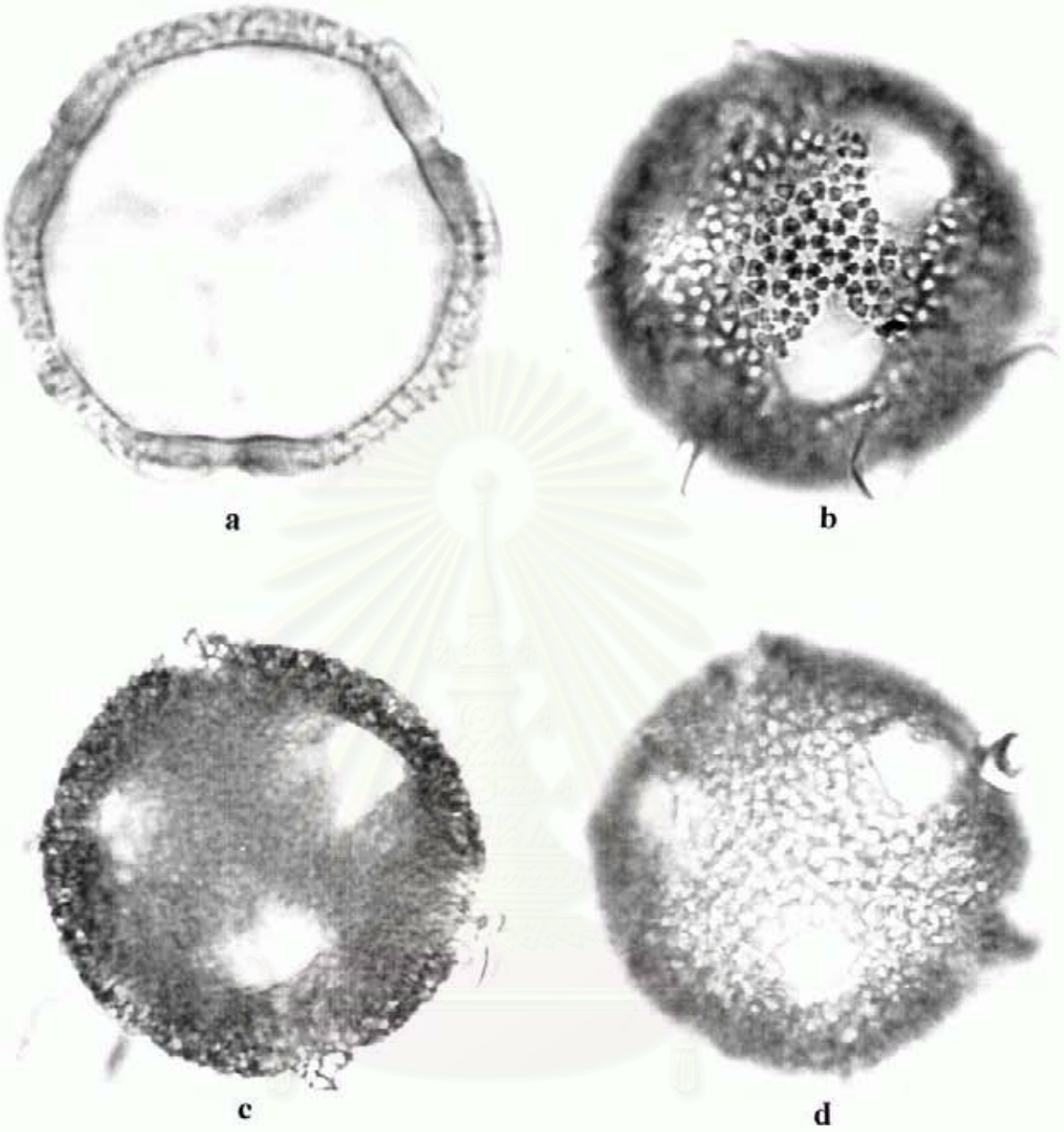
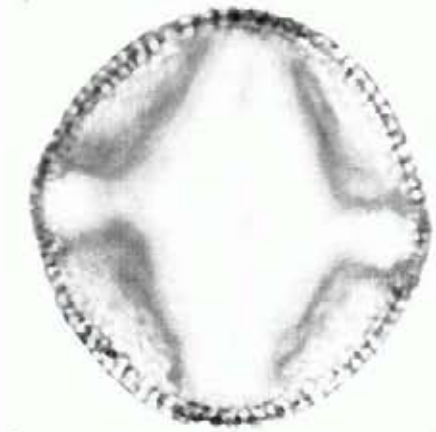
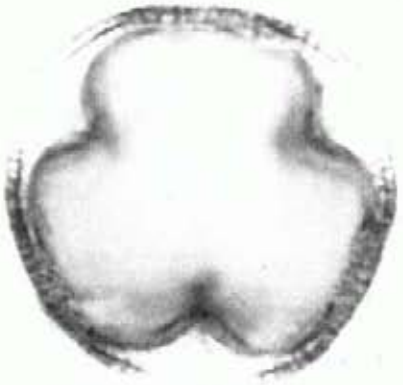


Plate 42. LM micrographs: a. ***Microstachys chamaelea* (L.) Juss.** (a) Polar view. b-d. ***Suregada multiflora* (Juss.) Baill.** (b, d) Top view of structure elements. (c) Equatorial view of grain. All Micrographs ×1,750.

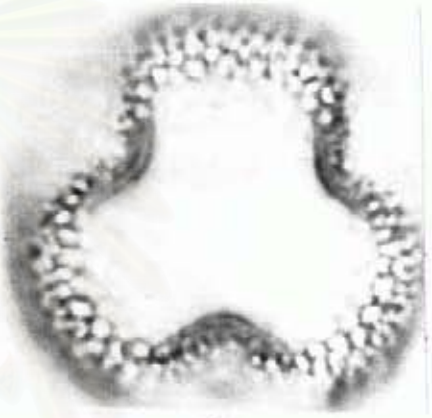


a

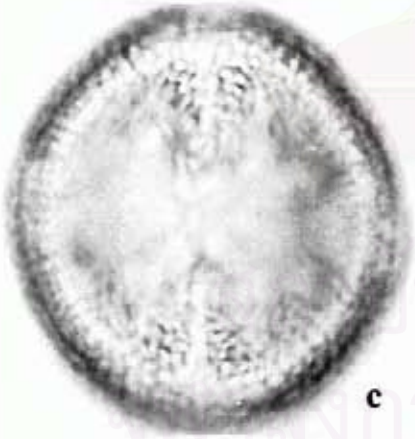


d

b



e



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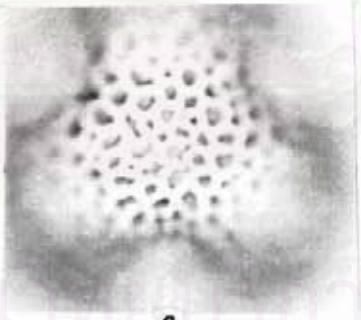
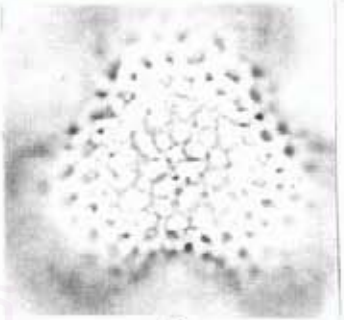


f



g

Plate 43. LM micrographs: a-g. ***Thyrsanthera suborbicularis*** **Pierre ex Gagnep.** (a-c) Equatorial view. (d-e) Polar view. (f-g) Sculpturing. All Micrographs ×1,750.

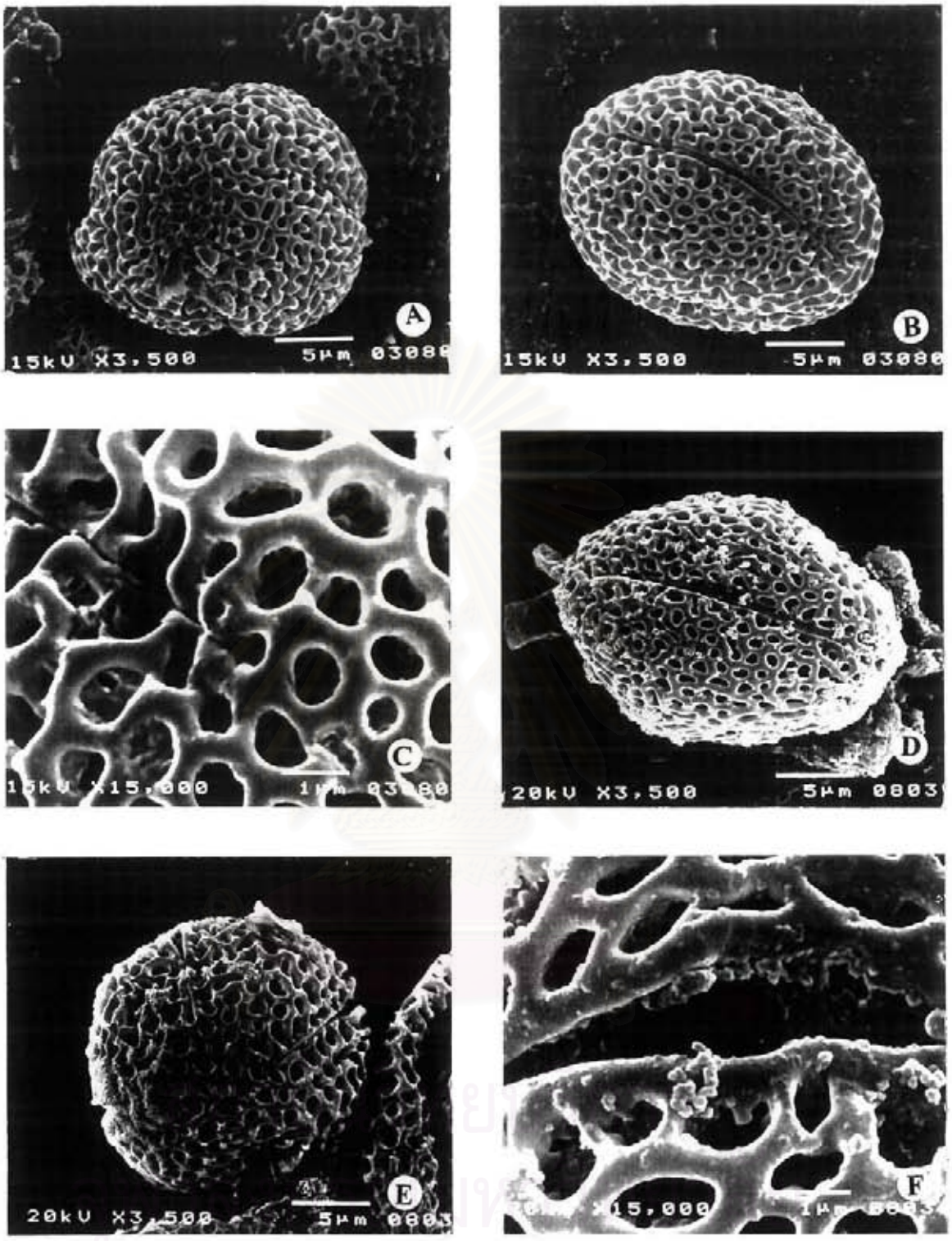


Plate 44. SEM micrographs: A-C. ***Glochidion acuminatum* Muell. Arg. var. *siamense* Airy Show.** (A) Equatorial view. (B) Polar view. (C) Sculpturing. D-F. ***Glochidion assamicum (Muell. Arg.)* Hook. f.** (D) Equatorial view. (E) Polar view. (F) Sculpturing.

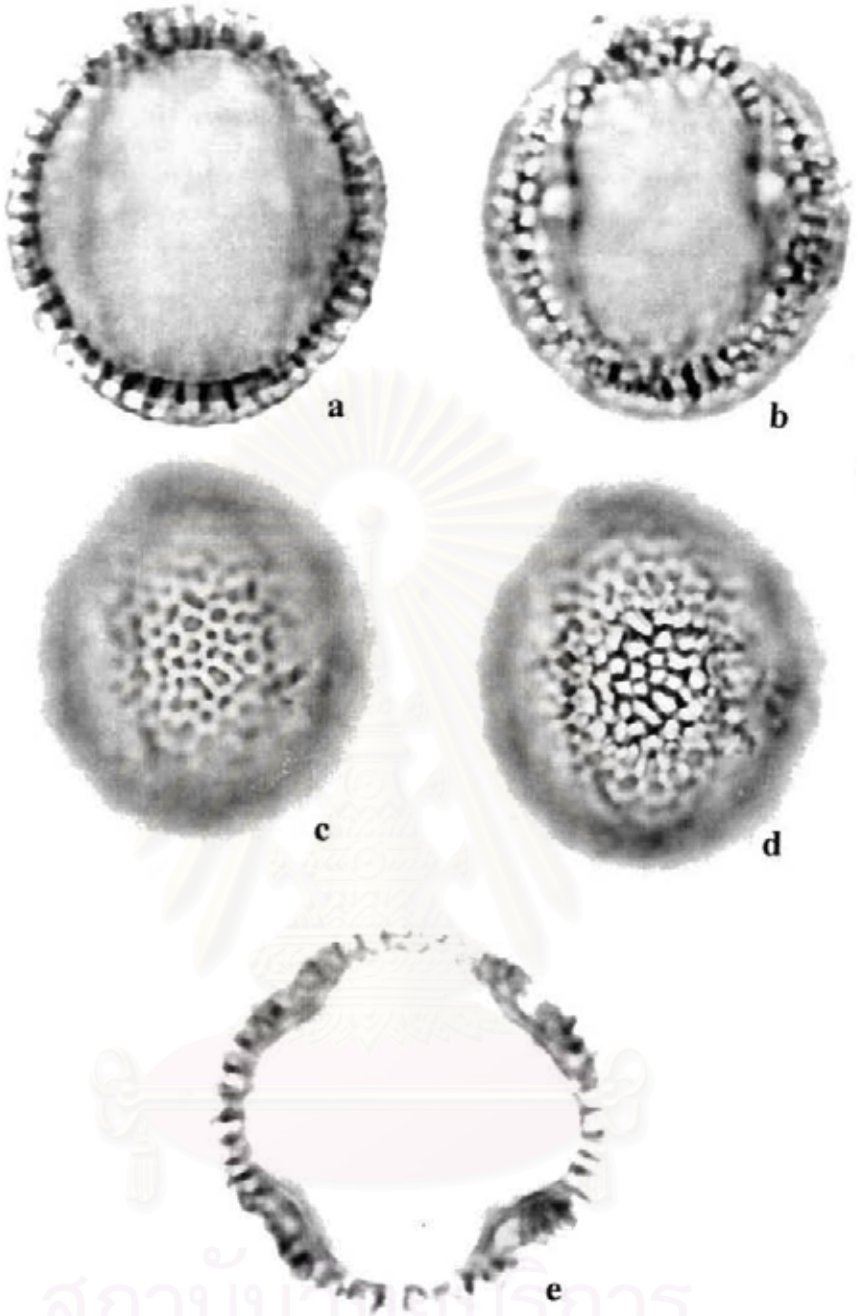


Plate 45. LM micrographs: a-e. ***Glochidion acuminatum* Muell. Arg. var. *siamense* Airy Show.** (a)) Equatorial view. (c-d) Sculpturing. All Micrographs ×1,750.

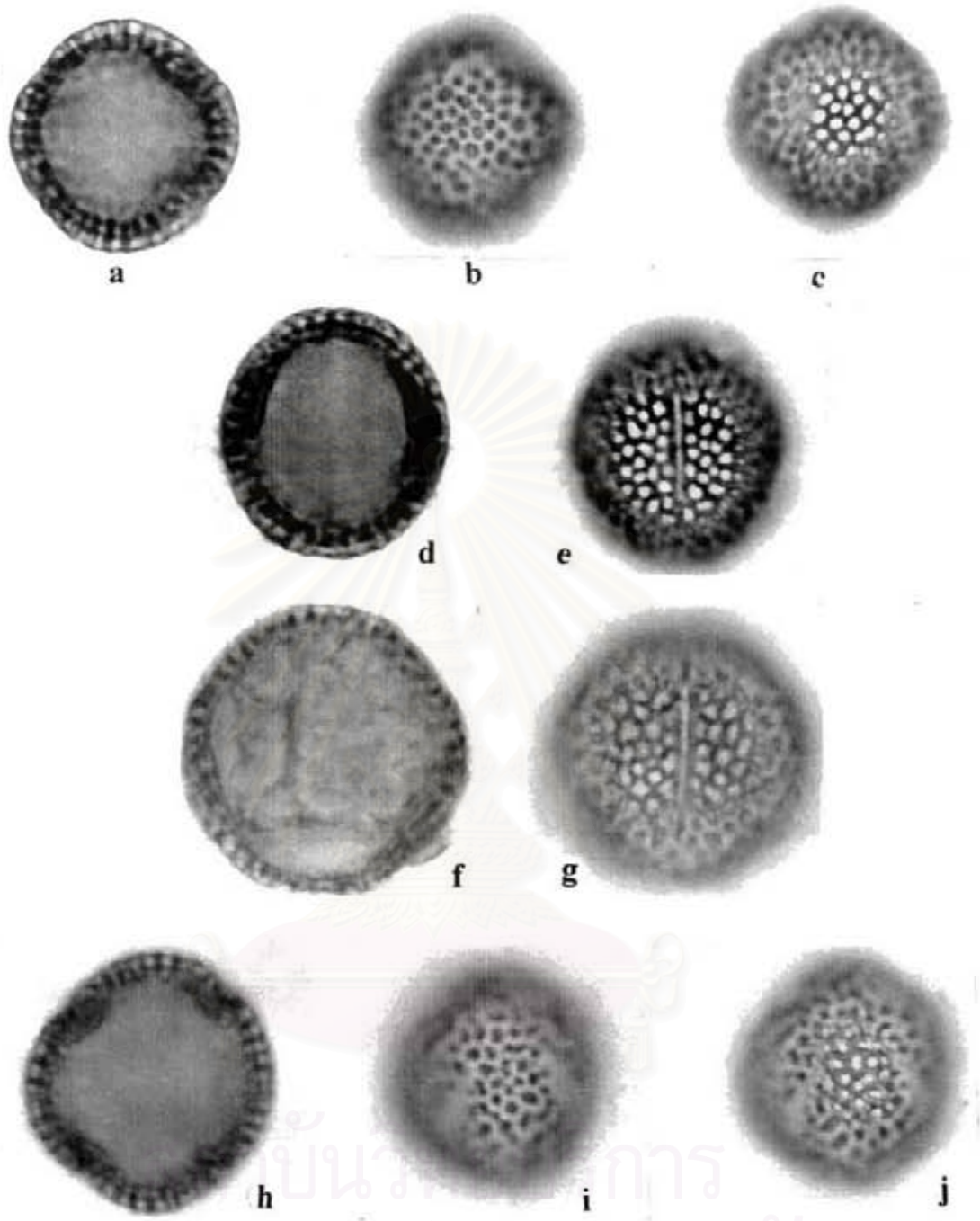


Plate 46. LM micrographs: a-e. ***Glochidion arborescens* Bl.** (a-c) Polar view. (d-e) Equatorial view. g-j. ***Glochidion assamicum* (Muell. Arg.) Hook. f.** (f-g) Equatorial view. (h) Polar view.(i-j) Sculpturing. All Micrographs ×1,750.

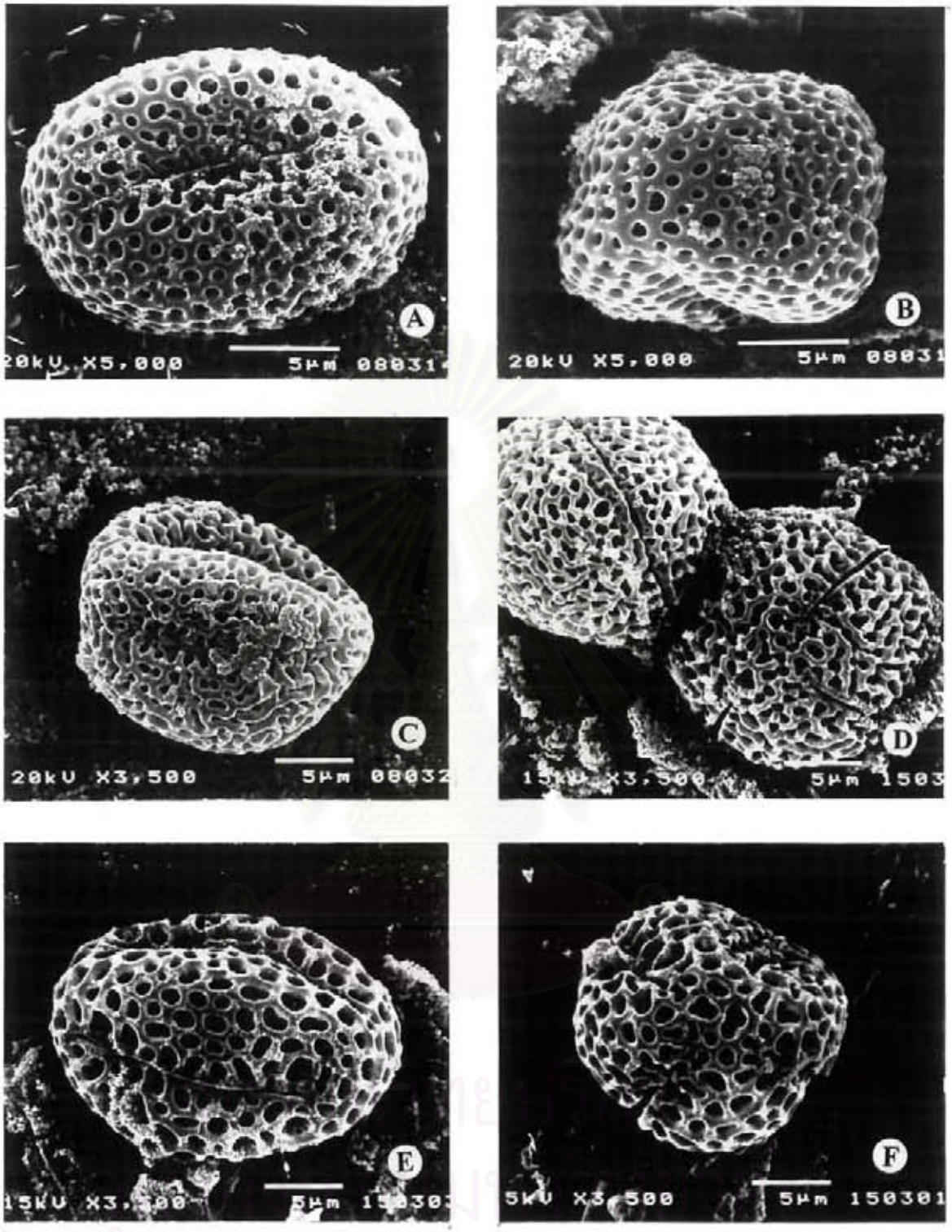


Plate 47. SEM micrographs: A-B. ***Glochidion arborescens* Bl.** (A) Equatorial view. (B) Polar view. C. ***Glochidion coccineum* (Buch-Ham.) Muell. Arg.** (C) Equatorial view. D. ***Glochidion glomerulatum* (Miq.) Boerl** (D) Polar view and Equatorial view. E-F. ***Glochidion hirsutum* (Roxb.) Voight** (E) Equatorial view. (F) Polar view.

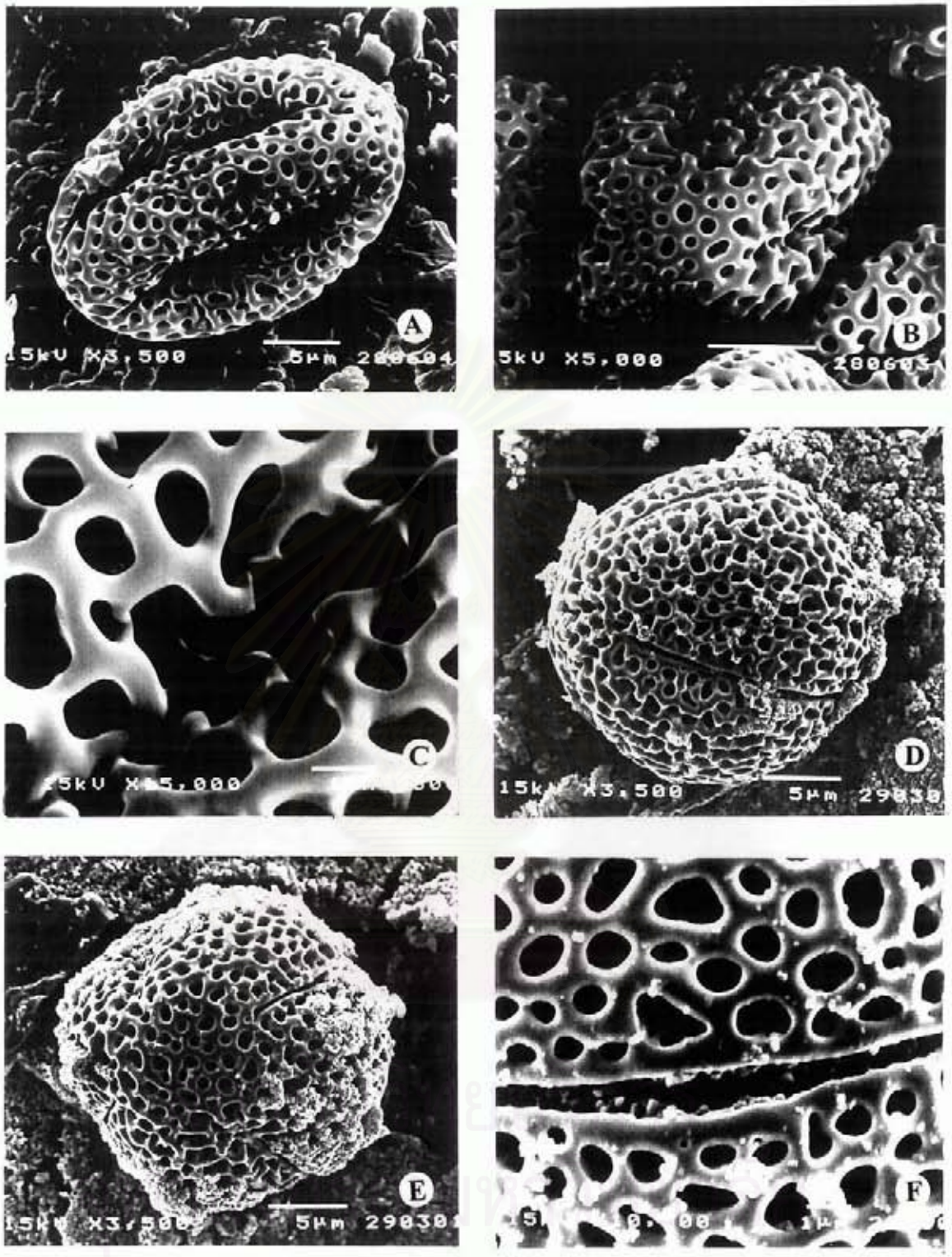


Plate 48. SEM micrographs: A-C. ***Glochidion eriocarpum*** **Champ. Muell. Arg.** (A) Equatorial view. (B) Polar view. (C) Sculpturing. D-F. ***Glochidion lanceolarium*** **(Roxb.) Voight** (D) Equatorial view. (E) Polar view. (F) Sculpturing.

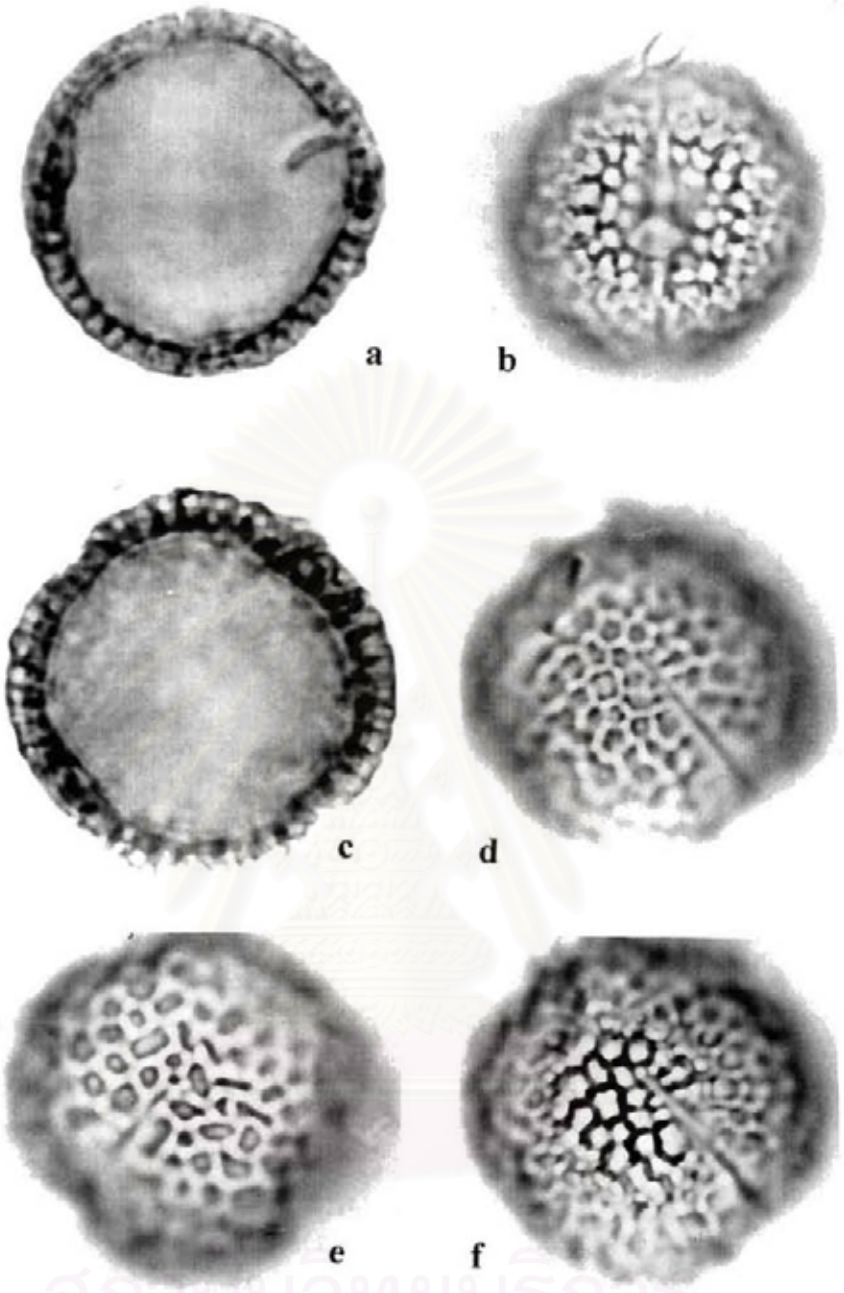


Plate 49. LM micrographs: a-f. ***Glochidion glomerulatum*** **(Miq.) Boerl** (a-b) Equatorial view. (c) Polar view. (d-f) Sculpturing. All Micrographs ×1,750.

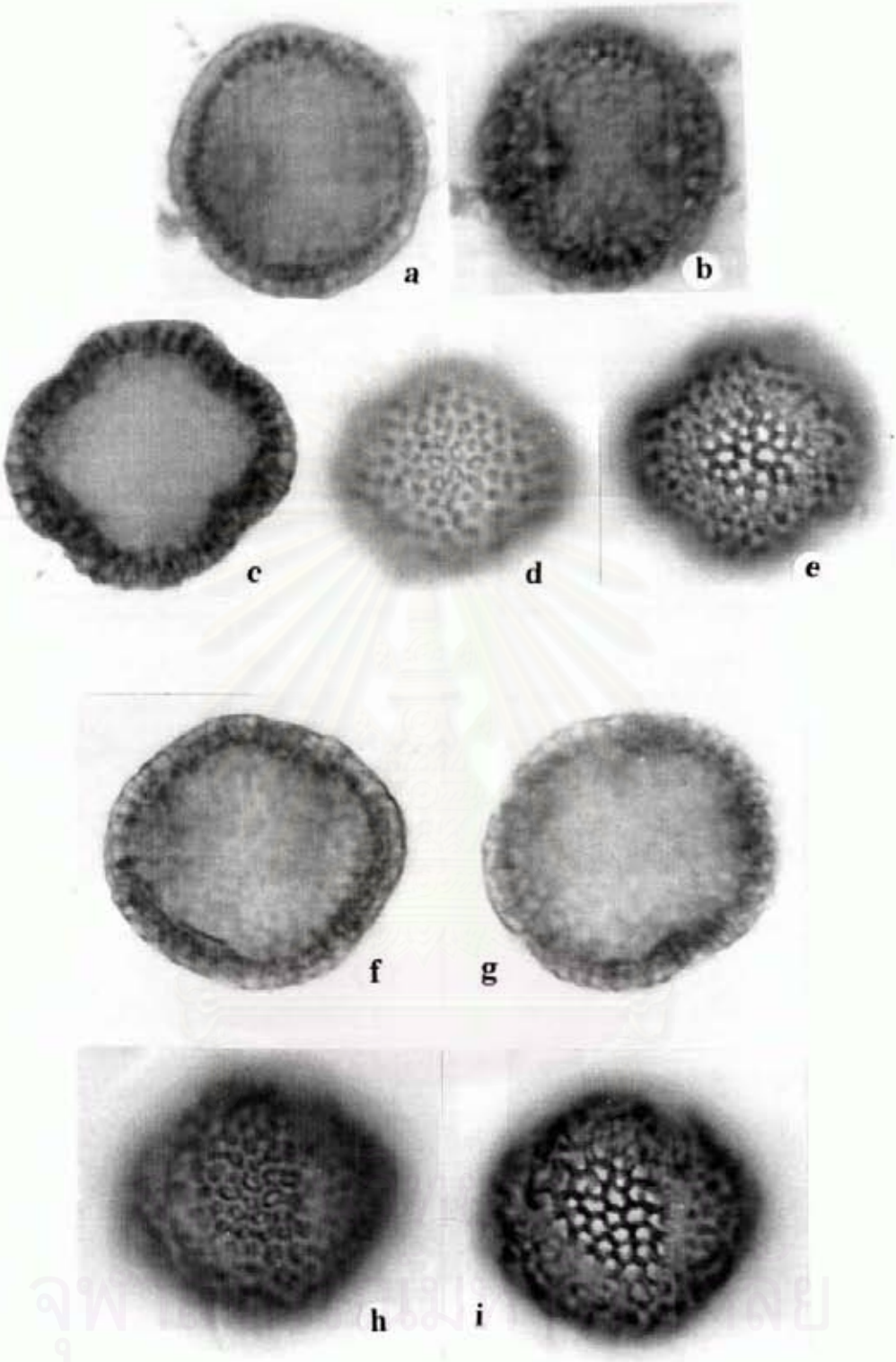


Plate 50. LM micrographs: a-e. ***Glochidion coccineum*** **(Buch-Ham.) Muell. Arg.** (a-b) Equatorial view. (c) Polar view. (d-e) Sculpturing. f-i. ***Glochidion eriocarpum*** **Champ.** (f) Equatorial view. (g) Polar view. (h-i) Sculpturing. All Micrographs ×1,750.

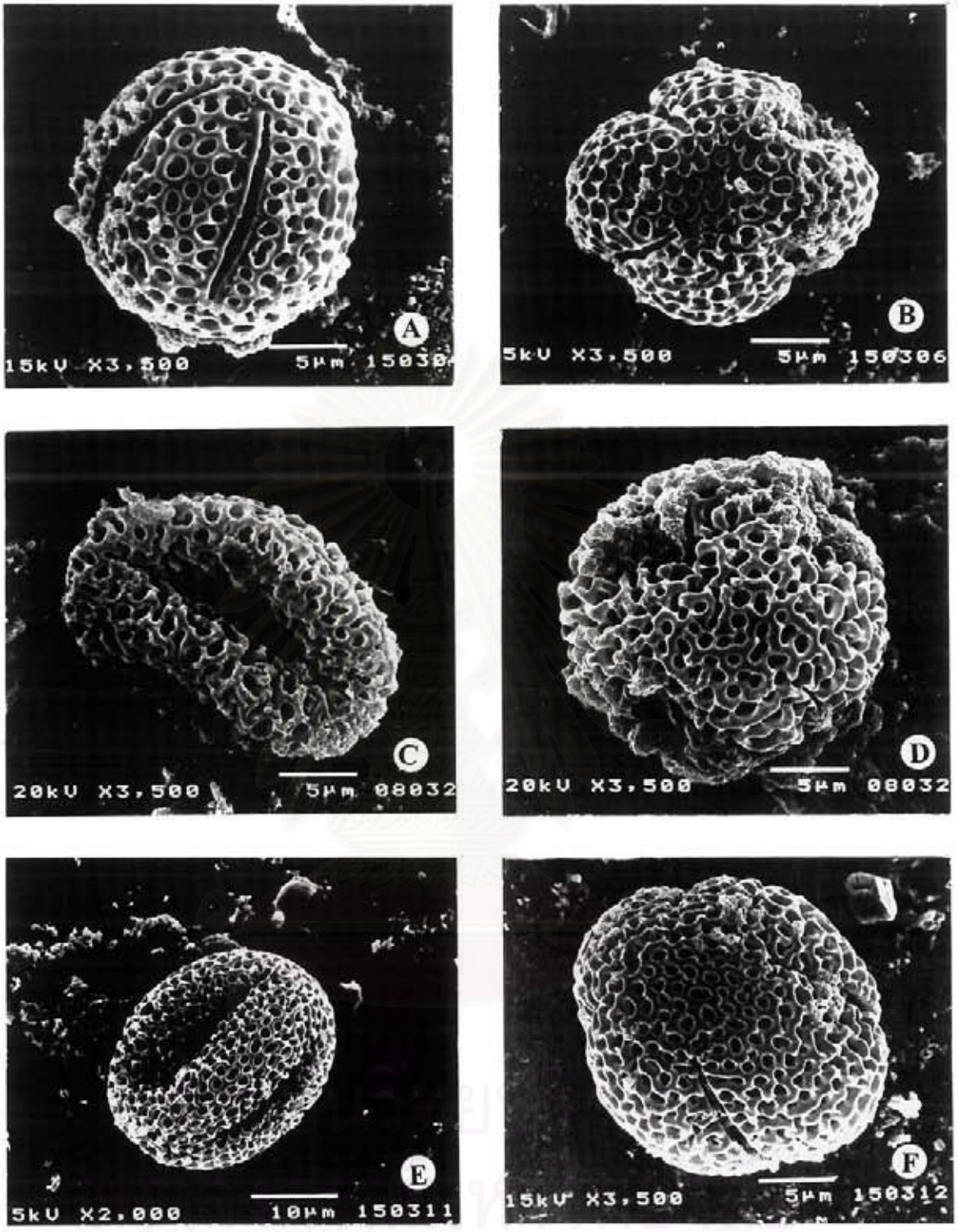


Plate 51. SEM micrographs: A-B. ***Glochidion hongkongensis*** **Muell. Arg.** (A) Equatorial view. (B) Polar view. C-D. ***Glochidion daltnii*** **(Muell. Arg.) Kurz** (C) Equatorial view. (D) Polar view. E-F. ***Glochidion kerrii*** **Craib** (E) Equatorial view. (F) Polar view.

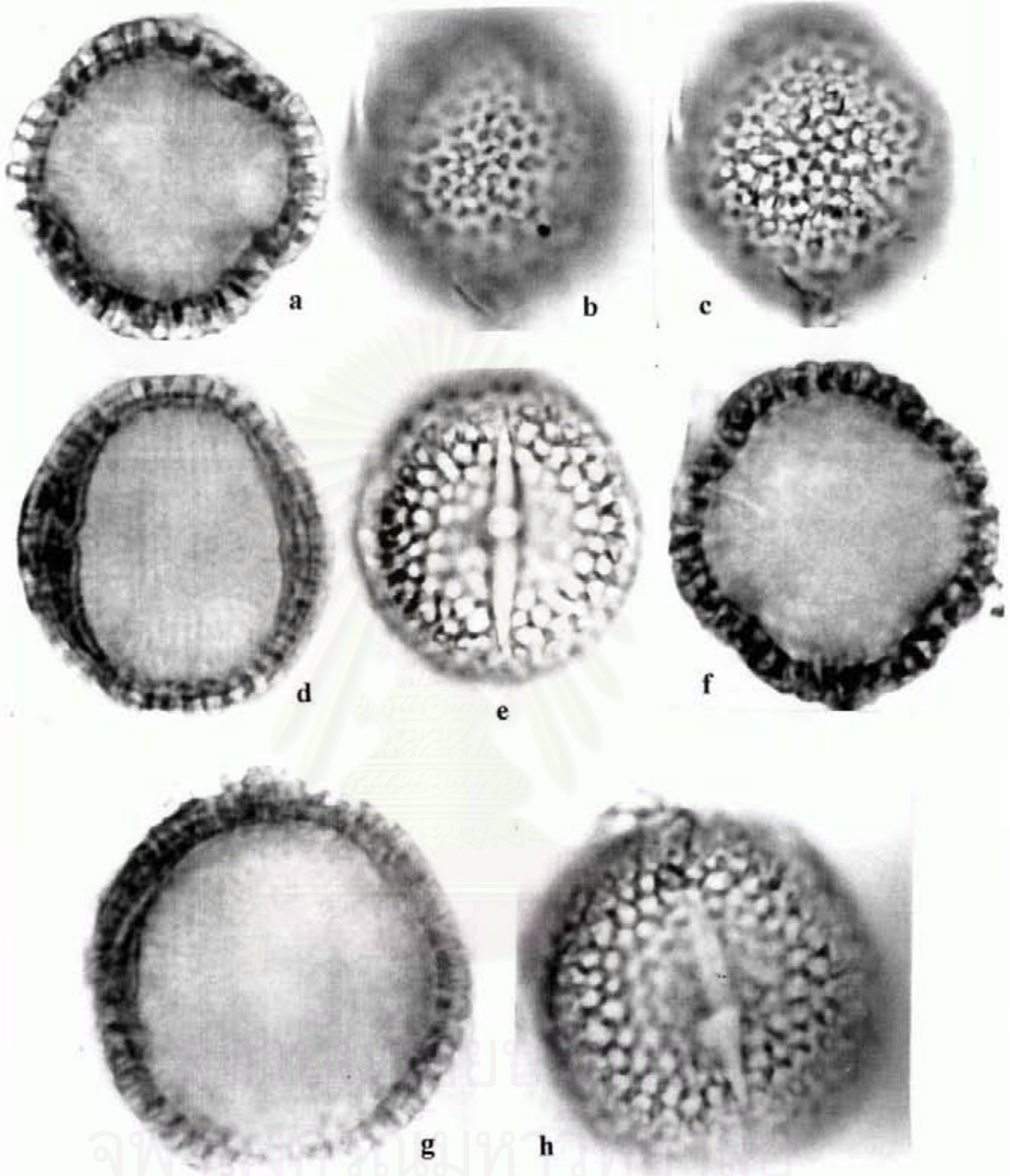


Plate 52. LM micrographs: a-e. ***Glochidion hongkongensis*** **Muell. Arg.** (a) Polar view. (b-c) Sculpturing. (d-e) Equatorial view. f-h. ***Glochidion kerrii*** **Craib** (f) Polar view. (g-h) Equatorial view. All Micrographs ×1,750.

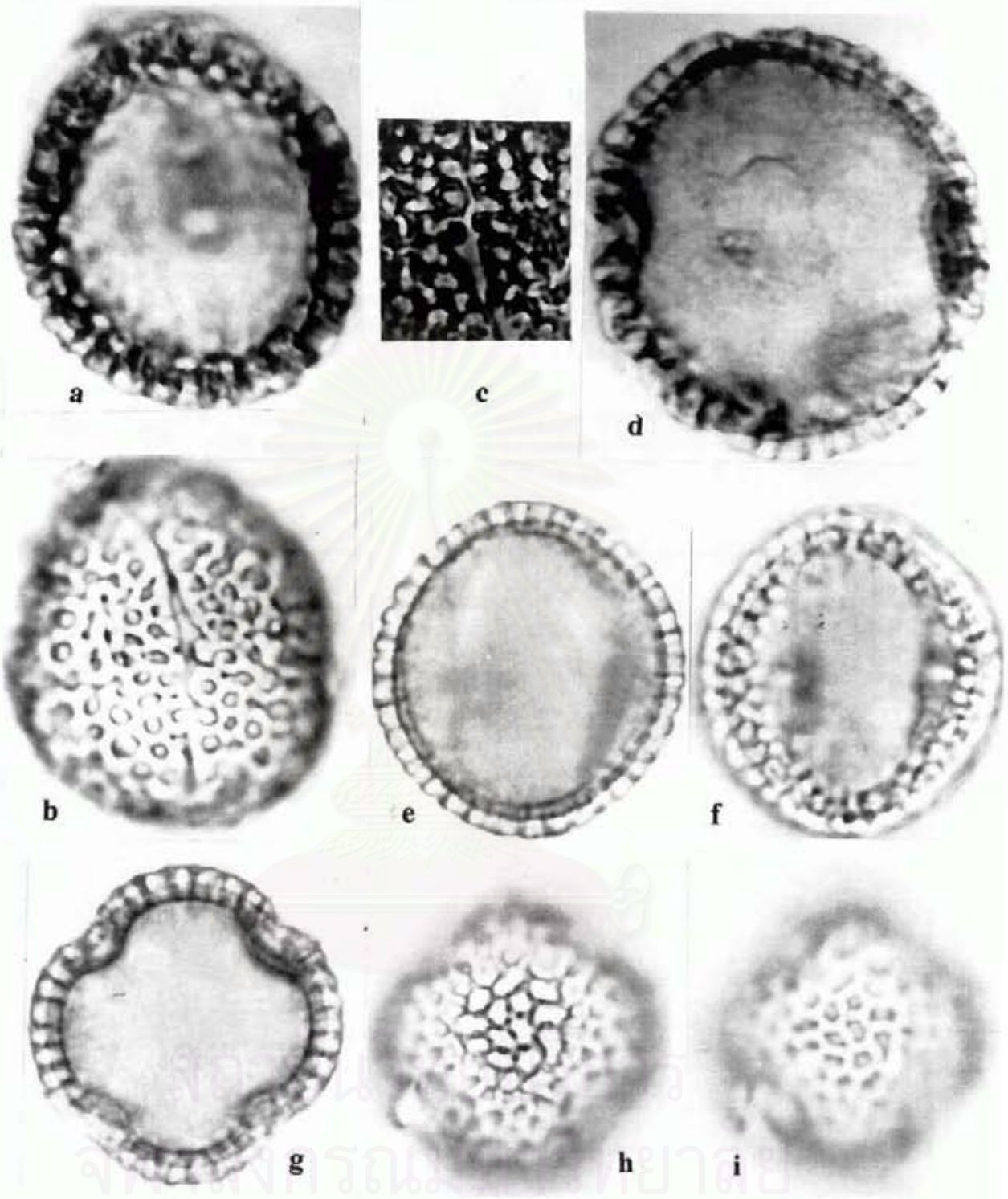


Plate 53. LM micrographs: a-d. ***Glochidion nubigenum*** **Hook. f.** (a-b) Equatorial view. (c) Sculpturing. (d) Polar view. **e-i** ***Glochidion obscurum*** **(Roxb. ex Willd.) Bl.** (e-f) Equatorial view. (g) Polar view. (h-i) Sculpturing. All Micrographs ×1,750.

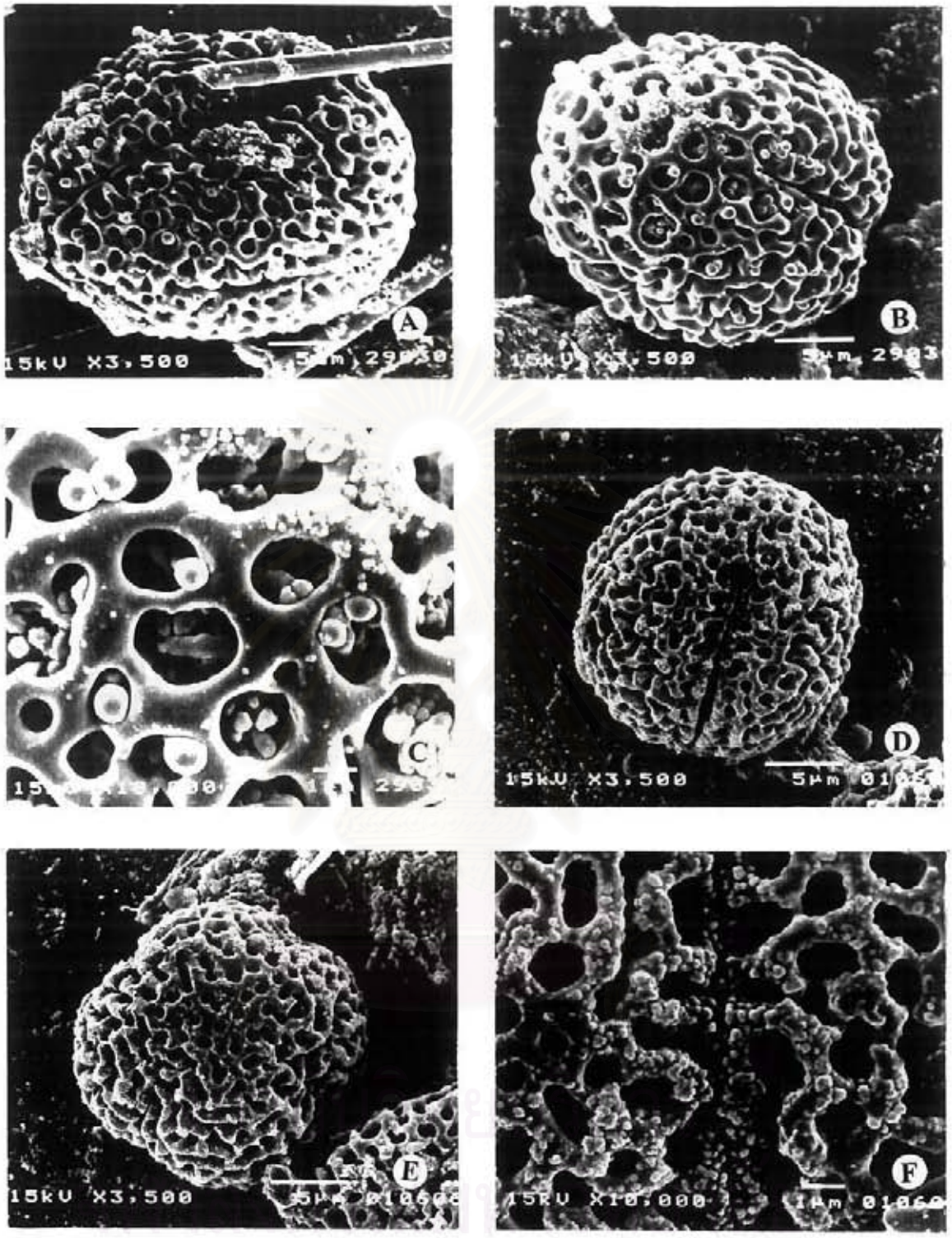


Plate 54. SEM micrographs: A-C. ***Glochidion nubigenum*** **Hook. f.** (A) Equatorial view. (B) Polar view. (C) Sculpturing. D-F. ***Glochidion sphaerogynum*** **(Muell. Arg.) Kurz** (D) Equatorial view. (E) Polar view. (F) Sculpturing.

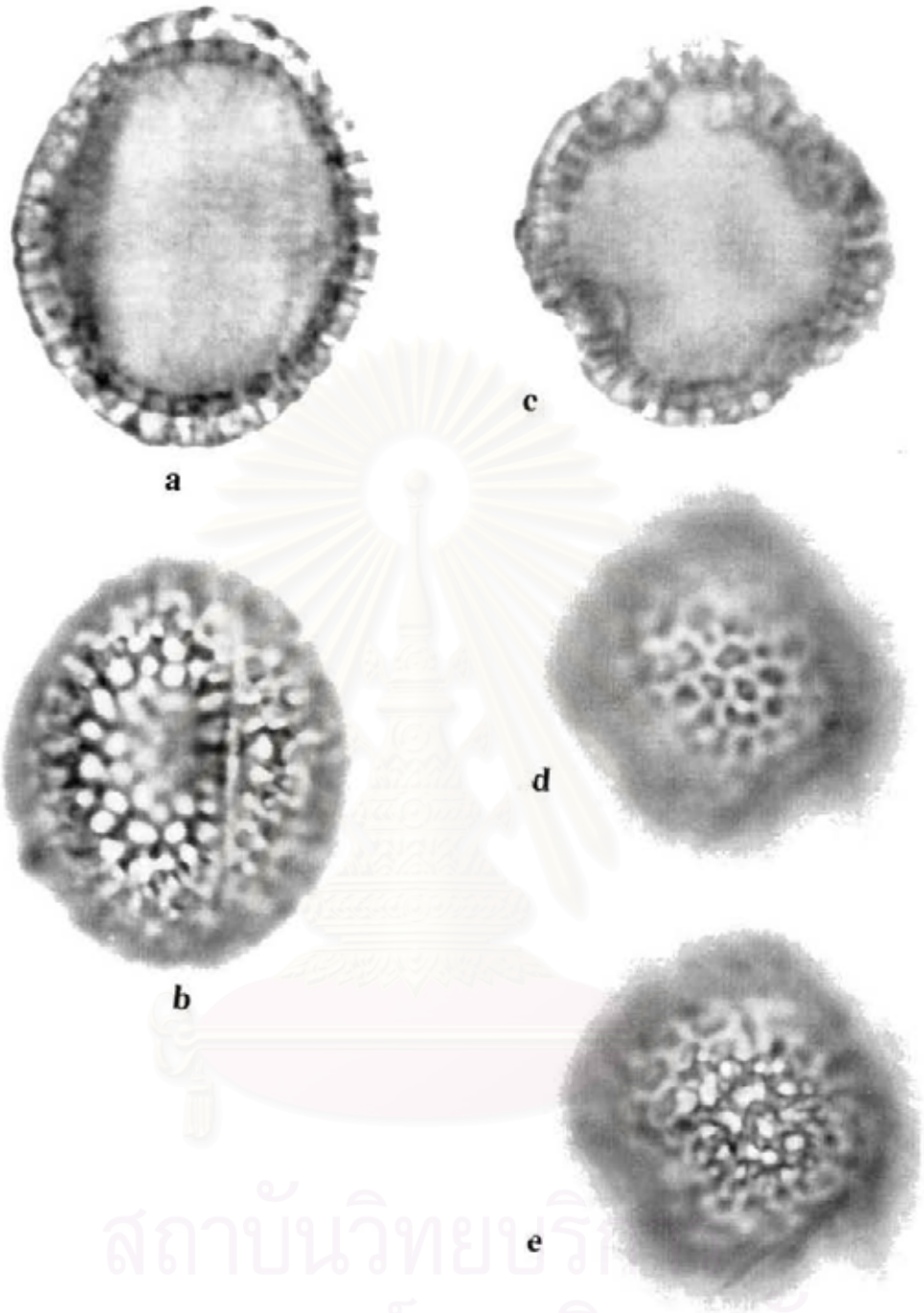


Plate 55. LM micrographs: a-d. ***Glochidion sphaerogynum*** **(Muell. Arg.) Kurz** (a-b) Equatorial view. (c) Polar view. (d) Sculpturing. All Micrographs ×1,750.

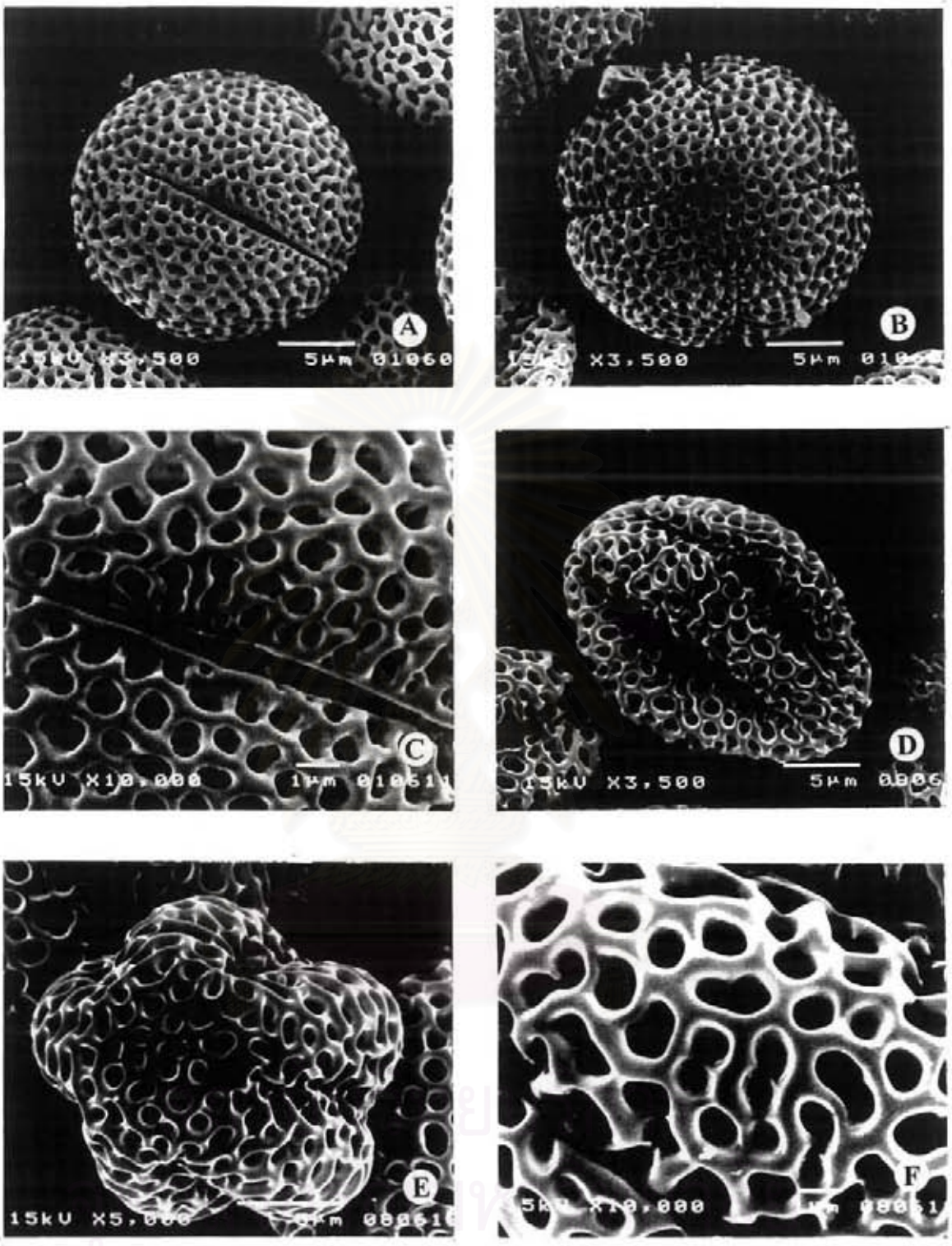


Plate 56. SEM micrographs: A-C. ***Glochidion littorale*** **Bl.** (A) Equatorial view. (B) Polar view. (C) Sculpturing. D-F. ***Glochidion rubrum*** **Bl.** (D) Equatorial view. (E) Polar view. (F) Sculpturing.

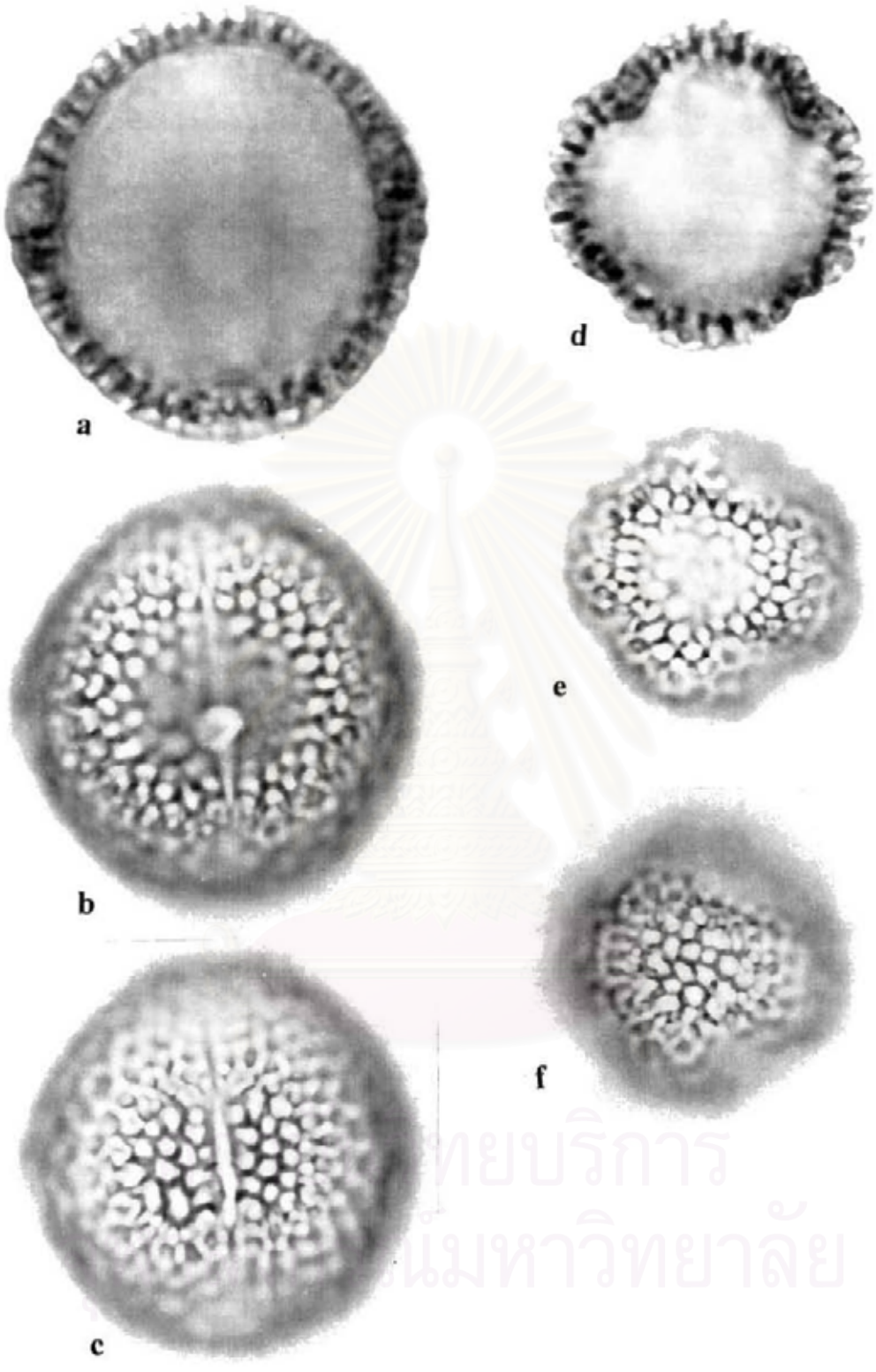


Plate 57. LM micrographs: a-f. ***Glochidion littorale*** **Bl.** (a-c) Equatorial view. (d) Polar view. (e-f) Sculpturing. All Micrographs ×1,750.

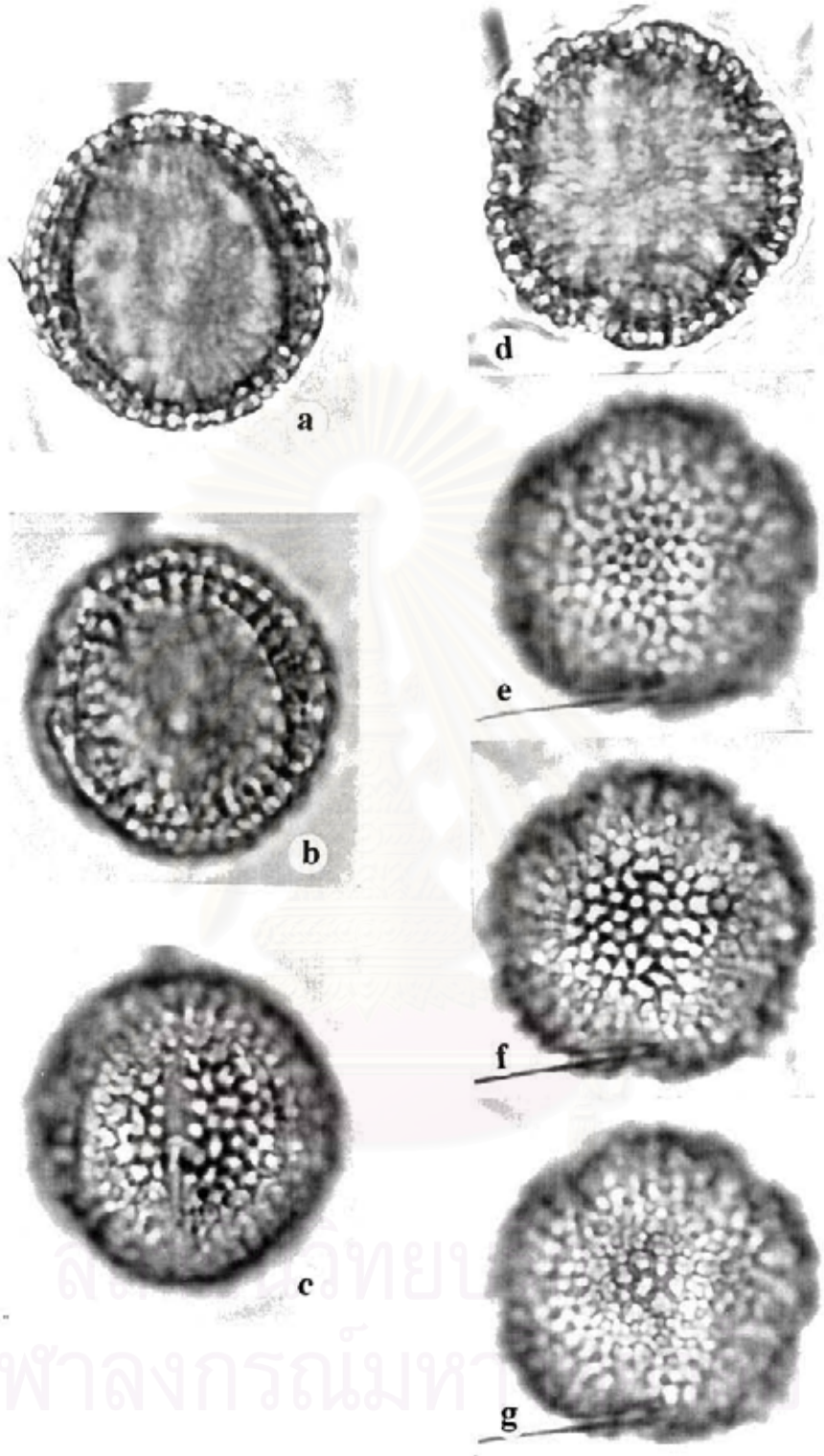


Plate 58. LM micrographs: a-g. ***Glochidion rubrum*** **Bl.** (a-c) Equatorial view. (d) Polar view. (e-f) Sculpturing. All Micrographs ×1,750.

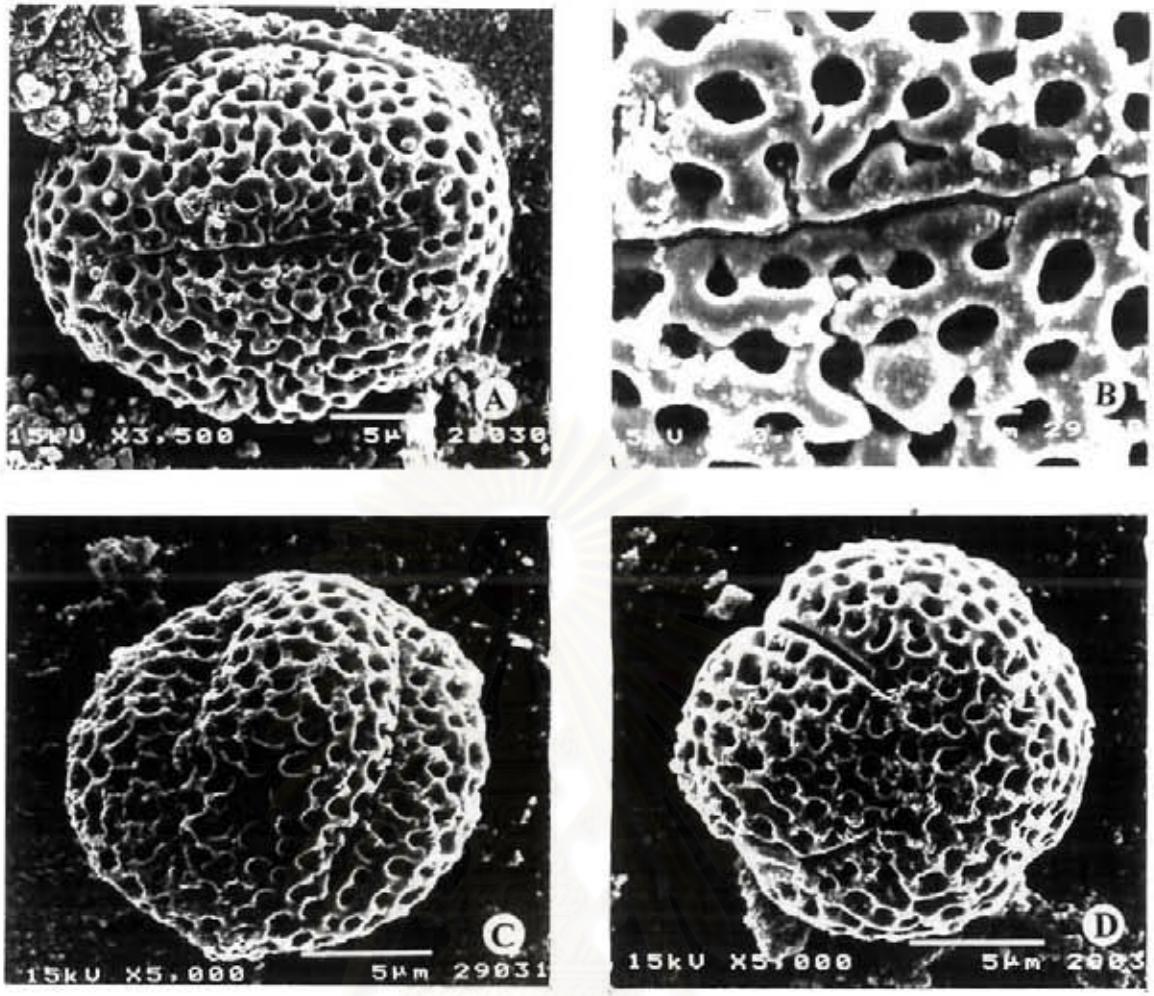


Plate 59. SEM micrographs: A-B. ***Glochidion sericeum*** **(Blume) Zoll et Marets** (A) Equatorial view. (B) Sculpturing. C-D. ***Glochidion superbum*** **Baill.** (C) Equatorial view. (D) Polar view.

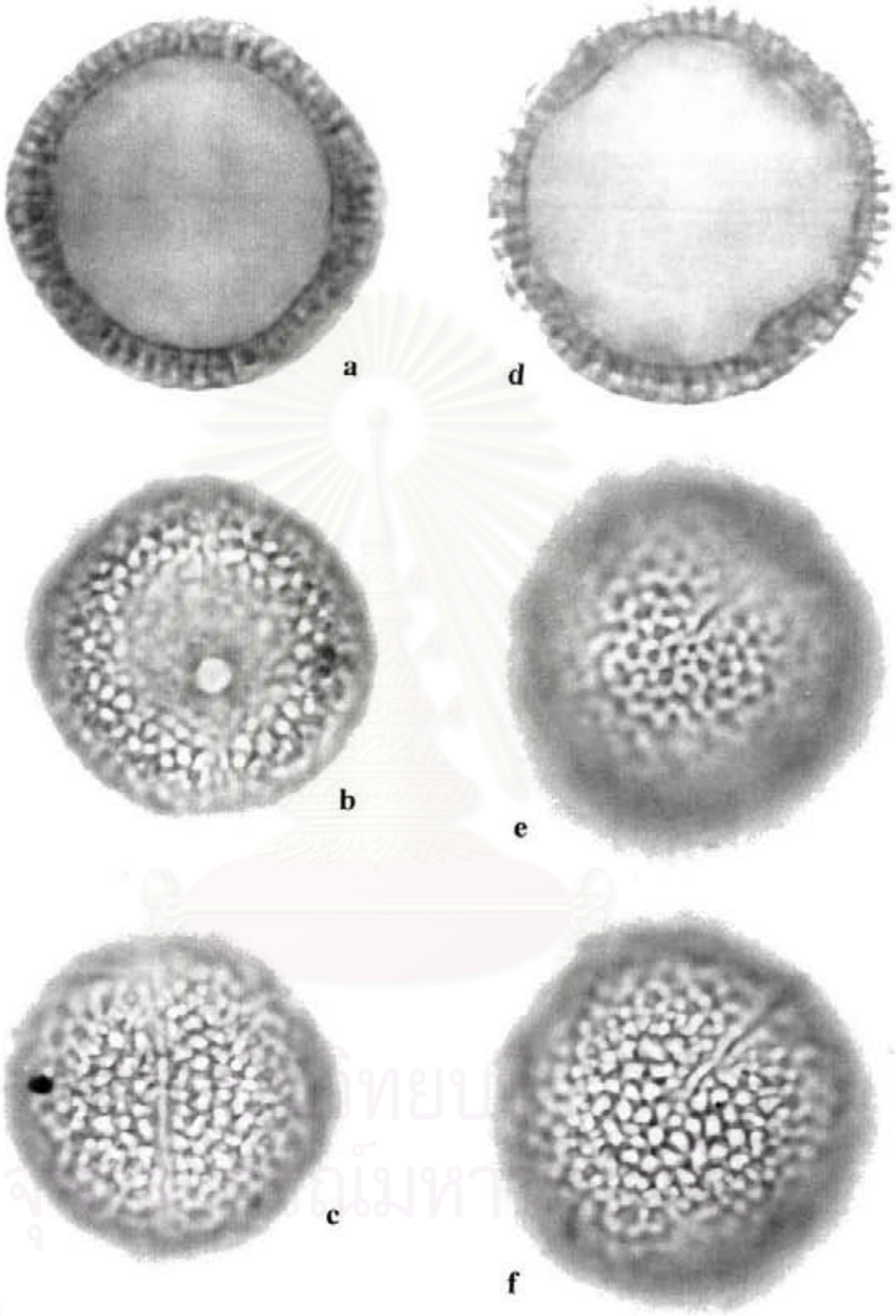


Plate 60. LM micrographs:a-f. ***Glochidion sericeum*** **(Blume) Zoll et Marets** (a-c) Equatorial view. (d) Polar view. (e-f) Sculpturing. All Micrographs ×1,750.

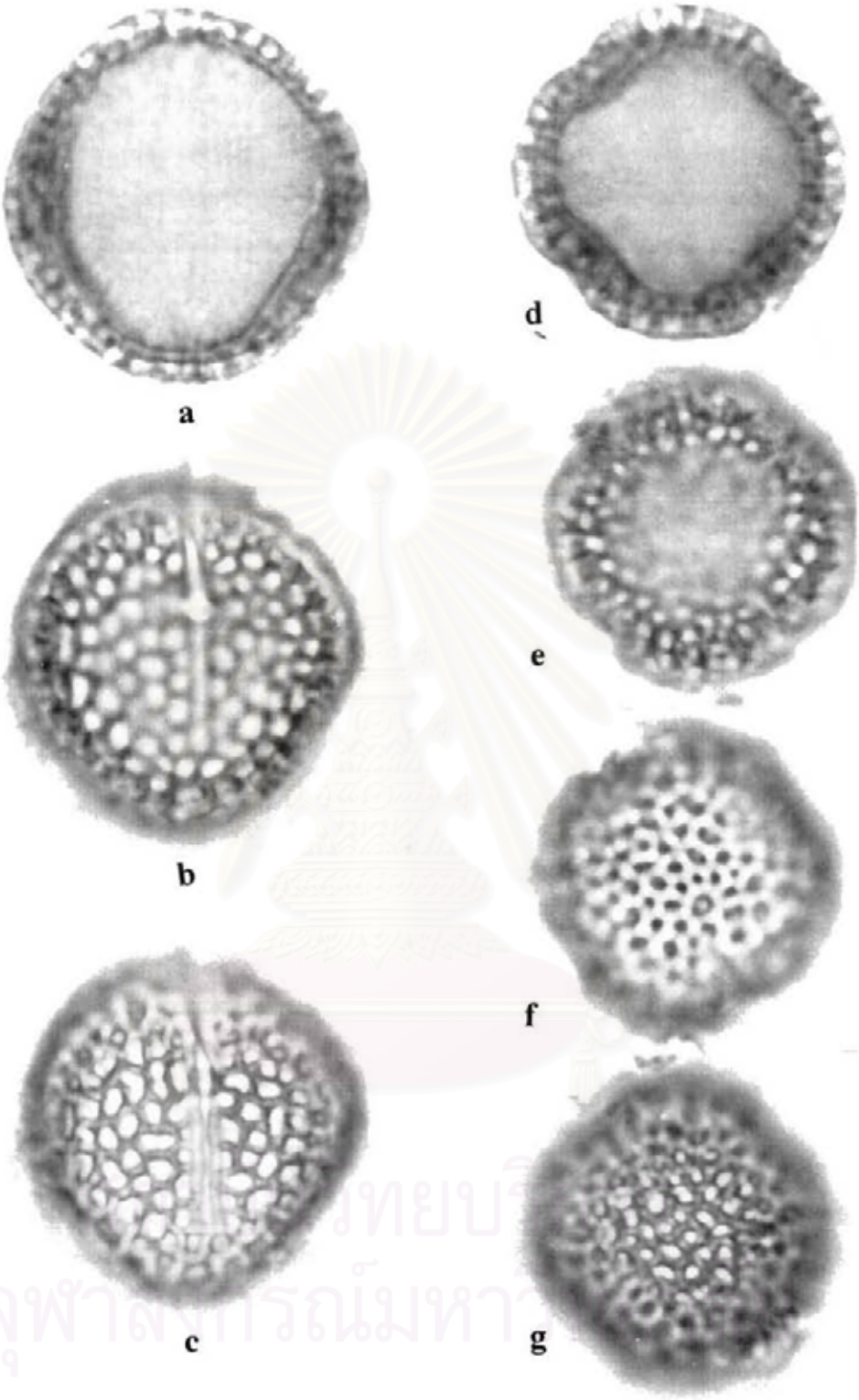


Plate 61. LM micrographs: a-g. ***Glochidion superbum*** **Baill.** (a-c) Equatorial view. (d) Polar view. (e-g) Sculpturing. All Micrographs ×1,750.

CHAPTER V

CONCLUSION AND DISCUSSION

1. General pollen morphology

The family Euphorbiaceae is distinctly eurypalynous. It displays a fairly wide range of pollen morphological characters; particularly in its sculpture and aperture.

1.1 Pollen polarity

Pollen grains of most genera studied, i. e *Baccaurea, Breynia, Bridelia, Cleidion, Glochidion, Hevea, Homonoia, Macaranga, Mallotus, Microstachys, Sampantaea, Thyrsanthera* and *Trewia* are isopolar and radial symmetry. A number of genera reveal apolarity, which is resulted from both inaperturate condition (in *Vernicia, Blachia, Baliospermum, Croton, Ostodes,* and *Trigonostemon*, and polyporate condition (in *Suregada*).

1.2 Polar field index

The polar field index of pollen grains can vary from very small (0.15 µm as in *Hevea brasiliensis*) to large (0.65 µm as in *Trewia nudiflora*)

1.3 Amb

The circumference of pollen grains in polar view, amb, within one species can vary from circular to triangular-obtuse with convex sides or three lobes as in the *Baccaurea, Bridelia, Cleidion, Hevea, Homonoia, Macaranga, Mallotus, Microstachys, Sampantaea, Thyrsanthera* and *Trewia.* However, many species show the consistent circumference of grains, the circular outline as in *Vernicia, Blachia, Baliospermum, Croton, Ostodes, Trigonostemon,* and *Suregada* or quadrangular-obtuse with convex sides as in *Glochidion.*

1.4 Shape

The apolar pollen grains, which have croton pattern of ornamentation usually occur in spheroidal shape, for instance, *Vernicia, Blachia, Baliospermum, Croton, Ostodes, Suregada*, and *Trigonostemon.* Though, the polar pollen grains of *Hevea brasiliensis* has also croton pattern because of its long 3-colpate character, its shape is then not exactly spheroidal, but suboblate or oblate-spheroidal. The genera

Baccaurea, Bridelia, Microstachys and *Thyrsanthera* are showed a shape of subprolate to prolate. The genera *Breynia, Cleidion, Glochidion, Homonoia, Macaranga, Mallotus, Sampantaea* and *Trewia* are showed a shape of oblate to oblate-spheroidal. Moreover, (*Microstachys chamealea*) shows rather acute poles, whilst *Homonoia riparia* has trucncate poles.

1.5 Size

The variation in size formed a gradient from small to large-sized. It seems that *Macaranga kurzii* (Kuntze) Pax et Hoffm. and *M. laciniata* Whitm. et Airy Shaw have the smallest pollen grains (about 9.00 µmin diameter), and *Vernicia montana* Lour. has the largest ones (about 60.00 µm in diameter).

1.6 Exine

Pollen grains included in this study are tectate, semitectate and intectate. Tectate grains are found in *Baccaurea, Cleidion, Homonoia, Macaranga, Mallotus, Sampantaea,* and *Trewia*. The intectate grains are typical structure of *Vernicia, Baliospermum, Croton, Hevea, Ostodes, a*nd *Suregada*. Semitectate grains are found in certain genera, i. e. *Breynia, Bridelia, Glochidion, Microstachys, Thyrtsanthera, Blachia, and Trigonostemon.*

1.7 Aperture

The basic number of the aperture is three, but 3-aperturate grains have never been found in the genus *Glochidion* which is usually 4-(5)–colporate. On one hand, an increase in number of aperture is, however, found in the genus *Breynia* (7-11 heterodiploporate) and *Suregada multiflora* (pantopolyporate). On the other hand, inaperturate grains are found in many genera, such as *Vernicia* and *Croton,* etc.

The position of aperture is mostly equatorial, however pantoaperture grains are accounted in *Suregada multiflora*. In *Breynia* spp., it is found that the apertures in one grain are usually diploporate, but the simple colporate apertures are also found, occasionally in the same grain. And the endoapertures of the colporate ones are not always situated at the equator, but vary from one ectocolpus to another.

The most common aperture type, which is found in most genera is colporate. colpate, porate, diploporate and inaperturate are also presented in some certain taxa, as shown in the table 5.

Table 5. Summary of aperture types of seventy species of Euphorbiaceae.

Aperture	Taxa
Colporate	*Baccaurea, Bridelia, Cliedion, Homonoia, Macaranga, Mallotus, Microstachys, Sampantaea, Thrysanthera, Trewia*
Colpate	*Hevea*
Diploporate	*Breynia*
Porate	*Suregada*
Inaperturate	*Vernicia, Blachia, Baliospermum, Croton, Ostodes, Trigonostemon*

The other significant details of aperture are endoaperture with costae occur in the genus *Baccaurea, Breynia, Bridelia, Cleidion, Homonoia, Glochidion, Macaranga, Mallotus, Sampantaea, Trewia,* and *Thrysanthera subobicularis* and ectoaperture with margo in the genus *Microstachys chamaelea*.

1.8 Sculpturing

The exine sculpturing of Euphorbiaceae pollen found in this present study is rather diversed. It reveals qualitative patterns that allow to discriminate 8 pattern of ornamentation, which are based on characters seen by both LM and SEM observation. They are:

1. Croton pattern, this is the most outstanding and the easiest recognisable ornamentation. It compossed more or less triangular, somewhat polygonal, structural elements, arranged in ring around a circular area. Even there is a basic similarity of this pattern, but there are quite clear the difference between these structural elements or subunits with respect to the detail of ornamentation that appeared on their surface, which could be seen only under SEM, as well as their arrangement that can be closely spaced or arranged in more open configurations. The croton pattern is found in the genus *Blachia, Baliospermum, Croton, Hevea, Ostodes, Trigonostemon, Suregada, Vernicia* of subfamily Crotonoideae.

2. Psilate (LM) or granulate (SEM) as in *Cleidion spiciflorum, Macaranga heynei, M. kurzii, M. laciniata, M. lowii, M. pruinosa, Mallotus barbatus, M. oblongifolius, M. paniculatus, Sampantaea amentiflora, Trewia nudiflora*, which the granular elements are minute, short and broadened at the base, blunt or pointed end and uniformly orientated or sometimes disorientated arrangment. Because of the very small-sized of granular elements (less than 1 μm), the ornamentation is thus, appeared as psilate under light microscope.

3. Scabrate as found in *Macaranga denticulata, M. indica, M. tanarius*. The sculptural elements are spine-like minute (height and diameter less than 1 μm) and uniformly orientated.

4. Perforate as in *Baccaurea,* with unevenly distributed tiny pores.

5. Foveolate as in *Baccaurea kuntleri,* with surface pitted. The pits are smaller than 1 μm, vary from rather round to elongate shapes or irregular in size. Muri not ridge.

6. Striato-reticulate as in *Bridelia harmandii* and *B. ovata*. The muri are curved uneven thickening and branched forming the continuous striate-network.

7. Striate as in *Bridelia tomentosa* and *B. stipularis*. The muri are curved and branched, parallel or subparallel running in the direction of pole to pole.

8. Microreticulate as in *Microstachys chamaelea* and *Baccaurea motleyana, B. lanceolata* and *B. ramiflora*.

9. Reticulate as in *Breybia, Glochidion,* which is rather coarse reticulation and *Thrysanthera suborbicularis* type with medium reticulation.

2. Pollen morphology in related to classification some genera.

The genera *Baccaurea, Breynia, Bridelia* and *Glochidion* are classified in the subfamily Phyllanthoideae, which is characterised by two consistent characters of 2 ovules per locule and lacking of laticifer (Keng, 1983). However, these four genera are rather morphologically heterogenous. The *Baccaurea* has no petal; stamen 4-10, free. The *Breynia* and *Glochidion* are also apetalous, but their stamens are united into a column, however, *Glochidion* has 2-dentate, erect stigmas while *Breynia* has 3-free stigma and style connect into column. The *Bridelia* has, on the other hand, 5 petal and free stamen. Palynologically, their pollen morphology is also rather diverse. The *Baccaurea* has 3- colporate, perforate to microreticulate pollen. The *Breynia* has a unique pollen type of polydiploporate and reticulate. The *Glochidion* has 4-(5)–colporate, reticulate and *Bridelia* has 3-colporate, striato-reticulate to striate pollen. However there are three important basic similarity among pollen grains of these four taxa, i.e. the zonoaperturate, colporate, and reticulate pattern. The diploporate of *Breynia* can be a derivation from colporate with one endoaperture (Thanikaimoni, 1986). The striato-reticulate, striate or perforate and microreticulate can be also be the allied type derived from reticulate pattern (Punt, 1975).

According to pollen morphology, *Baccaurea* might be the most primitive genus among these four taxa which are more advanced, according to the higher number of aperture (4-(5)–colporate) in *Glochidion*, striate pattern in *Bridelia*, and the more complex aperture system (diploporate) in *Breynia*.

The genera *Blachia, Baliospermum, Croton, Hevea, Ostodes, Trigonostemon, Suregadaa* and *Vernicia* are classified in the subfamily Crotonoideae which is characterised by of 1 ovule per locule (Keng, 1983). Pollen morphologically, they are rather uniform in regard to their croton pattern of ornamentation, which has never been found in any other subfamilies. The aperture type is mostly inaperturate, except in two genera, *Hevea* and *Suregada*, which posseses 3-colpate and polyporate, respectively.

In conclusion, these 8 genera are rather stenopalynous. It might palynologically suggest the monoplyly of those taxa indicated by the unique croton pattern.

3. Phylogenetic relationships of genera in the Euphorbiaceae

As proposed by many authors, the phylogenetic relationships of the Euphorbiaceae have been varied (cited in Punt, 1967). In this study phylogenetic trends would base mainly on apertural characters and ornamentation of exine. And the possible groups of related genera were presented. Though, it can only be the hypothetical aspect. This proposed hypothetical relationships must be considered as highly possibility. In conclusion all investigated species can be established into nine phylogenetic trends (Table 6).

Table 6. Proposal of possible phylogenetic trends.

Aperture:	
1. inaperturate	→ 3-colpate / 3-colporate / polyporate
2. 3-colpate	→ polyporate
3. 3-colporate	→ 4-, 5-colporate / polydiploporate
4. ectocolpi without margo	→ ectocolpi with margo
Exine:	
5. tectate	↔ semitectate → intectate
Sculpturing:	
6. reticulate	↔ perforate / foveolate → granulate / scabrate
7. reticulate	→ striato-reticulate → striate
8. lumina small	→ lumina larger
Polarity:	
9. Apolar	→ isopolar

Trend 1. According to Muller (1981) quoted the work of Baksi et al, 1979, the first appearance of the Euphorbiaceous was in Tertiary period. The oldest pollen fossil record was of *Crotonipollis burduranensis* from the Paleocene and Eocene of Bengal (India), which was very similar to the Croton type, which was inaperturate. The younger ones were of *Crototricolpites densus* from the Oligocene and lower Miocene of Cameroon found by Salard-Cheboldoeff in 1978, both of them had 3-colpate aperture. The composite aperture (colporate) seemed to appear a bit later in middle Eocene which was represented by *Retitricolporites irregularis* found in Tennessee in 1974 by Elsik and Dilcher (Muller, 1981)

Walker (1974) also suggested that colpate pollen was evolved from monosulcate through inaperturate intermediate form in angiosperms. Thus, its seems that, within Euphorbiaceae, the inaperturate condition is probably the most primitive aperture type, then it might independently evolve to be colpate, colporate or polyporate.

Trend 2. This trend from colpate aperture to colporate is accepted by Walker and Doyle, 1974 and Thanikaimoni, 1986. In this present study, the colporate (*Baccarea, Bridelia, Cleodion, Homonoia, Macaranga, etc.*) can be a derivation from colpate (*Hevea brasiliensis*).

Trend 3 This trend is accepted by most palynologist (Punt, 1975). In this present study, the basic number of aperture is three. An increasing in number of aperture is accounted the genera *Glochidion*, which is always 4-(5)-colporate, and *Breynia* which has 7-11-diploporate pollen grain.

Trend 4. This trend has already suggested by most author (Punt, 1975). The presence of a margo was found only in the *Microstachys chamaelea* type. This pollen type is very closed to the *Baccaurea motleyana* type in all aspects, except the absence of margo in the latter type.

Trend 5 The trend of the exine from tectate to semitectate, to intectate respectively, was previously suggested by Walker and Doyle (1975) and intectate exine was the advanced from in angiosperms (Walker, 1975). Most of pollen type is found in the present study are tectate and semitectate. The intectate grain was found only in Croton type, and was quite characteristic the pollen grains of the subfamily Crotonoideae. The reversed direction from semitectate to tectate was also possible and already suggest by Walker (1974).

Trend 6, 7, and 8. The basic pattern of sculpturing of angiosperm pollen is reticulation (Punt, 1975). Of seventy species studied, the pollen sculpturing is mostly reticulation. Granulate, perforate, foveolate, striato-reticulate, and striation were the derivative pattern. So the trend 5, 6, and 7 were presented.

Trend 9. A major evolution trend in the polarity of angiosperm pollen grains have been discussed by Walker and Doyle (1975). They presented the heteropolar pollen the main evolutionary trend has been to apolar inaperturate pollen. Apolar character is found in inaperturate pollen of *Croton* spp. and polypantoporate pollen of *Suregada multiflora*. The major grounps of species, for instance of *Baccaurea, Breynia, Bridelia, Hevea, Homonoia, Macaranga, Mallotus,* etc. shows the isopalrity of pollen grains. Thus, the isopolar pollen type could evolve apolar pollen.

According to pollen morphology of 70 species representation 20 genera of Euphorbiaceae in Thailand, the result revealed that the pollen grains are eurypalynous family. The fifteen pollen types were separated mainly by their apertural and exine sculpturing. It is found that the pollen morphology of the same genus has related remarkable character (Table 7). Some characters are distinctive enough to allow the identification of individual grain to a generic or specific levels, which the SEM observation could interprete more detail of pollen ornamentation. Hence, the differentiation of sexine pattern seen under SEM is varied from perforation into foveolation, microreticulation, reticulation, striato-reticulation, and striation. Croton pattern, there is a basic similarity of Crotonoideae which the structural elements or subunits with respect to the detail of ornamentation that appeared on their surface and can be closely spaced or arranged in more open configurations.

In conclusion, aperture type of pollen grains is a significant evidence using for phylogenetic trend (Fig. 3). However, the completely classification or phylogenetic trends would be studied about cytogenetics and palynology. This may help to solve the taxonomic and evolution problem of this family.

Table 7. The relationship between the essential characters of Euphorbiaceous grains, based on SEM data of 70 species.

Aperture	Sculpturing	Other distinguished characters	Taxa
inaperturate	croton pattern	a circular ridge on tectum absent; clavae elements rather closely space in arrangement; clavae head with triangular-circular shape, undulate margin.	*Croton sublyratus*, *C. caudatus*, *C. kongensis*, *C. oblongifolius*, *C. poilanei*, *C. robustus*, *C. tiglium*, *C. roxburghii*
		a circular ridge on tectum absent; clavae elements distantly space in arrangement; clavae head with triangular-circular shape, entire margin.	*Vernicia montana*, *Croton cascarilloides*, *C.kerrii*
		a circular ridge on tectum present; clavae elements distantly space in arrangement; clavae head with triangular-circular shape, acute apices, deeply lobed and undulate margin.	*Baliospermum effusum*, *B. micranthum*, *B. montanum*, *B. siamense*, *Croton bonplandianus*, *Ostodes paniculata*
		a circular ridge on tectum present; clavae elements distantly space in arrangement; clavae head with triangular-circular shape, round apices, with triangular-circular shape, entire margin.	*Croton thorelii*
		structure elements form a reticulum of semitectum; clavae head with a very small and irregular in shape, rather acute apices, undulate margin; small granules occur in circular ring	*Trigonostemon reidioides*, *Blachia siamensis*

Table 7 (continued)

Aperture	Sculpturing	Other distinguished characters	Taxa
zonocolpate	croton pattern	3-colpate, baculate	*Hevea brasiliensis*
zonocolporate	granulate	3-colporate, lalongate and equatorial endocolpus	*Cleidion spiciflorum Homonoia riparia, Macaranga heynei, M.kurzii, M. laciniata, M. lowii, M. pruinosa, Mallotus barbatus, M. oblongifolius, M. paniculatus, Sampantaea amentiflora, Trewia nudiflora*
	scabrate	3-colporate,equatorial endocolpus, costae present.	*Macaranga denticulata, M. indica, M. tanarius*
	perforate	3-colporate, lalongate, costae present.	*Baccaurea bracteata,*
	foveolate	3-colporate, lalongate, costae present.	*Baccaurea kunstleri, B. lanceolata*
	striate	3-colporate,lalongate, costae present.	*Bridelia tomentosa, B. stipularis*

Table 7 (continued)

Aperture	Sculpturing	Other distinguished characters	Taxa
zonocolporate	striato-reticulate	3-colporate,lalongate	*Bridelia harmandii*, *B. ovata*
	microreticulate	3-colporate, lalongate, without margo	*Baccaurea motleyana*, *B. ramiflora*
		3-colporate,lalongate, with margo, costae present.	*Microstachys chamaelea*,
	reticulate	3-colporate, lalongate	*Thyrsanthera suborbicularis*
		4-(5)-colporate, lalongate	*Glochidion acuminatum* var. *siamense*, *G. arborescens*, *G. assamicum*, *G. coccineum*, *G. eriocarpum*, *G. daltnii*, *G. glomerulatum*, *G. hirsutum* , *G. hongkongenesis*, *G. kerri* , *G. lanceolarium*, *G. littorale*, *G. nubigenum*, *G. obscurum*, *G. rubrum*, *G. sericeum*, *G. sphaerogynum*, *G. superbum*.
7-11-zonohetero-diploporate	reticulate	two pori per colpi, rarely with one pore at nearly the pole, costae present.	*Breynia fruticosa*, *B. glauca*, *B. vitis-idaea*
pantopoly-porate	croton pattern	a circular ridge on tectum absent; clavae elements rather closely space in arrangement; clavae head with triangular-circular shape, undulate margin.	*Suregada multiflora*

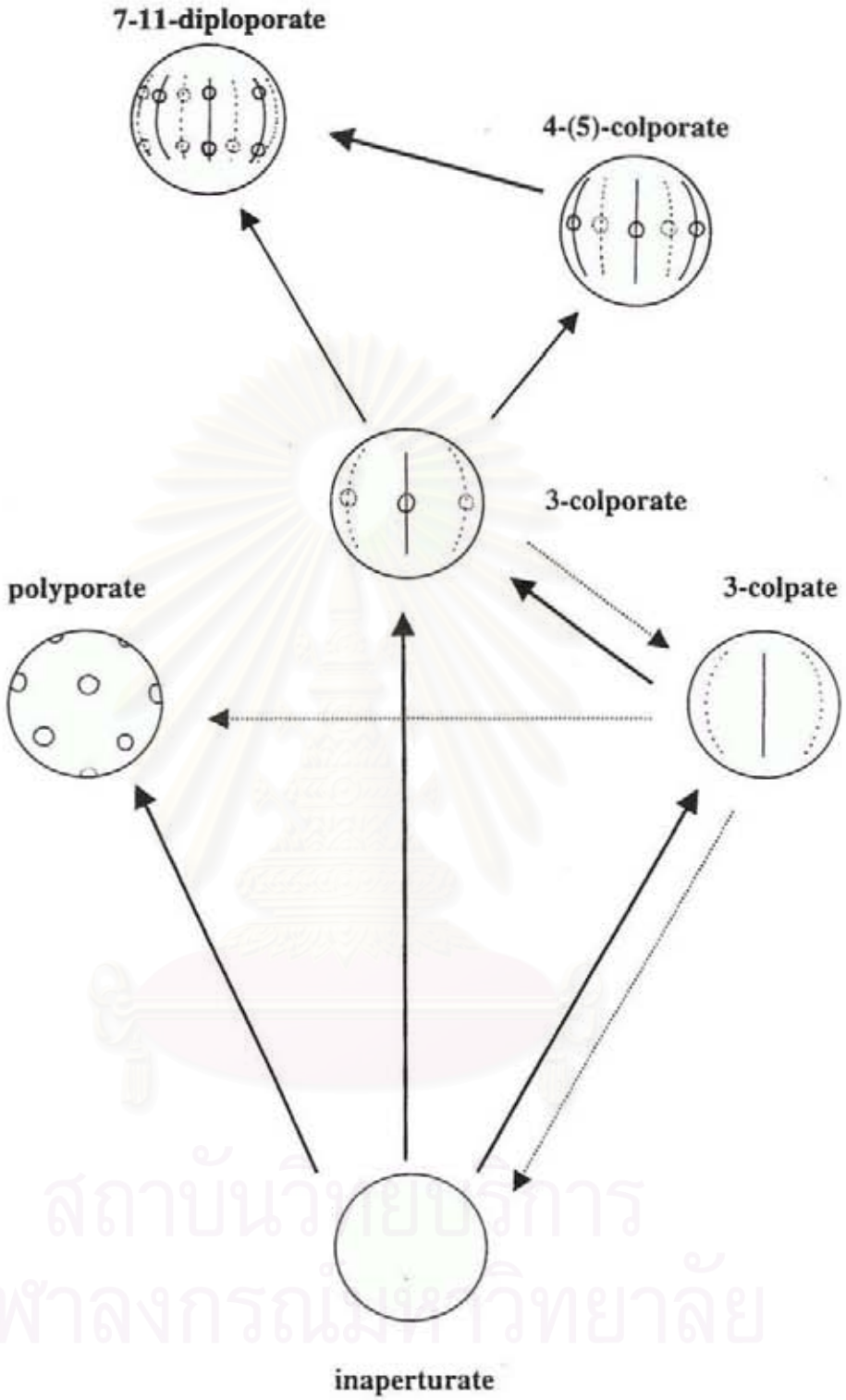


Figure 3 A possible phylogenetic trend of apertures types of pollen in 20 genera of Euphorbiaceae in Thailand.

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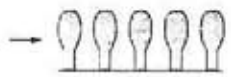
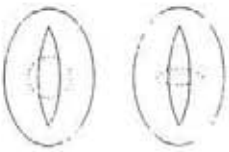
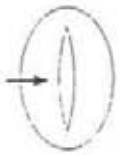
APPENDIX

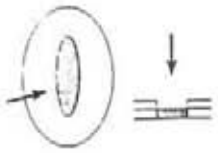
GLOSSARY

Acetolysis	A widely used technique for preparing pollen and spore exine for study.
Amb	The outline of a pollen grain or spore seen in polar view.
Aperture (adj. aperturate)	A specialised region of sporoderm, that is thinner than the remainder of the sporoderm and generally differ in ornamentation and/or structure.
Apolar	Describing pollen and spores without distinct polarity 
Baculum (bacula,pl. , baculate adj.)	Structure elements with at least one dimension 1µm or large in the shape of rod. Occur on the tectum only. 
Clavate (clavae, pl.)	Structure elements with at least one dimension 1µm or large in the shape of clubs. Occur on the tectum only. 
Colporus (colpori, pl. colporate,adj.)	A compound aperture consisting of an ectocolpus with one or more endoapertures. 

Colpus (colpi, pl. colpate, adj.) — An elongate, aperture with a length/ breadth ratio greater than 2 .



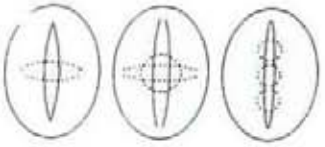
Colpus menbrane — The aperture membrane of a colpus.



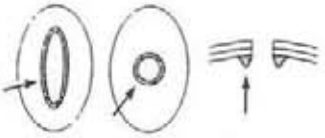
Columella (columellae, pl. , columellate, adj) — A rod-like element of the ectexine/sexine, either supporting a tectum or a caput.

Composite aperture — Synonym of compound aperture.

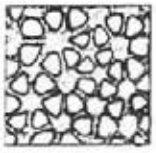
Compound aperture — An aperture with two or more components that are situated on more than one wall layer.



Costa (costae, pl. colporate, adj.) — A thickening of the endexine/nexine bordering an endoapeture, or following the outline of an ectoaperture.

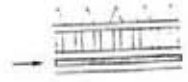


Croton pattern — A characteristic type of ornamental comprising rings of five or six (sometimes more) raised, often triangular, sexine elements arrange around a circular area, usually formed by capitate columellae.

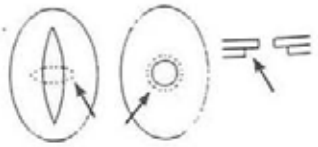


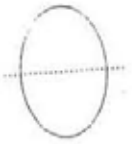
Diploporate (adj.) — Describing an ectocolpus with two endoaperture.

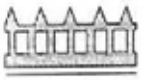
Endexine — The inner part of the exine which remains relatively unstained with basic fuchsin in optical microscopy and has a lower electron density in conventionally prepared TEM sections (synonym of nexine).



Ektexine	The outer part of the exine, which stains positively with basic fuchsin in optical microscopy and has a higher electron density in conventionally prepared TEM sections (synonym of ectexine).
Endoaperture	An aperture in the inner layer of the sporoderm, often the inner aperture of a compound aperture.
Equatorial axis	Often misappropriately used as a synonym of equatorial diameter.
Equatorial diameter	A line, lying in the equatorial plane.
Equatorial view	The view of pollen grain or spore where the equatorial plane is directed towards the observer.
Eurypalynous (adj.)	Describing plant taxa characterized by possession of a great diversity of palynomorphs.
Exine	The outer layer of the wall of a palynomorph, which is highly resistant to strong acids and bases, and is composed primarily of sporopollenin.
Foveola (foveolae, pl. foveolate, adj.)	A feature of ornamentation consisting of more or less rounded depresions or lumina more than 1 μm in diameter. The distance between foveolae is greater than their breadth.
Granulum (granula, pl. granulate,adj.)	A very small and rounded element of the ectexine/sexine that is less than 1μm in all directions.
Inapeturate	Pollen without apertures.







Intectate (adj.) Describing a pollen grains or spore with an arrangement of elements irregularly distributed.

Intine The inner most of the major layers of the pollen grain wall underlying the exine and bordering the surface of cytoplasm.

Isopolar (adj.) Describing a pollen grains or spore in which the proximal and distal faces of the exine are alike.

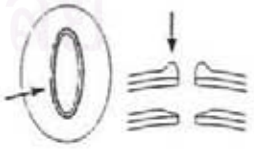
Lalongate (adj.) Describing the shape of a transversely elongate endoaperture.

LO-analysis A method for analyzing pattern of sexine organization by mean of light microscopy.

OL-pattern A pattern of ornamentation that appears to show bright islands at high focus (H) and that become dark at low focus (L).

Lumina (pl.) The space enclosed by muri.

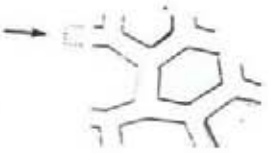
Margo An area of exine around an ectocolpus that is differentiated from the remainder of the sexine, either in ornamentation or by difference in thickness.



Microreticulate(adj.) A reticulate ornamentation consisting of muri and lumina smaller than 1μm.

Monad — A pollen grain or spore dispersed as an individual unit, rather than in association with others, such as in a dyad, tetrad or polyad.

Muri (pl.) — A ridge that is part of the ornamentation and, for example, separates the lumina in a reticulate pollen grain or the striae in striate pollen grain.



Nexine — The inner, non-apertured part of the exine which lies below the sexine.

Nexine 1 — Synonym of foot layer.

Nexine 2 — Synonym of endexine.

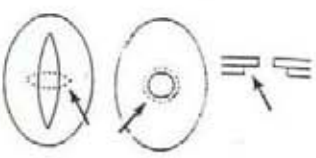
Non-aperture — Synonym of inaperturate.

Oblate — Describing the shape of a pollen grain or spore in which the polar axis is shorter than the equatorial diameter. In the system oblate is defined as a ratio the polar axis and equatorial diameter of 0.50-0.75.

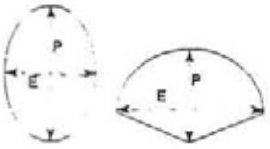
Oblate-spheroidal — Describing the shape of a pollen grain or spore in which the ratio between the polar axis and equatorial diameter is 0.88-1.00.

Ornamentation — A general term that is useful for describing the organization of features (synonym of pattern, sculpture)

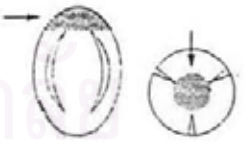
Ora (adj.) — That part of a composite aperture which is formed by the crossing of the colpus and the colpus transversalis.



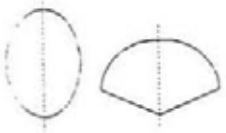
Outline	A general descriptive word. Applied in descriptive terms like equatorial outline and outline in polar view.
Palynology	The study of pollen grains and spore and of other biological materials that can be studies by means of palynological techniques.
Palynomorph	A general term for entities found in palynological preparations
Pattern	A general word, applied in palynology either to surface feature or infratectal elements.
P/E ratio	The ratio of the length of the polar axis (P) to the equatorial diameter (E).



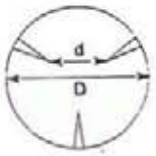
Perforate (adj.)	A general adjective indicating the presence of holes, applied in palynology to holes less than 1 μm in diameter and generally situated in the tectum.
Perprolate (adj.)	Describing the shape of a pollen grain or spore in which the ratio between the polar axis and equatorial diameter is more than 2.
Pitted	A general term for small depressions.
Polar area	Synonym of apocolpium.



Polar axis	The straight line between the distal and proximal poles of a pollen grain or spore.



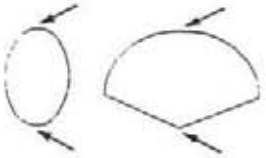
Polar field index — The proportion of the greatst distance between the ends of two furrows and the greatest breadth of the pollen grain (Equatorial axis).



Polypantoporate — With more than six pori scattered all over the surface of the grain.

Polarity — The condition of having distinct poles.

Pole — Either of the two extremitics of polar axis.



Pollen — The microgametophyte of seed plants, developed from the microspore.

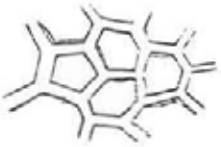
Pore (pores, pl., porate, adj.) — A general term, applied in palynology to a circular or elliptic aperture with a length/breadth ratio less 2

Porus (pori, pl., porate, adj.) — Synonym of pore.

Prolate — Describing the shape of a pollen grain or spore in which the ratio between the polar axis and equatorial diameter is 1.33-32.00.

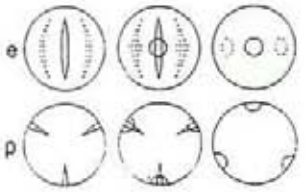
Prolate spheroidal — Describing the shape of a pollen grain or spore in which the ratio between the polar axis and equatorial diameter is 1.00-1.14.

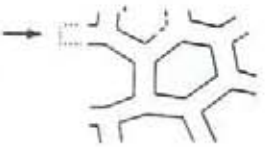
Proximal	A common descriptive term used in contrast to distal, applied in palynology to features on the surface that face towards the centre of the tetrad during development.
Psilate (adj.)	Describing a pollen or spore with a smooth surface.
Retangular-obtuse	Shape of a grain in equatorial view where the grain resembles a rhomboid with the corners rounded.
Reticulum (reticula, pl. reticulate,adj.)	A network-like pattern consisting of lumina or other spaces wider than 1 µm bordered by elements narrower than the lumina.
Rugulate (adj.)	Describing a type of ornamentation consisting of elongated sexine elements more than 1 µm long, arranged in irregular pattern that is intermediate between striate and reticulate.
Scabrate(scabra, sing, scabrae, pl.)	Describing elements of ornamental, of any shape, smaller than 1 µm in all directions.
Sculpturing	The surface relief, or topography, of a pollen grain or spore.
Semitectate	The outer, sculptured layer of the exine, which lies above the nexine.
Sexine	Outer sculptured part of the exine, which in angiosperms takes the form of a set of radially diarested rods supporting a roof.
Shape classes	Categories of pollen and spore shape based on the relations between polar axis (P) and equatorial diameter (E).
Simplicolumellate	With a single row of columellae under each murus.

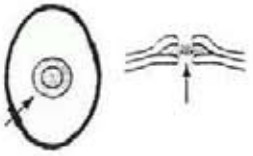


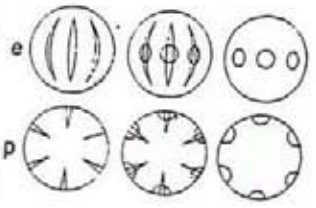
Size classes	Categories of pollen and spore shape based on the length of the longest of polar axis (P) or equatorial diameter (E). (very small = less than 10µm, small = more than 10-25µm, medium = more than 25-50µm, large = more than 50-100µm, very large = more than 100-200µm, gigantic = more than 200 µm).
Spheroidal	Describing the shape of a pollen grain or spore in which the polar axis and equatorial diameter are approximately equal.
Sporoderm	The entire wall of a pollen grain or spore.
Sporopollenin	The names given to the acetolysis resistant biopolymers which make up most of the material of the exine.
Stenopalynous	Describing plant taxa characterized by only a slight variation in their palynomorphs.
Striate	A general descriptive term applied in palynology to elongated generally parallel elements separated by grooves.
Striato-reticulate	Describing a pattern in which parallel or subparallel muri are cross-linked to form a reticulate in the grooves. The connections between the muri lie on a single level or different levels.
Structure elements	Individual element either on the endexine or on the tectum.
Subprolate	Describing the shape of a pollen grain or spore in which the ratio between the polar axis and equatorial diameter is 1.14-1.33.

Subspheroidal	Describing the shape of a pollen grain or spore in which the ratio between the polar axis and equatorial diameter is 0.75-1.33.
Tectum (tecta, pl., tectate, adj.)	The layer of sexine, which forms a roof over the columellae, granules or other infractectal elements.
Tricolpate, tricolporate, triporate	Describing pollen grains with three ectocolpi, three compound aperture or three pores arranged in an equatorial zone.
Vallum (valla, pl.)	Sometimes used to describe a single, broad, raised feature in certain fossil spores.
Vermiculate (adj.)	A general descriptive term used to describe winding features.
Verrucate	A wart-like sexine element, more than 1 μm wide, that is broader than it's highly and is not constricted at the base.
Vestibulum (vestibula, pl.)	A separation between layers of the exine forming a cavity between the inner and outer pores.
Zono-aperturate	Describing apertures which situated only on the equator.









BIOGRAPHY

Miss Kunda Kasetsinsombat was born on February 11, 1972 in Prachaup Kiri Khan province. She got Bachelor degree from Department of Botany, Faculty of Science, Chulalongkorn University in 1995, then continued her study for Master of Science in Department of Botany, Faculty of Science, Chulalongkorn University from 1996-1999.