

## Pollen Flora of Yuenyang Lake Nature Preserve, Taiwan (III)

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**ABSTRACT:** This is a supplementary study to previous reports (Chen and Wang, 1999; Wang and Chen, 2001). The pollen morphology of sixteen taxa belonging to four families, collected from Yuenyang Lake Nature Preserve, was examined under light and scanning electron microscopes in the present study. The following are pollen classes obtained on the basis of the pollen aperture: pantoporate, 3-colporate and 4-7-colporate pollen. The results could be useful in the reconstruction of vegetation history around the Yuenyang Lake.

**KEY WORDS:** Pollen Flora, Yuenyang Lake Nature Preserve, Taiwan.

### INTRODUCTION

Yuenyang Lake is an acidic lake situated within a nature preserve in northern Taiwan. This study is the third in the series on the pollen flora of Yuenyang Lake Nature Preserve of Taiwan. The first and the second parts had been published by Chen and Wang (1999) and Wang and Chen (2001). The present study includes pollen types of the families of Primulaceae, Ranunculaceae, Rhamnaceae and Rosaceae. The study on pollen flora of Yuenyang Lake is intended to facilitate the reconstruction of the past terrestrial vegetation around Yuenyang Lake (Chen and Wu, 1999).

### MATERIALS AND METHODS

Fresh pollen grains of 16 species, belonging to 4 families of angiosperms (Tab. 1), were collected from the Yuenyang Lake Nature Preserve. The treatment of all specimens for LM- and SEM-observation was the same as in our previous study (Chen and Wang, 1999). Voucher specimens are deposited in the Palynological Laboratory, Department of Botany, National Taiwan University.

### RESULTS

The pollen morphology of 16 species is described in alphabetical order by the families.

#### Primulaceae

##### *Lysimachia congestiflora* Hemsl (Plate 1)

Pollen grains 3-5-colporate, sometimes parasyncolporate, isopolar, prolate-spheroidal to subprolate in equatorial view,  $28.5-46.5 \times 25-36 \mu\text{m}$  (P/E = 1.06-1.27), circular-lobate or circular in polar view,  $23.5-39 \mu\text{m}$  in diameter.

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Table 1. List of plant specimens used for this study.

Family	Scientific name	Collection	Collection date
Primulaceae	<i>Lysimachia congestiflora</i> Hemsl.	Wang 1126	5 Jul 1994
Ranunculaceae	<i>Coptis quinquefolia</i> Miq.	Wang 1175	25 Jan 1995
Rhamnaceae	<i>Rhamnus crenata</i> Sieb. & Zucc.	Wang 1059	24 May 1994
Rosaceae	<i>Photinia niitakayamensis</i> Hayata	Wang 784	2 Aug 1993
	<i>Pourthiaea villosa</i> (Thunb. Ex Murray) Decne. var. <i>parvifolia</i> (Pritz.) Iketani & Ohashi	Wang 1037	26 Apr 1994
	<i>Prunus matuurai</i> Sasaki	Wang 958	21 Mar 1994
	<i>Prunus phaeosticta</i> (Hance) Maxim.	Wang 1005	19 Apr 1994
	<i>Rhaphiolepis indica</i> (L.) Lindl. ex Ker var. <i>tashiroi</i> Hayata ex Matsum. & Hayata	Wang 678	21 May 1993
	<i>Rhaphiolepis indica</i> (L.) Lindl. ex Ker var. <i>umbellata</i> (Thunb. ex Murray) Ohashi	Wang 1026	26 Apr 1994
	<i>Rosa taiwanensis</i> Nakai	Wang 736	21 Jun 1993
	<i>Rubus corchorifolius</i> L. f.	Wang 648	27 Apr 1993
	<i>Rubus croceacanthus</i> Levl.	Wang 636	27 Apr 1993
	<i>Rubus formosensis</i> Ktze.	Wang 807	3 Aug 1993
	<i>Rubus liuii</i> Yang & Lu	Wang 675	21 May 1993
	<i>Rubus pectinellus</i> Maxim.	Wang 666	21 May 1993
	<i>Rubus sumatranus</i> Miq.	Wang 662	21 May 1993

Colpi long, narrow, crassimarginate, with margo. Colpus membranes easily ruptured during acetolysis. Ora transversally parallel, ends obtuse.

Exine 2.5-4  $\mu\text{m}$  thick. Columellae distinct. Sexine reticulate. Muri simpli-columellate, 0.3-0.5  $\mu\text{m}$  wide. Perforations irregular, polygonal, less than 2  $\mu\text{m}$  in dimension, diameter larger than the width of the separating muri in the mesocolpia, decreasing in size towards the colpi, densely covered with verrucae in the perforations, verrucae 0.15-0.4  $\mu\text{m}$  in dimension.

Herbs; growing at medium to high altitudes of northern and central parts of the island, and on forest floors around Yuenyang Lake.

### Ranunculaceae

#### *Coptis quinquefolia* Miq. (Plate 2)

Pollen grains pantoporate, 12-16-porate, apolar, spheroidal to polyhedral, radially symmetrical, 18.5-27  $\mu\text{m}$  in diameter.

Pores circular, recessed, margins inconspicuous, 2-4.8  $\mu\text{m}$  in diameter, pore membranes densely spinulate, spinules conical, 0.5-1  $\mu\text{m}$  wide, remaining intact after acetolysis.

Exine 2-2.5  $\mu\text{m}$  thick, decreasing in thickness near pores. Columellae distinct. Sexine spinulate, spinules with wide-based cone, evenly spaced throughout, less than 0.4  $\mu\text{m}$  long, 0.2-0.4  $\mu\text{m}$  wide. Tectal surface minutely perforated, perforations densely spaced, less than 0.07  $\mu\text{m}$  in dimension. Nexine as thick as sexine.

Perennial herbs; growing at medium to high altitudes under wet and shady forests, and on forest floors around Yuenyang Lake.

### Rhamnaceae

#### *Rhamnus crenata* Sieb. & Zucc. (Plate 3)

Pollen grains 3-colporate, isopolar, oblate to oblate-spheroidal in equatorial view, 13-23.5  $\times$  16-25.5  $\mu\text{m}$  (P/E = 0.73-0.95), mesocolpia flattened, triangular-truncate with slightly concave sides in polar view, 16.0-27  $\mu\text{m}$  in diameter.

Aperture atrium type. Colpi long and narrow, margins uneven, end tapering, granules irregularly and sparsely distributed on the colpus membranes. Ora lalongate, with two ends connected to the thinner part of exine, forming a distinct H-shape, four thickenings large and distinct stretched along colpi.

Exine 1.5-2  $\mu\text{m}$  thick. Sexine rugulate-perforate in mesocolpia and decreasing in size in apocolpia and towards the colpi, rugulae 0.2-0.6  $\mu\text{m}$  wide, perforation less than 0.1  $\mu\text{m}$  wide.

Shrubs; growing in upland broad-leaved forests in central mountains, and a dominant shrub community in the marsh around Yuenyang Lake.

### Rosaceae

There are 6 genera and 13 species of Rosaceae in this study which possess mainly the 3-colporate pollen. Occasionally, some species vary in their colpus number as 4- to 7-colporate pollen. The exine ornamentation of most species are striate to striato-perforate.

#### Key to species

1a. Sexine perforate to finely reticulate	<i>Rubus formosensis</i>
1b. Sexine not perforate to finely reticulate	2
2a. Sexine rugulo-perforate	<i>Photinia niitakayamensis</i>
	<i>Rhaphiolepis indica</i> var. <i>tashiroi</i>
2b. Sexine not rugulo-perforate	3
3a. Ora covered by well-demarcated, centrally enlarged fusiform opercula	<i>Rosa taiwanensis</i>
3b. Ora not covered by well-demarcated, centrally enlarged fusiform opercula	4
4a. Sexine striate	5
4b. Sexine prominently striate with perforate grooves, or striato-reticulate	8
5a. Striae less than 0.2 $\mu\text{m}$ wide	<i>Pourthiaea villosa</i> var. <i>parvifolia</i>
5b. Striae more than 0.2 $\mu\text{m}$ wide	6
6a. Pollen grains circular in polar view	<i>Prunus matuurai</i>
6b. Pollen grains semiangular in polar view	7
7a. Striae prominent in LM	<i>Prunus phaeosticta</i>
7b. Striae not prominent in LM	<i>Rhaphiolepis indica</i> var. <i>umbellata</i>
8a. Sexine prominently striate with perforate grooves	9
8b. Sexine striato-reticulate	10
9a. Pollen grains more than 25 $\mu\text{m}$ in diameter	<i>Rubus pectinellus</i>
9b. Pollen grains less than 25 $\mu\text{m}$ in diameter	<i>Rubus sumatranus</i>
10a. Pollen grains more than 27 $\mu\text{m}$ in diameter	<i>Rubus liuii</i>
10b. Pollen grains less than 27 $\mu\text{m}$ in diameter	<i>Rubus corchorifolius</i>
	<i>Rubus croceacanthus</i>

#### *Photinia niitakayamensis* Hayata (Plate 4)

Pollen grains 3-colporate (rarely 4-colporate), isopolar, prolate-spheroidal to prolate (P/E = 1.04-1.42) in equatorial view, 24.5-34  $\times$  20.5-28  $\mu\text{m}$ ; circular or semiangular (rarely quadrangular) in polar view, 24.5-32  $\mu\text{m}$  in diameter.

Colpi long, crassimarginate, ends acuminate, constricted in the equator, colpus membranes scabrate to verrucate, sexine raised over the ora, not anastomosed, forming pore flaps, pore flaps easily ruptured after acetolysis. Ora x-shaped, protruding. Aperture fastigium type.

Exine 1.5-2  $\mu\text{m}$  thick. Columellae distinct. Sexine rugulo-perforate, striae short, sometimes parallel to the colpi or irregularly distributed, inconspicuous toward apocolpia and colpi, 0.25-0.6  $\mu\text{m}$  wide, perforations less than 0.1  $\mu\text{m}$  in dimension. Nexine as thick as or thinner than sexine.

Evergreen medium trees; growing on forest floors around Yuenyang Lake, and at 2,000-2,500 m in the central mountains.

**Pourthiaea villosa** (Thunb. ex Murray) Decne. var. **parvifolia** (Pritz.) Iketani & Ohashi (Plate 5)

Pollen grains 3-colporate, isopolar, prolate-spheroidal to prolate (P/E = 1.02-1.42) in equatorial view, 18-25.5 × 17-22 μm, semiangular in polar view, 17-23 μm in diameter.

Colpi long, crassimarginate, constricted in the equator, ends acuminate, colpus membrans scabrate, sexine raised over the ora forming pore flaps, not connected, pore flaps easily ruptured after acetolysis. Ora protruding. Aperture fastigium type.

Exine 1-1.5 μm thick. Columellae distinct. Sexine striate, striae long, parallel to the colpi, less than 0.2 μm wide. Nexine as thick as sexine.

Deciduous small trees or shrubs; growing on forest floors around Yuenyang Lake, and at low to medium altitudes in northern parts of Taiwan.

**Prunus matuurai** Sasaki (Plate 6)

Pollen grains 3-colporate, isopolar, oblate-spheroidal to prolate (P/E = 0.92-1.67) in equatorial view, 29.5-43.5 × 24-32.5 μm, circular in polar view, 32-40.5 μm in diameter.

Colpi long, crassimarginate, 1.5-3.5 μm wide, constricted in the equator, ends acuminate, colpus membrane scabrate, sexine raised on both sides of the ora forming pore flaps, not connected, pore flaps easily ruptured after acetolysis. Ora transversally parallel, protruding. Aperture fastigium type.

Exine 2-2.5 μm thick. Columellae distinct. Sexine striate, striae parallel to the colpi, 0.3-0.7 μm wide in equatorial view, 0.2-1 μm wide in polar view. Nexine as thick as or thinner than sexine.

Deciduous trees; growing on forest floors around Yuenyang Lake, and at ca. 2,000 m from Taipingshan.

**Prunus phaeosticta** (Hance) Maxim. (Plate 7)

Pollen grains 3-colporate, isopolar, prolate-spheroidal to prolate (P/E = 1.09-1.39) in equatorial view, 26.5-32 × 21.5-27 μm; semiangular in polar view, 24-32 μm in diameter.

Colpi long, crassimarginate, 0.6-1.9 μm wide, constricted in the equator, ends acuminate, colpus membrane scabrate to granulate, sexine raised over the ora forming pore flaps, not connected, pore flaps easily ruptured after acetolysis. Ora protruding. Aperture fastigium type.

Exine 1.5-2 μm thick. Columellae distinct. Sexine striate, striae parallel to the colpi or looping, 0.25-0.6 μm wide in equatorial view, 0.3-0.6 μm wide in polar view. Nexine as thick as sexine.

The pollen of *P. phaeosticta* can be distinguished from *P. matuurai* by its semiangular shape in polar view.

Evergreen trees; growing on forest floors around Yuenyang Lake, and very common at 500-1,000 m in thickets.

**Rhaphiolepis indica** (L.) Lindl. ex Ker var. **tashiroi** Hayata ex Matsum. & Hayata (Plate 8)

Pollen grains 3-colporate, isopolar, subprolate to prolate (P/E = 1.18-1.65) in equatorial view, 29-40 × 23-27 μm; semiangular in polar view, 31.5-41.5 μm in diameter.

Colpi long, crassimarginate, ends acuminate, constricted in the equator. Sexine raised over the ora forming pore flaps, not connected. Sculpture of colpus membranes similar to that of the rest of the exine surface. Ora protruding. Aperture fastigium type.

Exine 1.5-2  $\mu\text{m}$  thick. Columellae distinct. Sexine rugulo-perforate, with perforations in the slit-like grooves; striae fingerprinted, undulate, 0.2-0.5  $\mu\text{m}$  wide, indistinct in apocolpia; perforations less than 0.1  $\mu\text{m}$  in dimension. Nexine as thick as sexine.

Evergreen shrubs or small trees; growing on forest floors around the Yuenyang Lake, at low altitudes.

**Rhaphiolepis indica** (L.) Lindl. ex Ker var. **umbellata** (Thunb. ex Murray) Ohashi (Plate 9)

Pollen grains 3-colporate (rarely 4-colporate), isopolar, subprolate to prolate (P/E = 1.15-1.60) in equatorial view, 26.5-40.5  $\times$  21.5-27  $\mu\text{m}$ ; circular or semiangular (rarely quadrangular) in polar view, 27.5-41.5  $\mu\text{m}$  in diameter.

Colpi long and crassimarginate, ends acuminate, constricted in the equator, colpus membranes scabrate to finely granulate, sexine raised over the ora forming pore flaps, not connected, pore flaps easily ruptured after acetolysis. Ora protruding. Aperture fastigium type.

Exine 1.5-2  $\mu\text{m}$  thick. Columellae distinct. Sexine striate, striae sometimes parallel to the colpi, or irregularly curving, 0.1-0.4  $\mu\text{m}$  wide. Nexine as thick as sexine.

The pollen of *R. indica* var. *tashiroi* can be distinguished from *R. indica* var. *umbrella* by its rugulo-perforate sexine.

Evergreen shrubs or trees; growing on forest floors around Yuenyang Lake.

**Rosa taiwanensis** Nakai (Plate 10)

Pollen grains 3-colporae, isopolar, spheroidal to prolate (P/E = 1-1.53) in equatorial view, 24-34  $\times$  18.5-26  $\mu\text{m}$ ; circular or semiangular in polar view, 21.5-28.5  $\mu\text{m}$  in diameter.

Colpi long, crassimarginate, ends acuminate, equatorial bridges constituted by sexine lateral extensions, colpus membranes scabrate. Ora lalongate or rectangular, protruding. Colpi covered by well-demarcated, exine thickened, centrally enlarged fusiform opercula, sculpture of opercula similar to that of the rest of the exine surface. Aperture fastigium type.

Exine 2  $\mu\text{m}$  thick. Columellae distinct. Sexine prominently striate, with perforations in the grooves, striae of irregular length and width, parallel to the colpi, 0.1-0.55  $\mu\text{m}$  wide, perforations less than 0.2  $\mu\text{m}$  in dimension. Nexine as thick as sexine.

An endemic evergreen climbing shrubs; growing on forest floors around Yuenyang Lake, at low to medium altitudes.

**Rubus corchorifolius** L. f. (Plate 11)

Pollen grains 3-colporate (rarely 4-colporate), isopolar, oblate-spheroidal to prolate (P/E = 0.93-1.5) in equatorial view, 18.5-24.5  $\times$  16-23  $\mu\text{m}$ ; circular or semiangular (rarely quadrangular) in polar view, 16-24.5  $\mu\text{m}$  in diameter.

Colpi long, crassimarginate, constricted in the equator, ends acuminate, colpus membranes irregularly granulate, sexine raised over the ora forming pore flaps, not connected, and easily ruptured after acetolysis. Ora dumbbell-shaped or transversally parallel, protruding. Aperture fastigium type.

Exine 1.5  $\mu\text{m}$  thick. Columellae distinct. Sexine striato-reticulate, with linearly distributed perforations in the grooves, striae parallel to the colpi, 0.2-0.45  $\mu\text{m}$  wide, perforations less than 0.2  $\mu\text{m}$  in dimension.



Shrubs; commonly growing on forest floors around the Yuenyang Lake, at low to medium altitudes.

**Rubus croceacanthus** Lévl. (Plate 12)

Pollen grains 3-colporate (rarely 4-colporate), isopolar, spheroidal to subprolate (P/E = 1-1.2) in equatorial view, 19.5-24.5 × 17-22 μm; circular or semiangular (rarely quadrangular) in polar view, 17-22 μm in diameter.

Colpi long, ends acuminate, colpus membranes granulate, sexine raised on both sides of the ora forming pore flaps, not connected, pore flaps easily ruptured after acetolysis. Ora dumbbell-shaped or lalongate, protruding. Aperture fastigium type.

Exine 1-1.5 μm thick. Columellae distinct. Sexine striato-reticulate, striae looping or curving, 0.1-0.5 μm wide, perforations circular to elongated, less than 0.4 μm in dimension. Nexine as thick as sexine.

Shrubs; growing in open places like forest edges, roadsides, landsides, grassland and riverbanks and forest floors around the Yuenyang Lake, at low to medium altitudes.

**Rubus formosensis** Ktze. (Plate 13)

Pollen grains 3-colporate (rarely 4-colporate), isopolar, prolate-spheroidal to prolate (P/E = 1.05-1.54) in equatorial view, 29-53.5 × 24-51 μm; circular or semiangular (rarely quadrangular) in polar view, 26.5-53.5 μm in diameter.

Colpi long, crassimarginate, ends acuminate, colpus membranes scabrate, sexine raised over the ora forming pore flaps, not connected. Ora lalongate, protruding. Aperture fastigium type.

Exine 2 μm thick. Columellae distinct. Sexine perforate to finely reticulate, muri 0.1-0.3 μm wide, perforations less than 0.3 μm in dimension.

Evergreen climbing shrubs; growing in secondary thickets at medium to high altitudes in the mountains throughout the island, and forest floors around the Yuenyang Lake.

**Rubus liuii** Yang & Lu (Plate 14)

Pollen grains 3-colporate, isopolar, prolate-spheroidal to prolate (P/E = 1.11-1.40) in equatorial view, 29-39 × 24-33 μm; circular or semiangular in polar view, 29-38 μm in diameter.

Colpi long, crassimarginate, ends acuminate, colpus membranes scabrate to granulate, sexine raised over the ora forming pore flaps, not connected and easily ruptured after acetolysis. Ora transversally parallel or lalongate, protruding. Aperture fastigium type.

Exine 1.5-2 μm thick. Columellae distinct. Sexine striato-reticulate, with irregularly distributed perforations in the shallowly concealed grooves, striae short, parallel to the colpi, less than 0.2 μm wide, perforations less than 0.1 μm in dimension. Nexine as thick as sexine.

An endemic climbing shrubs; growing on forest floors around Yuenyang Lake, and in the northeastern part of Taiwan.

**Rubus pectinellus** Maxim. (Plate 15)

Pollen grains 3-colporate, isopolar, prolate-spheroidal to prolate (P/E = 1.08-1.60) in equatorial view, 29-39 × 21.5-29.5 μm; circular or semiangular in polar view, 31.5-36 μm in diameter.

Colpi long, crassimarginate, ends acuminate, sexine thickened in the equator forming two H-shaped bridges, sexine raised over the ora forming pore flaps, not connected and easily

ruptured after acetolysis, colpus membranes spinulate, spinules distributed compactly, less than  $0.5 \mu\text{m}$  wide and high. Ora lalongate, protruding. Aperture fastigium type.

Exine  $2 \mu\text{m}$  thick. Columellae distinct. Sexine prominently striate with deeply concealed perforations in the grooves, striae slightly undulate, parallel to the colpi,  $0.25\text{-}0.75 \mu\text{m}$  wide, perforations less than  $0.25 \mu\text{m}$  in dimension. Nexine as thick as sexine.

Small prostrate shrubs; growing on forest floors around the Yuenyang Lake, at 700-2,500 m.

### **Rubus sumatranus** Miq. (Plate 16)

Pollen grains 3-colporate, isopolar, subprolate to prolate ( $P/E = 1.21\text{-}1.58$ ) in equatorial view,  $19.5\text{-}24.5 \times 14.5\text{-}17 \mu\text{m}$ ; circular or circular-lobate semiangular in polar view;  $17\text{-}21.5 \mu\text{m}$  in diameter.

Colpi long, crassimarginate, constricted in the equator, ends acuminate, colpus membranes finely granulate, sexine raised over the ora forming pore flaps, not connected. Ora lalongate or dumbbell-shaped. Aperture fastigium type.

Exine  $1\text{-}1.5 \mu\text{m}$  thick. Columellae distinct. Sexine prominently striate with irregularly distributed and moderately concealed perforations in the grooves, striae parallel to the colpi in high relief,  $0.1\text{-}0.4 \mu\text{m}$  wide, perforations less than  $0.1 \mu\text{m}$  in dimension. Nexine as thick as sexine.

Small trees; growing on forest floors in thickets around Yuenyang Lake, at altitudes up to 1,800 m.

The degree of sculpture differentiations among species of *Rubus* is very complicated.

## DISCUSSION

The pollen types of the 16 species of their studied in this article can be classified into three kinds: pantoporate, 3-colporate and 4-7-colporate pollen classes. Among them, pollen of *Coptis quinquefolia* (Ranunculaceae), like two other species described previously (Chen and Wang, 1999), *Stellaria arisanensis*, and *Cucubalus baccifer* also belong to the pantoporate pollen class. However, the pore margin of *Coptis quinquefolia* is inconspicuous, while those of the other two is conspicuous.

The pollen of *Lysimachia congestiflora* (Primulaceae), *Rhamnus crenata* (Rhamnaceae) and all of rosacean pollen are 3-colporate class. Nevertheless, there are some variations in the colpus numbers of colpi among them. In addition, they have quite different ornamentation. The pollen wall ornamentation of *Lysimachia congestiflora* is reticulate, while that of *Rhamnus crenata* is rugulo-perforate, whereas most rosacean pollen are striate to striato-perforate.

In the genus *Lysimachia*, some variations in exine sculpture exist, from psilate to faintly reticulate (Wang *et al.*, 1997), finely perforate (Nowicke and Skvarla, 1977; Kurosawa, 1991), compactly rugulate (Chen, 1988), or reticulate (Nowicke and Skvarla, 1977; Crompton and Wojtas, 1993; Heusser, 1971) in different species.

The exine sculpture in different species of *Rhamnus* may vary from reticulate, reticulato-rugulate, rugulate, rugulo-perforated to foveolate (Choo *et al.*, 1993; Schirarend and Koehler, 1993; Crompton and Wojtas, 1993; Ishihara, 1995; Zhang and Chen, 1992). However, the H-shaped ora are the most distinctive characteristics of *Rhamnus crenata* and

certain other species of the same genus (Choo *et al.*, 1993; Schirarend and Koehler, 1993; Zhang and Chen, 1992).

The sexine of rosacean pollen protrudes at the equator of colpi. Sometimes these protrudings are connected with each other over the colpi to form equatorial bridges (Moore and Webb, 1978), and seem to be constricted at the equator under LM. But frequently, the bridges were found to break at the middle to form "pore flaps" (Hebda *et al.*, 1988). In our study, the majority of rosacean pollen, except *Rosa taiwanensis*, have pore flaps. The pore flaps of all the rosacean species studied were found to form an obvious pore chamber, or "fastigium", as that reported by Reitsma (1966).

*Rosa taiwanensis* pollen is distinguishable from other rosacean pollen in having a well-demarcated opercula. This coincides well with the studies of Eide (1981b) and Hebda and Chinnappa (1990, 1994). Ueda and his coworkers (Ueda and Tomita, 1989; Ueda, 1992) have distinguished the pollen of 126 roses into six types, based on the types of exine sculpture. Pollen of *Rosa taiwanensis* belongs to Type 3 of Ueda's system for having the distinct striae with perforations in the grooves.

The morphology of rosacean pollen has been studied by a number of researchers (Huang, 1972; Katiyar, 1980; Eide, 1981a, b; Hebda *et al.*, 1988, 1991; Hebda and Chinnappa, 1990, 1994; Lu *et al.*, 1990; Kurosawa, 1991; Jarvis *et al.*, 1992; Monasterio-Huelin and Pardo, 1995; Tomlik-Wyremblewska, 1995; Premathilake *et al.*, 1999; Zhou *et al.*, 1999, 2000). The majority of rosacean pollen has prominent striae with or without perforate grooves. Typical examples in the present study are *Pourthiaea villosa* var. *parvifolia*, *Prunus matuurai*, *P. phaeostica*, *Rhaphiolepis indica* var. *umbellate*, *Rosa taiwanensis*, *Rubus pectinellus* and *R. sumatranus*. Other species, such as *Photonia niitakayamensis*, *Rhaphiolepis indica* var. *tashiroi* have rugulo-perforate ornamentation, while *Rubus corchorifolis*, *R. croceacanthus*, and *R. liiii* have striato-reticulate ornamentation. *Rubus formosensis* is the only rosacean species with perforate to finely reticulate exine sculpture. Thus, the types of rosacean pollen ornamentation do not agree well with the classification based on other plant morphological criteria (Ohashi and Hsieh, 1993). Apparently, the validity of contemporary systematics of Rosaceae is worthy of further study.

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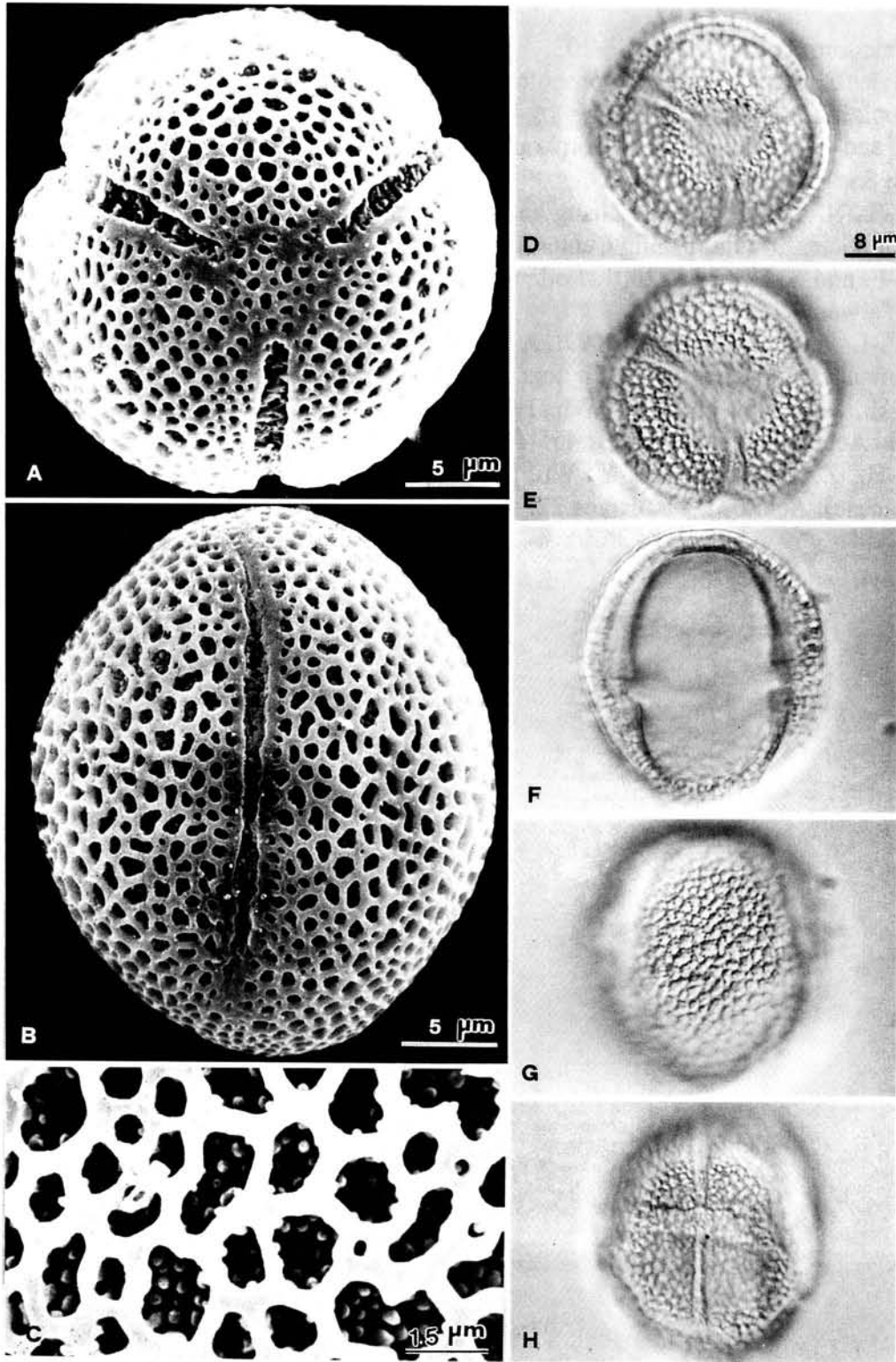


Plate 1. *Lysimachia congestiflora* Hemsl. A-C, SEM; D-H, LM. A, D & E, 3-colporate grains in polar view showing reticulate sexine. B & H, grains showing relatively long colpi and transversally parallel ora. F & G, grains in equatorial view showing reticulate sexine and simpli-collumellate muri. C, detail of sexine in mesocolpia showing irregular and polygonal muri and densely spaced verrucae in the lumina.

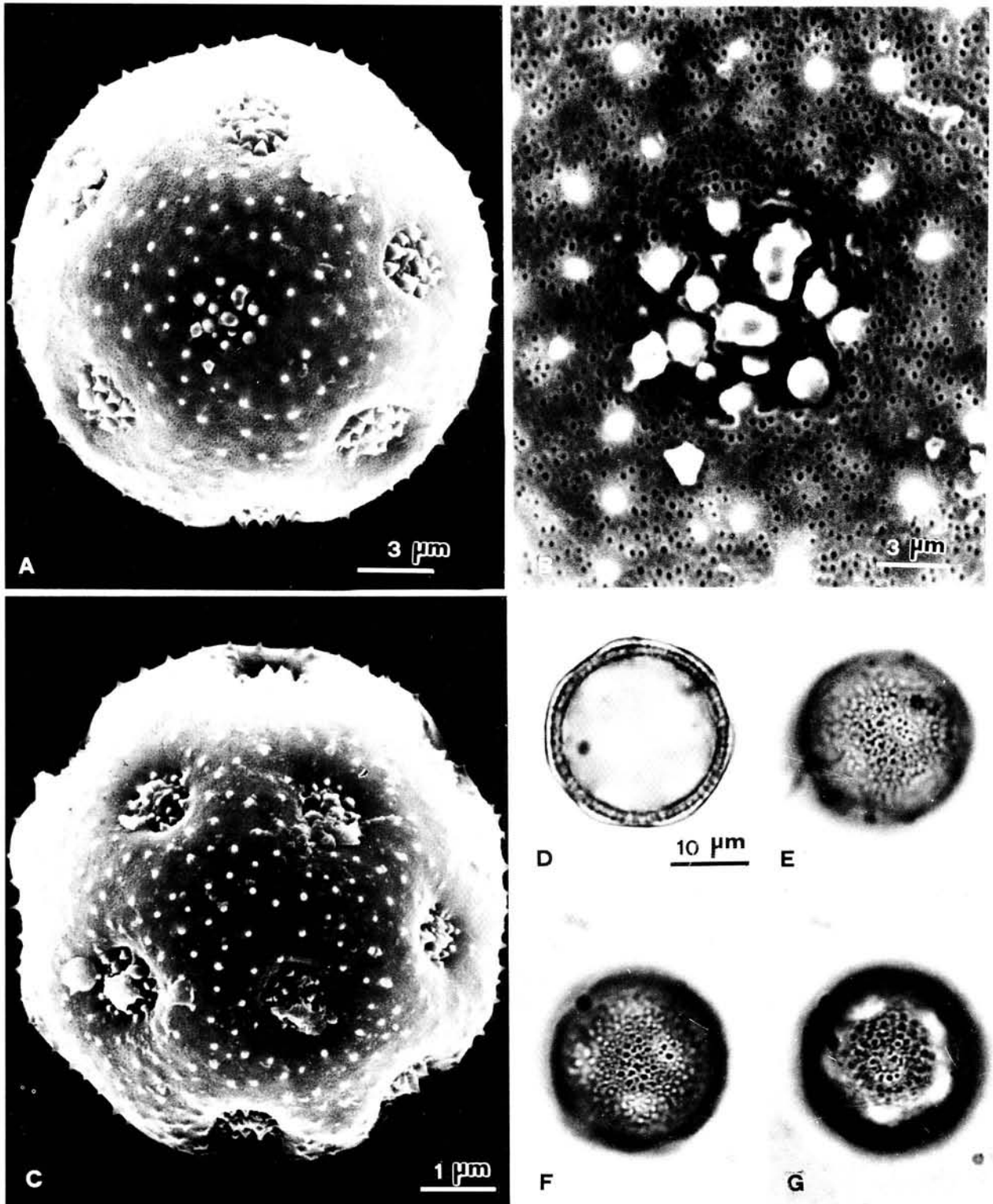


Plate 2. *Coptis quinquefolia* Miq. A-C, SEM; D-G, LM. A & C-G, pantoporate grains showing spinulate sexine and inconspicuous pore margins. B, detail of spinulate sexine surface and densely spaced pores with conical spinules.



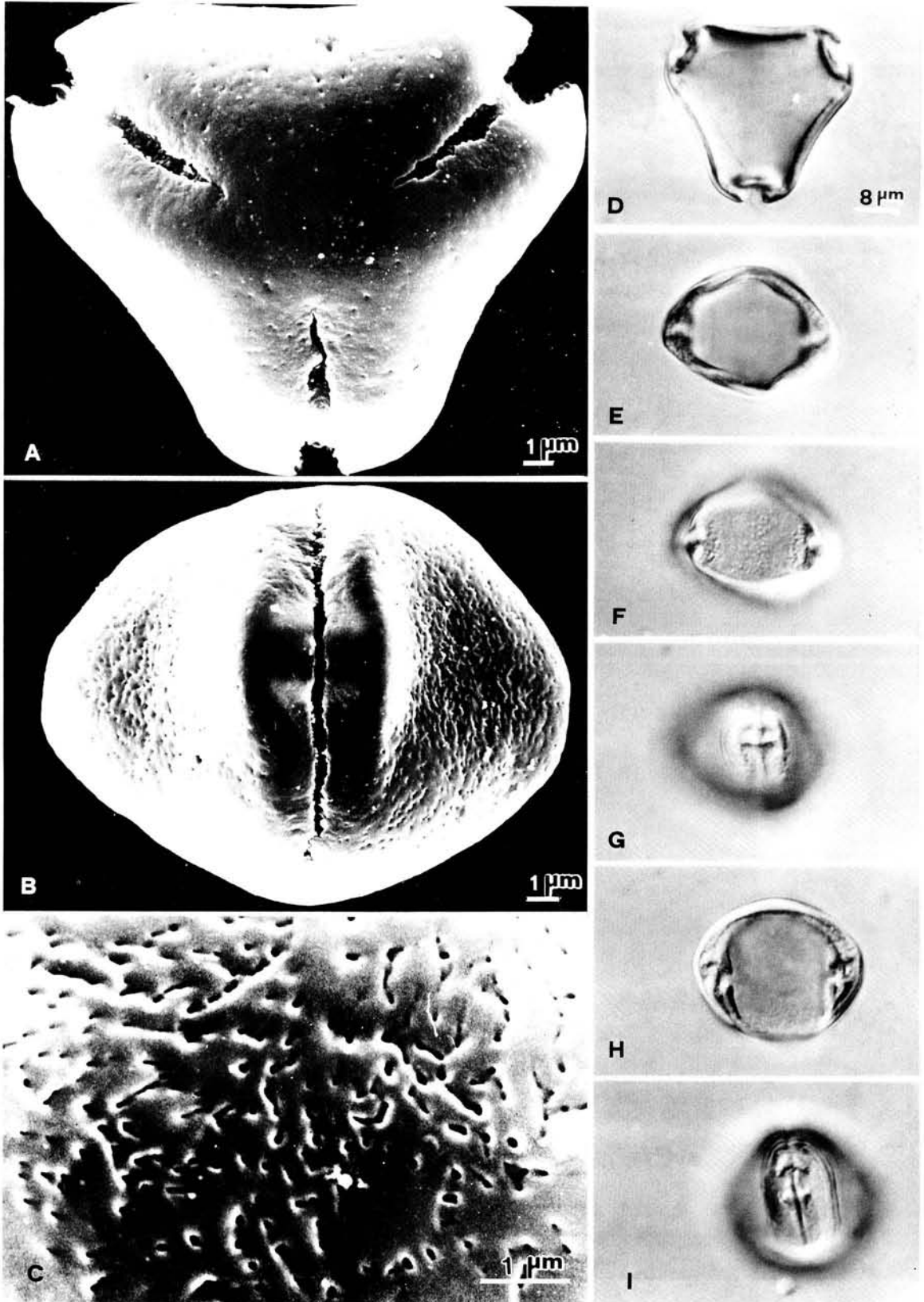


Plate 3. *Rhamnus crenata* Sieb. & Zucc. A-C, SEM. D-I, LM. A & D, 3-colporate grains in polar view showing triangular-truncate with relatively concave sides in polar view. B & E-I, grains in equatorial view showing narrow colpi, and lalongate and H-shaped ora. C. detail of rugulate-perforate sexine in mesocolpium.

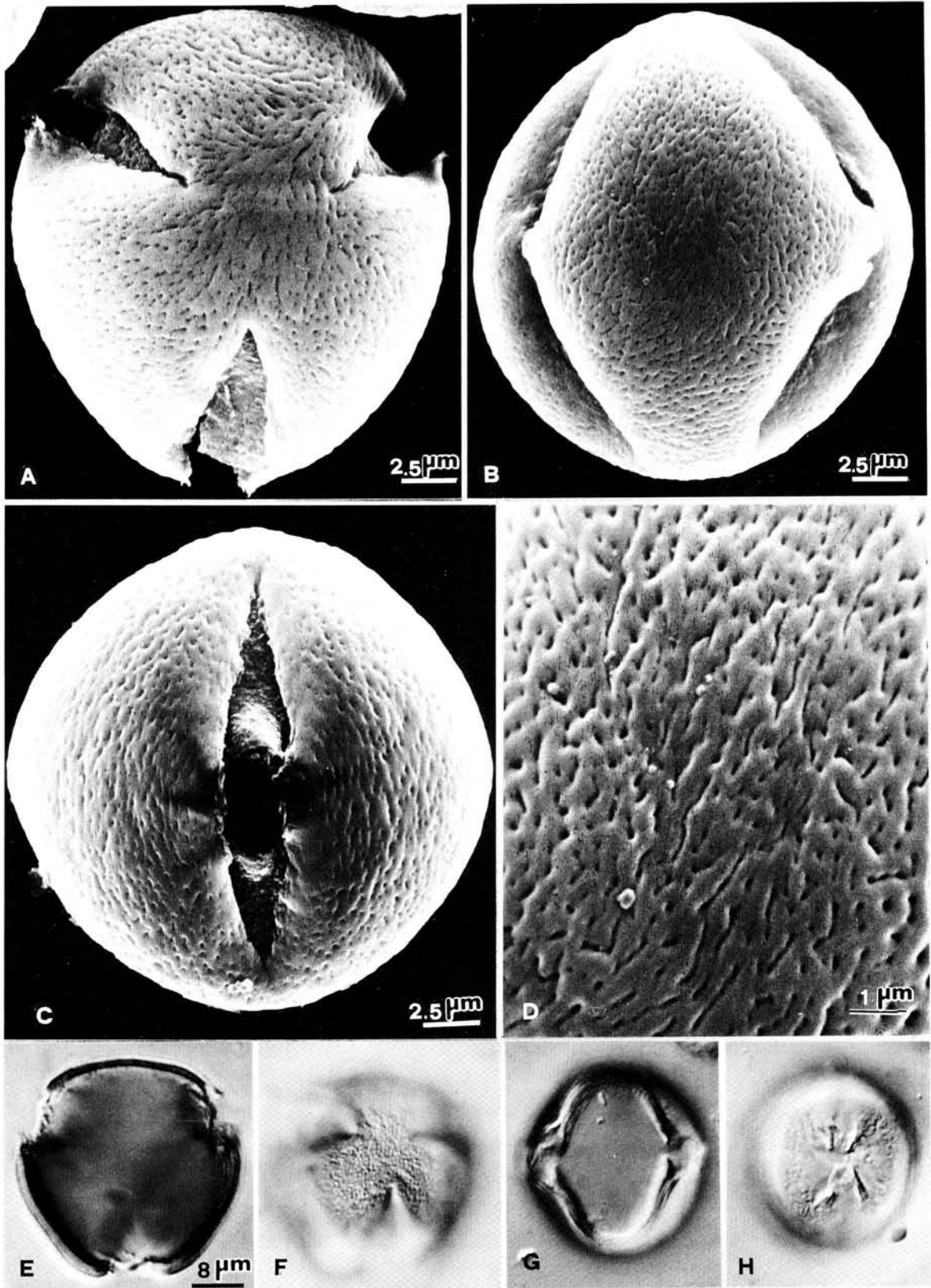


Plate 4. *Photinia nitakayamensis* Hayata. A-D, SEM; E-H, LM. A, E & F, 3-colporate grains in polar view. B, C, G & H, grains in equatorial view showing rugulo-perforate sexine, long colpi and x-shaped and circular ora. D, detail of rugulo-perforate sexine.

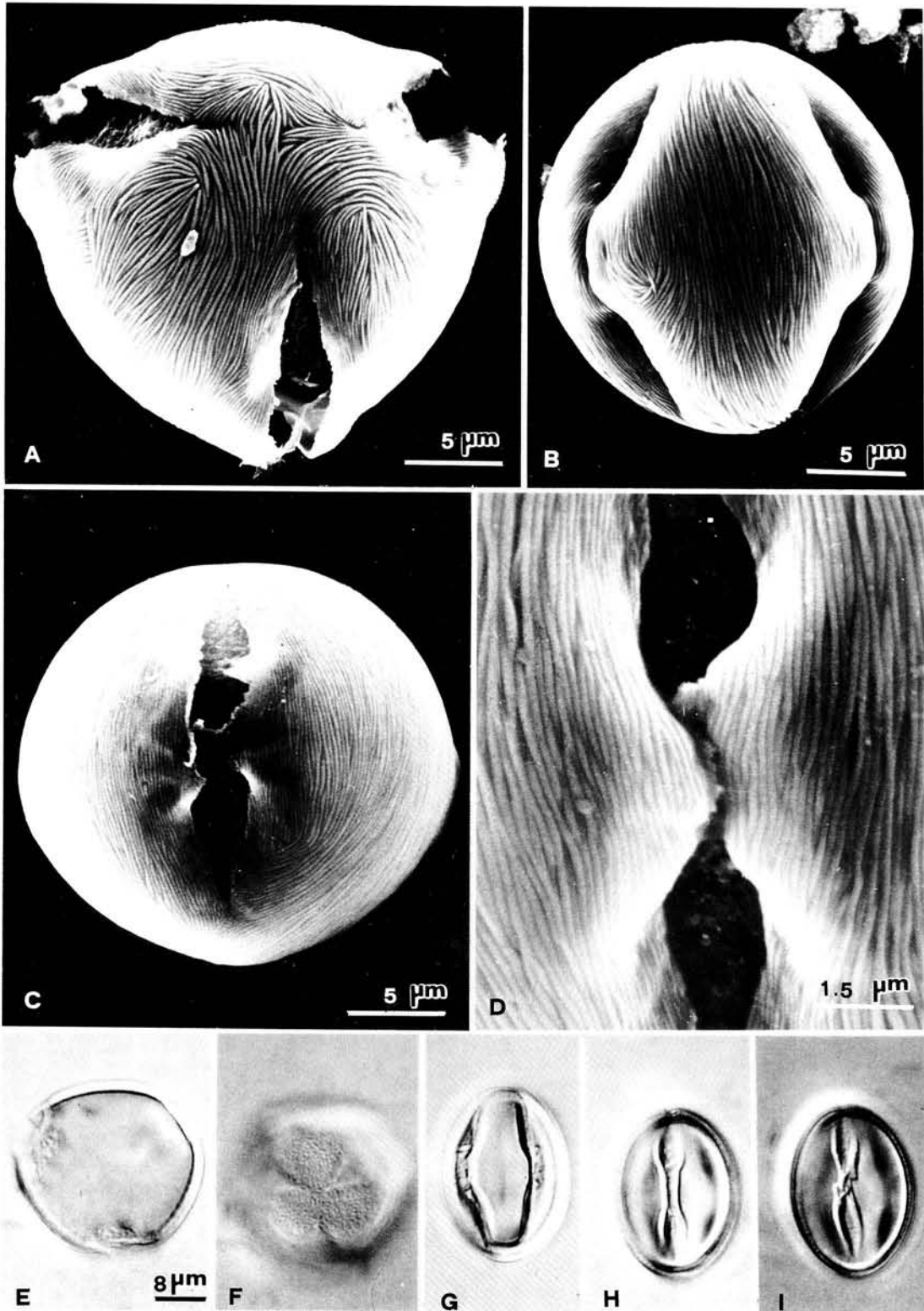


Plate 5. *Pourthiaea villosa* (Thunb. Ex Murray) Decne. var. *parvifolia* (Pritz.) Iketani & Ohashi. A-D, SEM; E-I, LM. A, E & F, 3-colporate grains in polar view showing striate sexine. B, C & G-I, grains in equatorial view, showing long colpi constricted in the equator and ruptured pore flaps. D. detail of colpus region showing pore flap and scabrate colpus membrane.

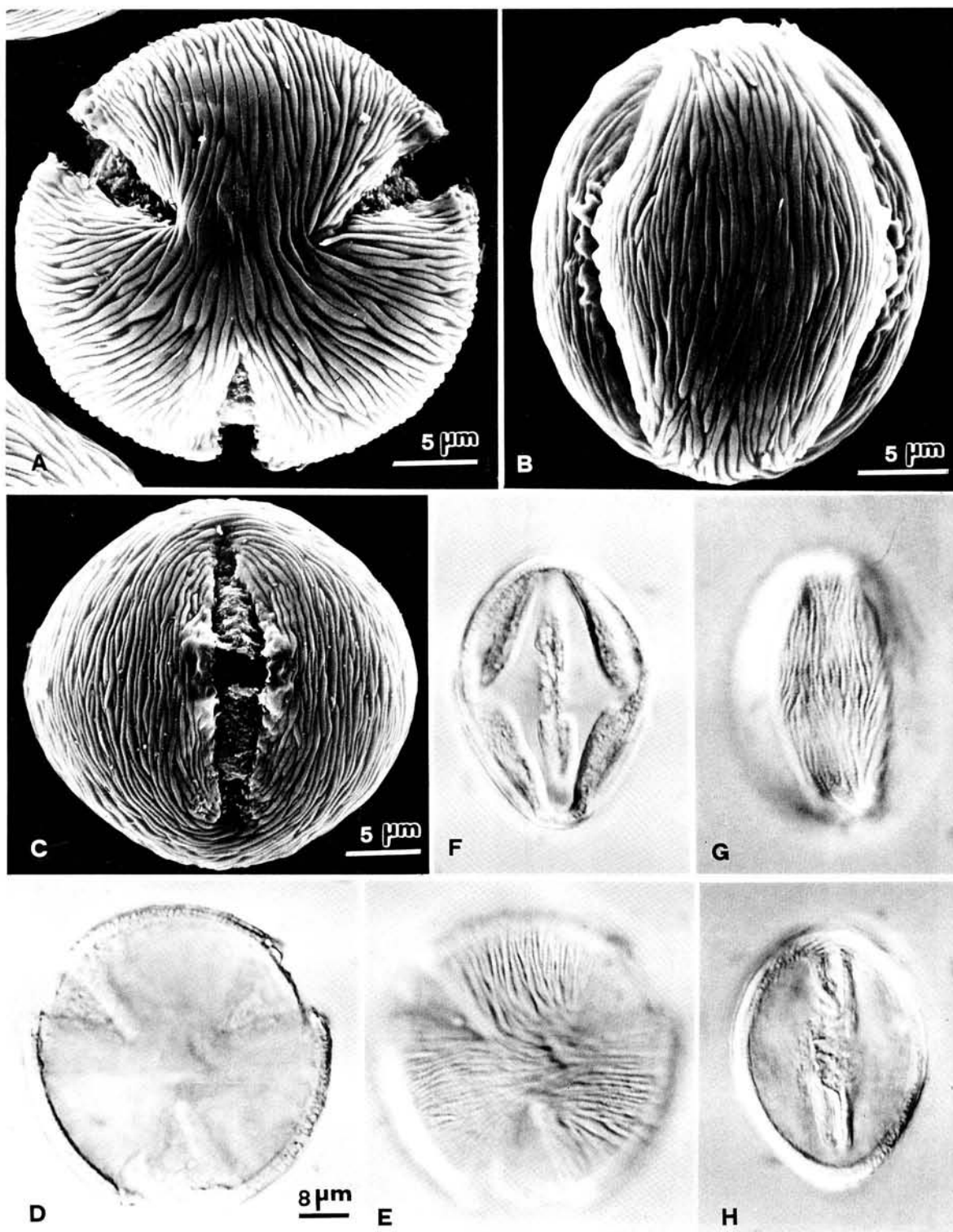


Plate 6. *Prunus matuurai* Sasaki. A-C, SEM; D-H, LM. A, D & E, 3-colporate grains in polar view showing striate sexine. B & F-H, grains in equatorial view showing parallel striae, long and crassimarginate colpi, and transversally parallel ora.



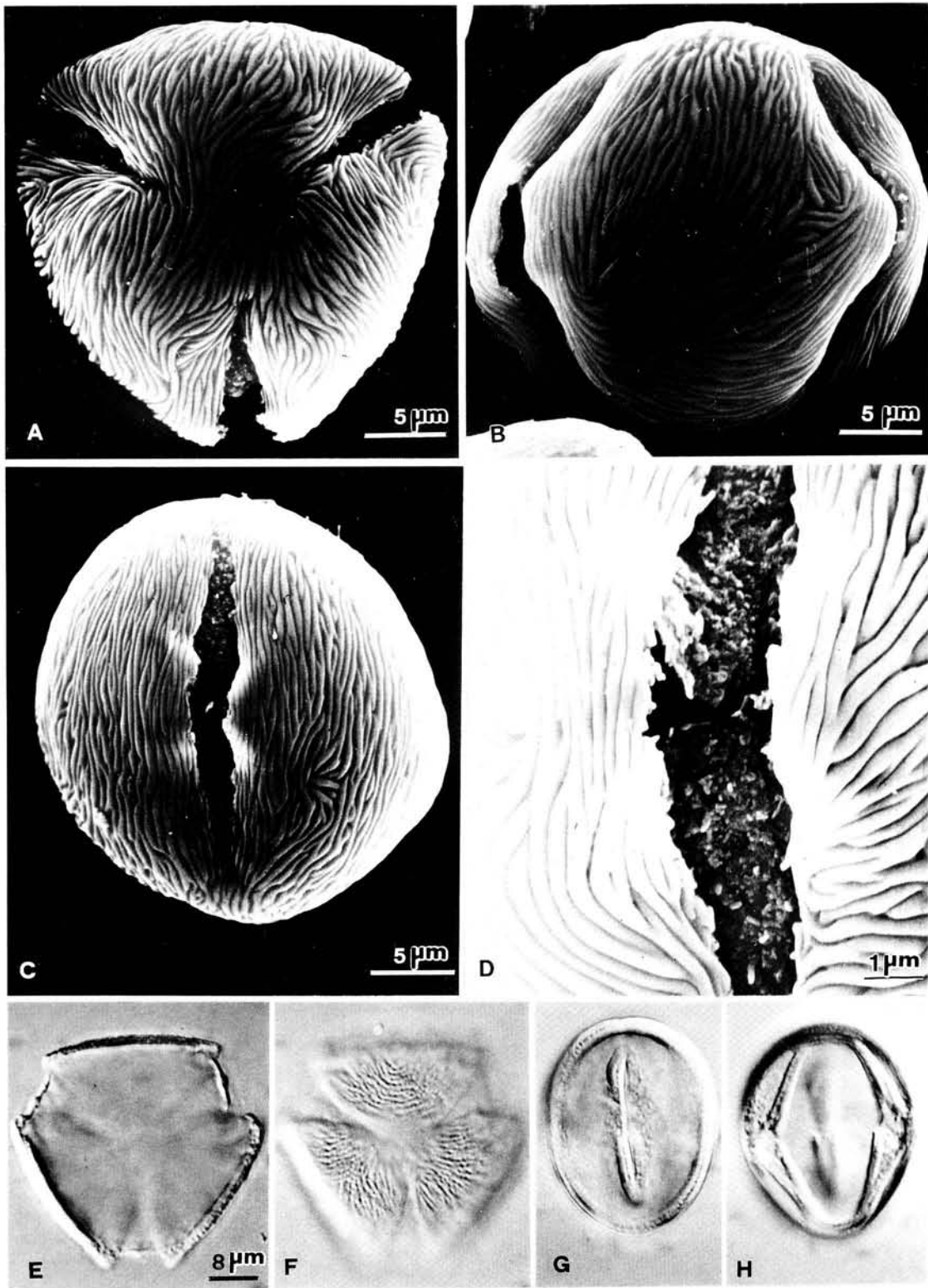


Plate 7. *Prunus phaeosticta* (Hance) Maxim. A-D, SEM; E-H, LM. A, E & F, 3-colporate grains in polar view showing striate sexine. B, C, G & H, grains in equatorial view showing long and crassimarginate colpi and parallel and looping striae. D, detail of colpus region showing scabrate colpus membrane and transversally parallel os.

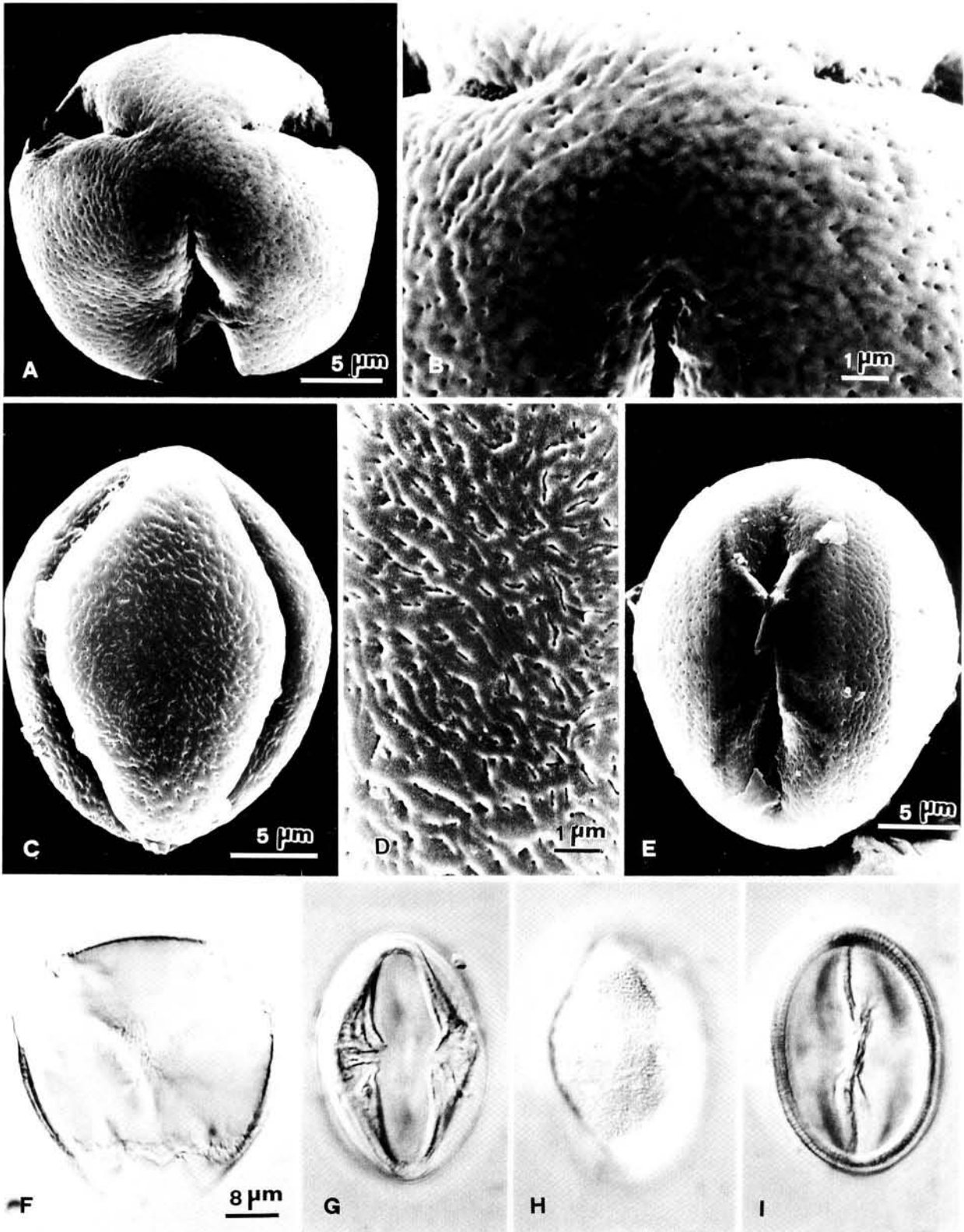


Plate 8. *Rhapsiolepis indica* (L.) Lindl. ex Ker var. *tashiroi* Hayata ex Matsum. & Hayata. A-E, SEM; F-I, LM. A & F, 3-colporate grains in polar view showing rugulo-perforate sexine. C, E & G-I, grain in equatorial view showing long and crassimarginate colpi and pore flap. B, detail of sexine in apocolpium showing indistinct striae. D, detail of rugulo-perforate sexine in mesocolpium.

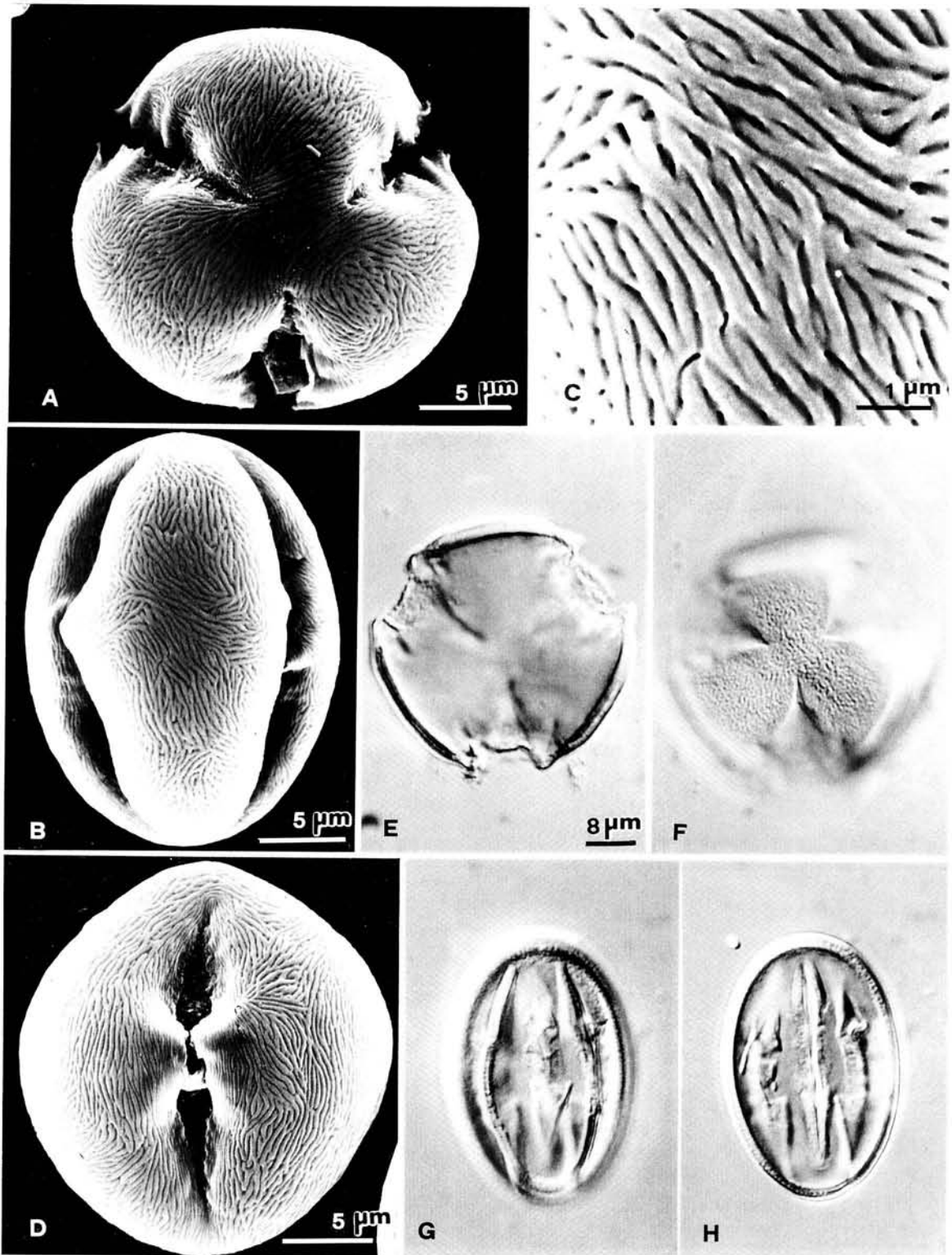


Plate 9. *Rhaphiolepis indica* (L.) Lindl. ex Ker var. *umbellata* (Thunb. ex Murray) Ohashi. A-D, SEM; E-H, LM. A, E & F, 3-colporate grains in polar view. B, D, G & H, grains in equatorial view showing long and crassimarginate colpi, and pore flaps. C, detail of striate sexine in mesocolpium.

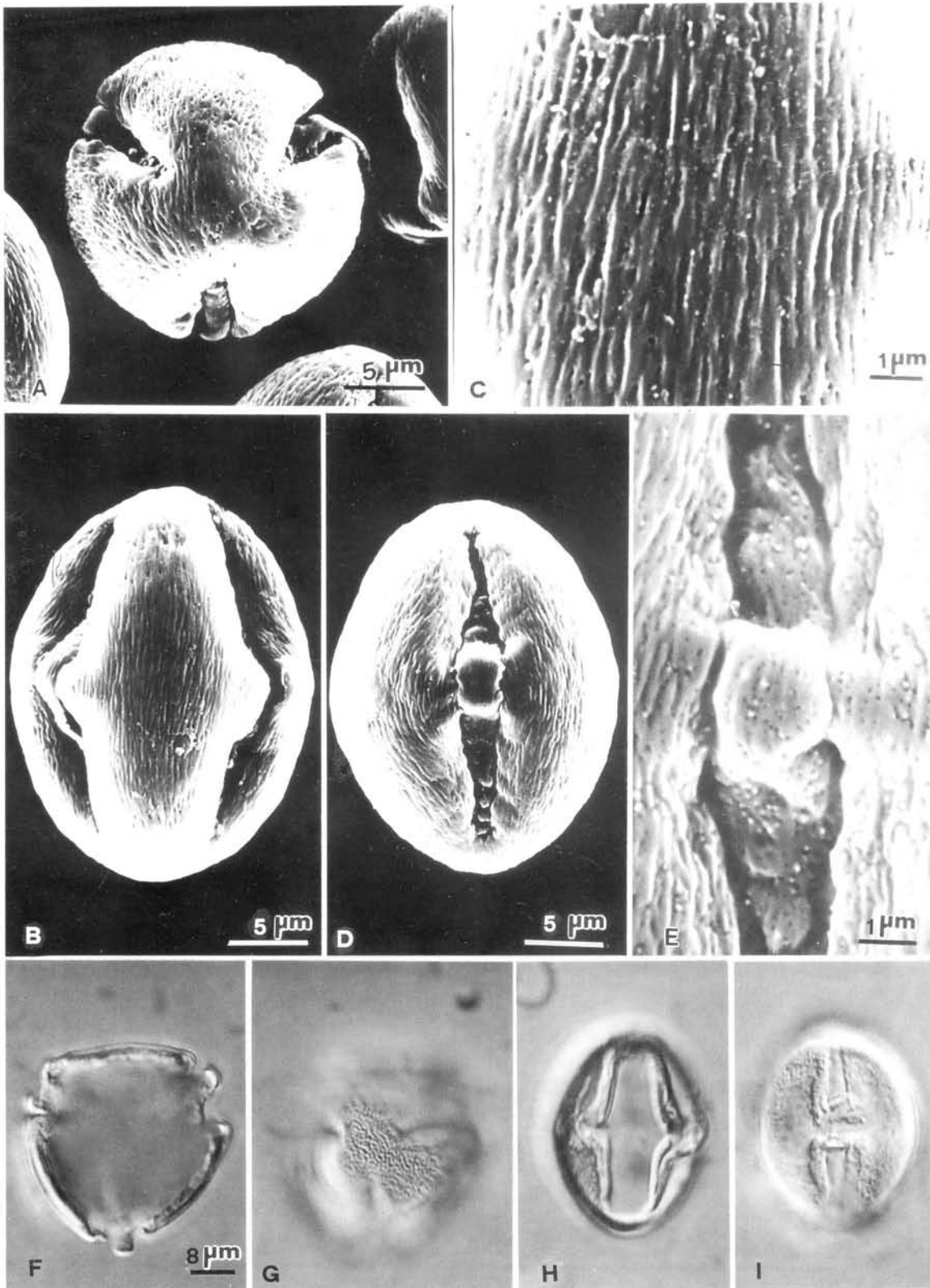


Plate 10. *Rosa taiwanensis* Nakai. A-E, SEM; F-I, LM. A, F & G, 3-colporate grains in polar view. B, D, H & I, grains in equatorial view showing striae parallel to the colpi, colpi long and crassimarginate, centrally enlarged fusiform operculum and rectangular os. C. detail of prominently striate sexine with perforations in the grooves in mesocolpium showing parallel striae. E. detail of centrally enlarged fusiform operculum showing sculpture of operculum similar to that of the rest of sexine surface.



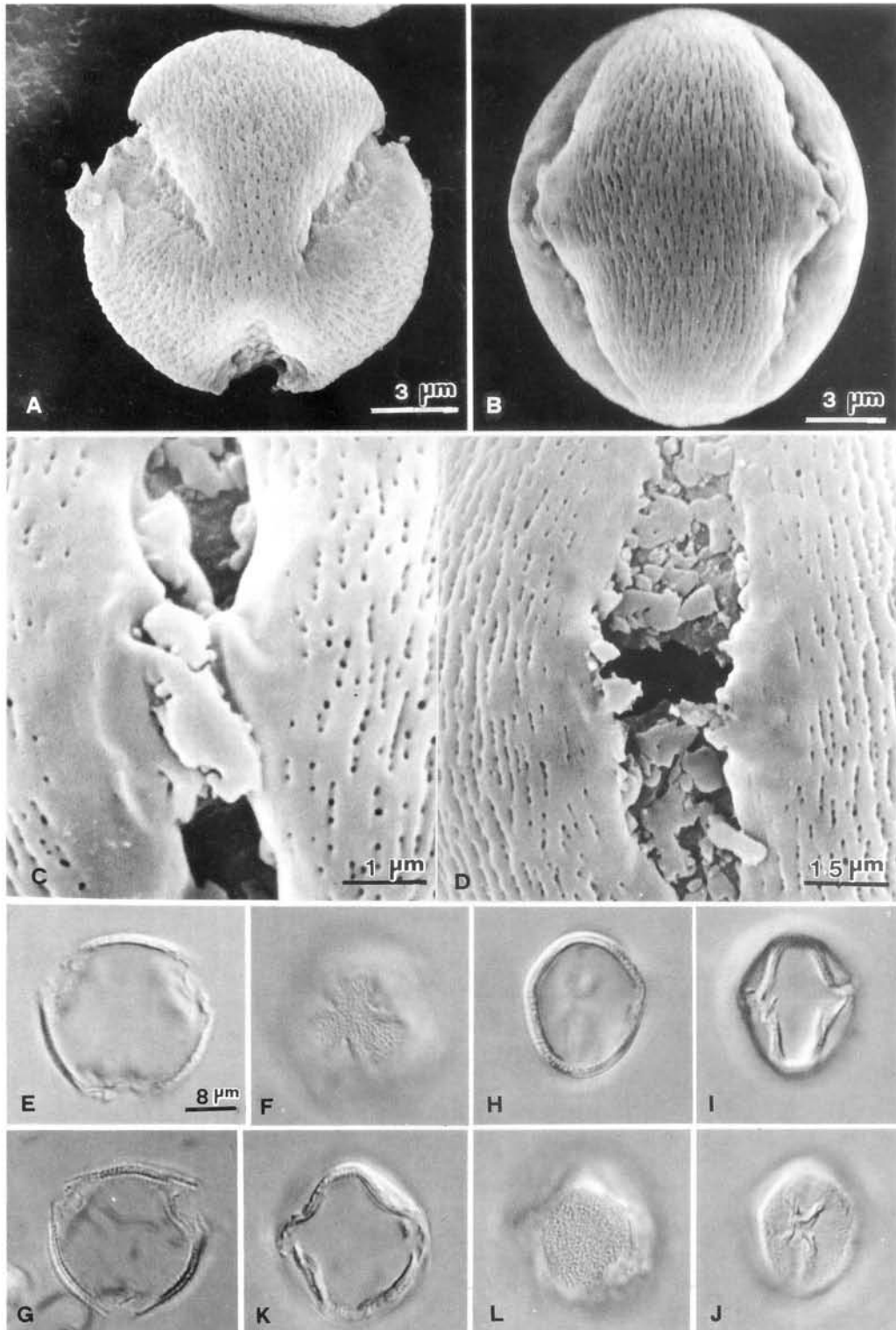


Plate 11. *Rubus corchorifolius* L. f. A-D, SEM; E-J, LM. A & E-G, 3-colporate grains in polar view showing striato-reticulate sexine with linearly distributed perforations in the grooves. H-J, grains in equatorial view showing colpus constricted in the equator and dumbbell-shaped os. C, detail of colpus region showing complete pore flap and irregularly granulate colpus membrane. D, detail of colpus region showing destroyed pore flaps and transversally parallel os.

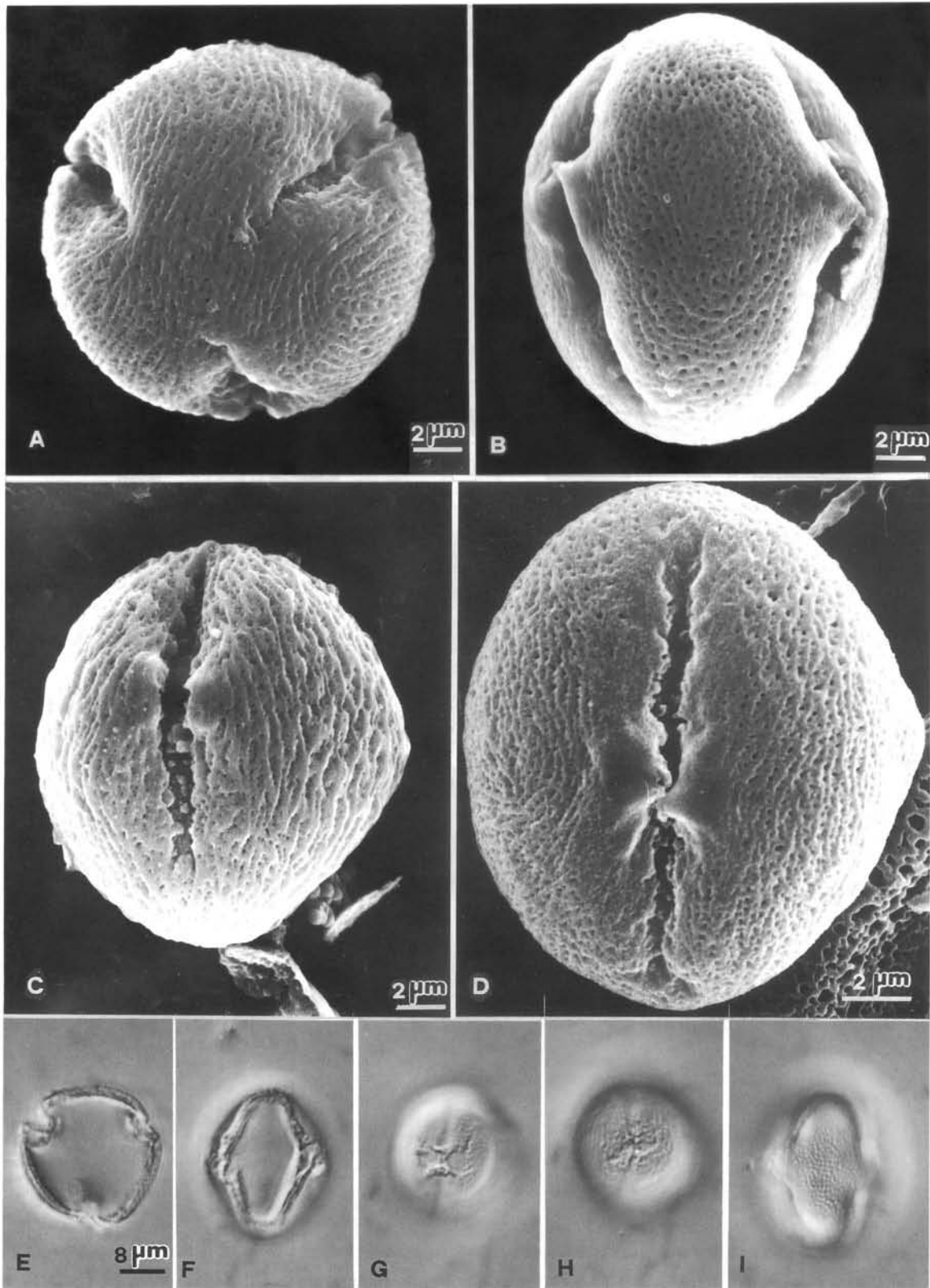


Plate 12. *Rubus croceacanthus* Lévl. A-D, SEM; E-I, LM. A & E, 3-colporate grains in polar view showing striato-reticulate sexine. B, F & I, grains in equatorial view. C, D, G & H, grains in equatorial view showing destroyed and complete pore flaps, dumbbell-shaped ora and granulate colpus membranes.

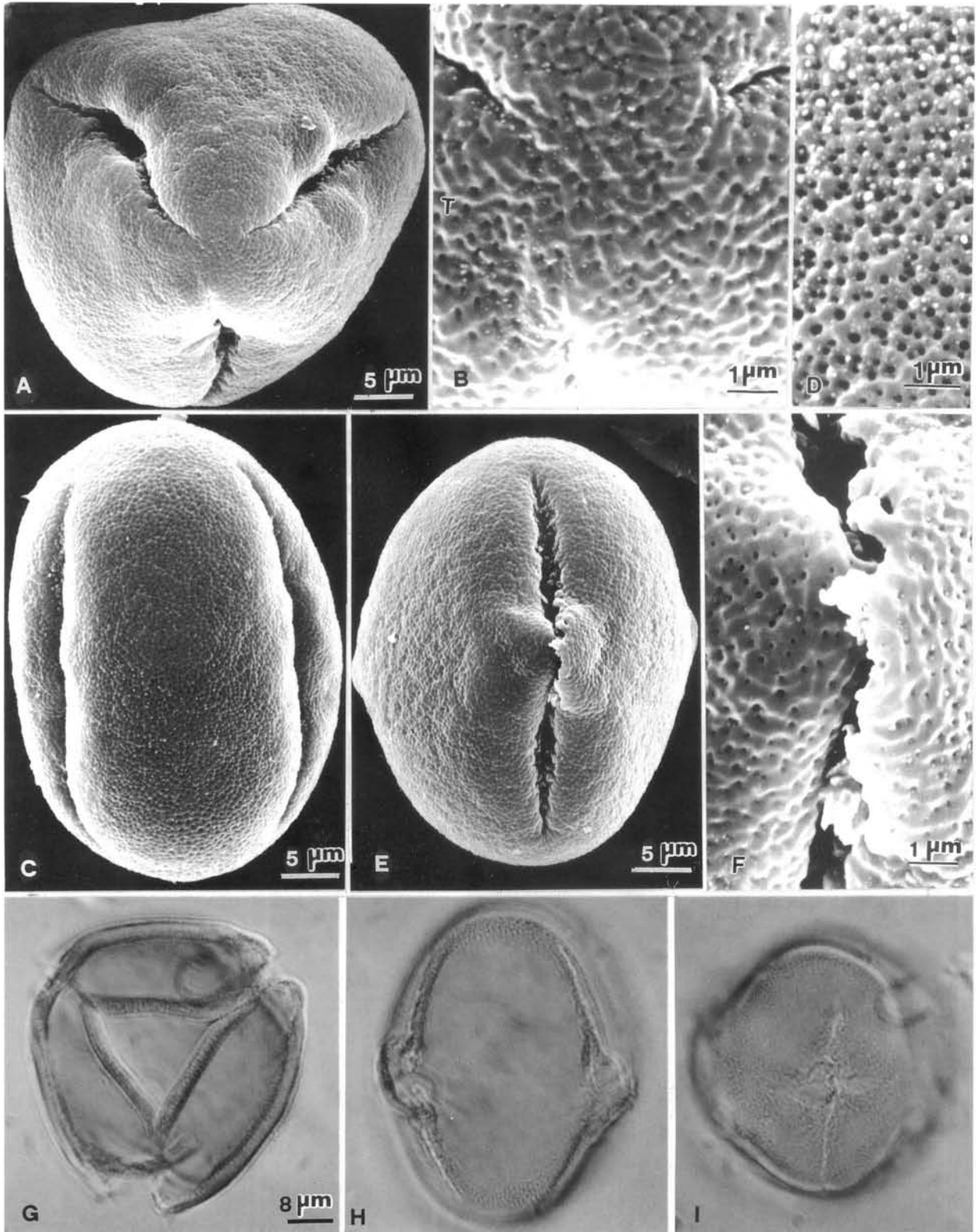


Plate 13. *Rubus formosensis* Ktze. A-F, SEM; G-I, LM. A, 3-colporate grains in polar view showing perforate to finely reticulate sexine. C, E, H & I, grains in equatorial view showing long colpi and pore flap. B & D, detail of perforate to finely reticulate sexine in apocolpium and mesocolpium. F, detail of pore flap, showing no connection in the equator. G, showing parasyncolpate grain.

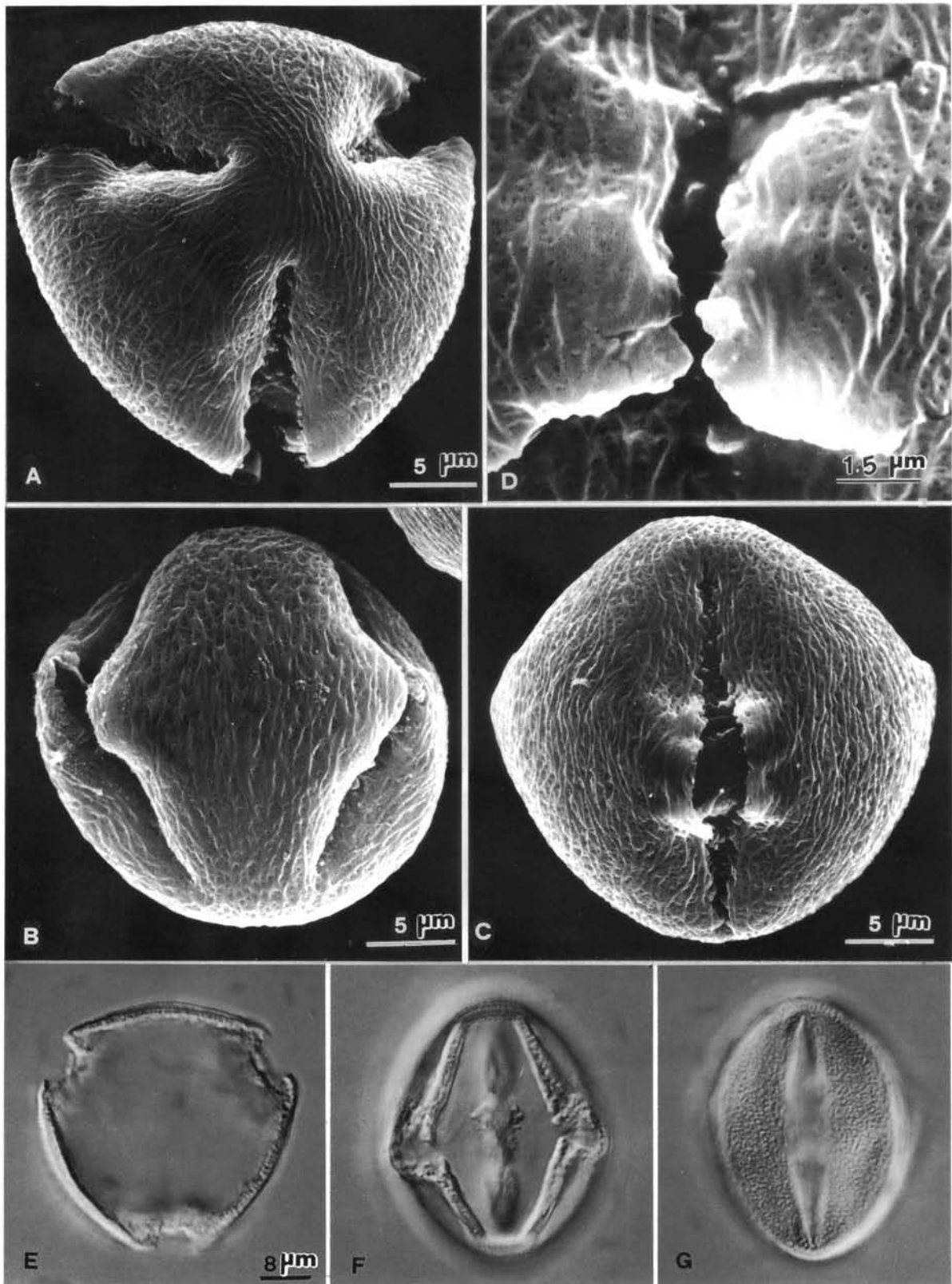


Plate 14. *Rubus liuii* Yang & Lu. A-D, SEM; E-G, LM. A & E, 3-colporate grains in polar view showing striato-reticulate sexine irregularly distributed perforations in the shallowly concealed grooves. B, C, F & G, grains in equatorial view showing long colpi, transversally parallel ora and pore flaps. D, detail of pore flap not connected in the equator.



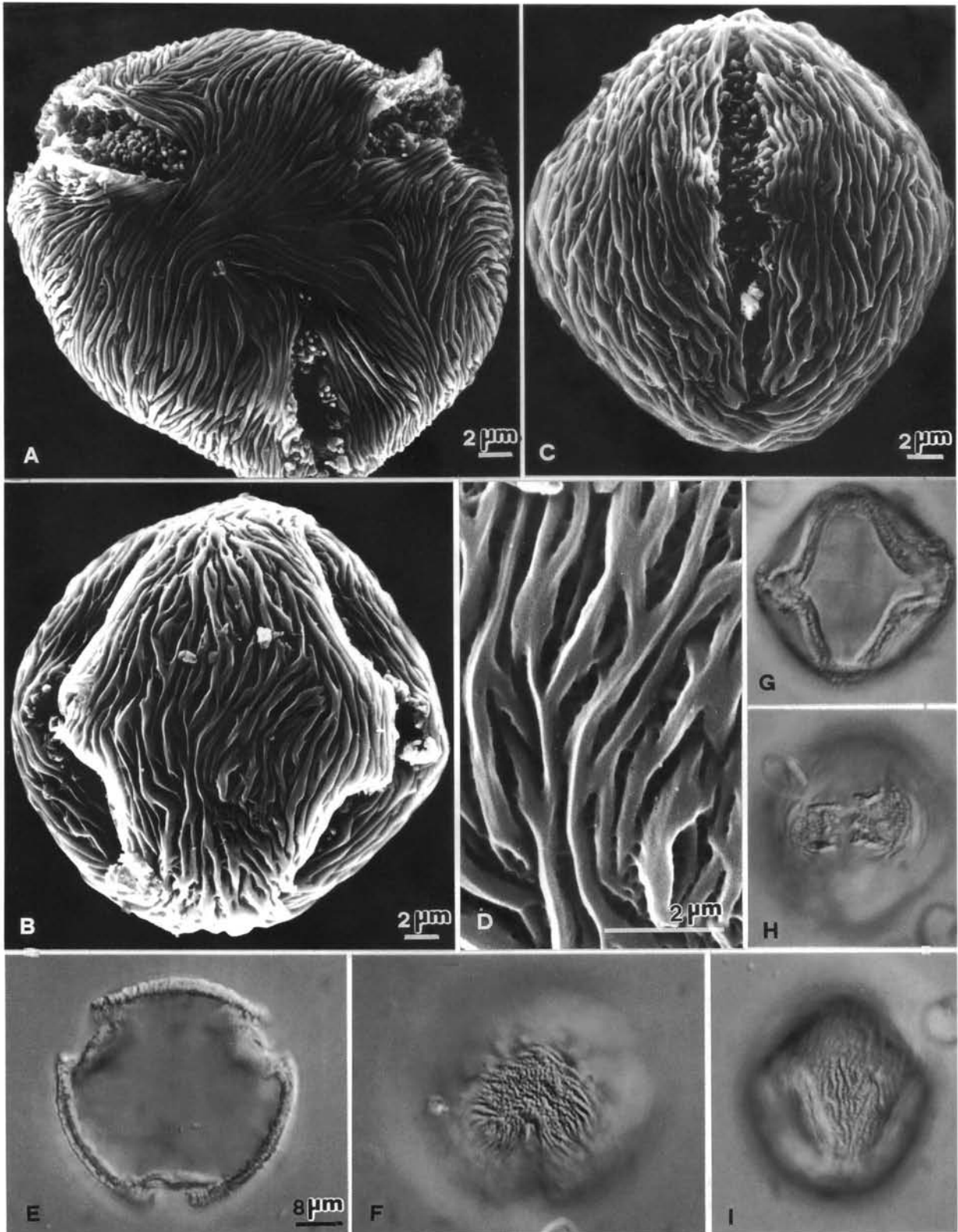


Plate 15. *Rubus pectinellus* Maxim. A-D, SEM; E-I, LM. A, E & F, 3-colporate grains in polar view showing prominently striate sexine with perforate grooves. B, C & G-I, grains in equatorial view showing long colpi, two H-shaped bridge. D, detail of prominently striate sexine with deeply concealed perforations in the grooves in mesocolpium.



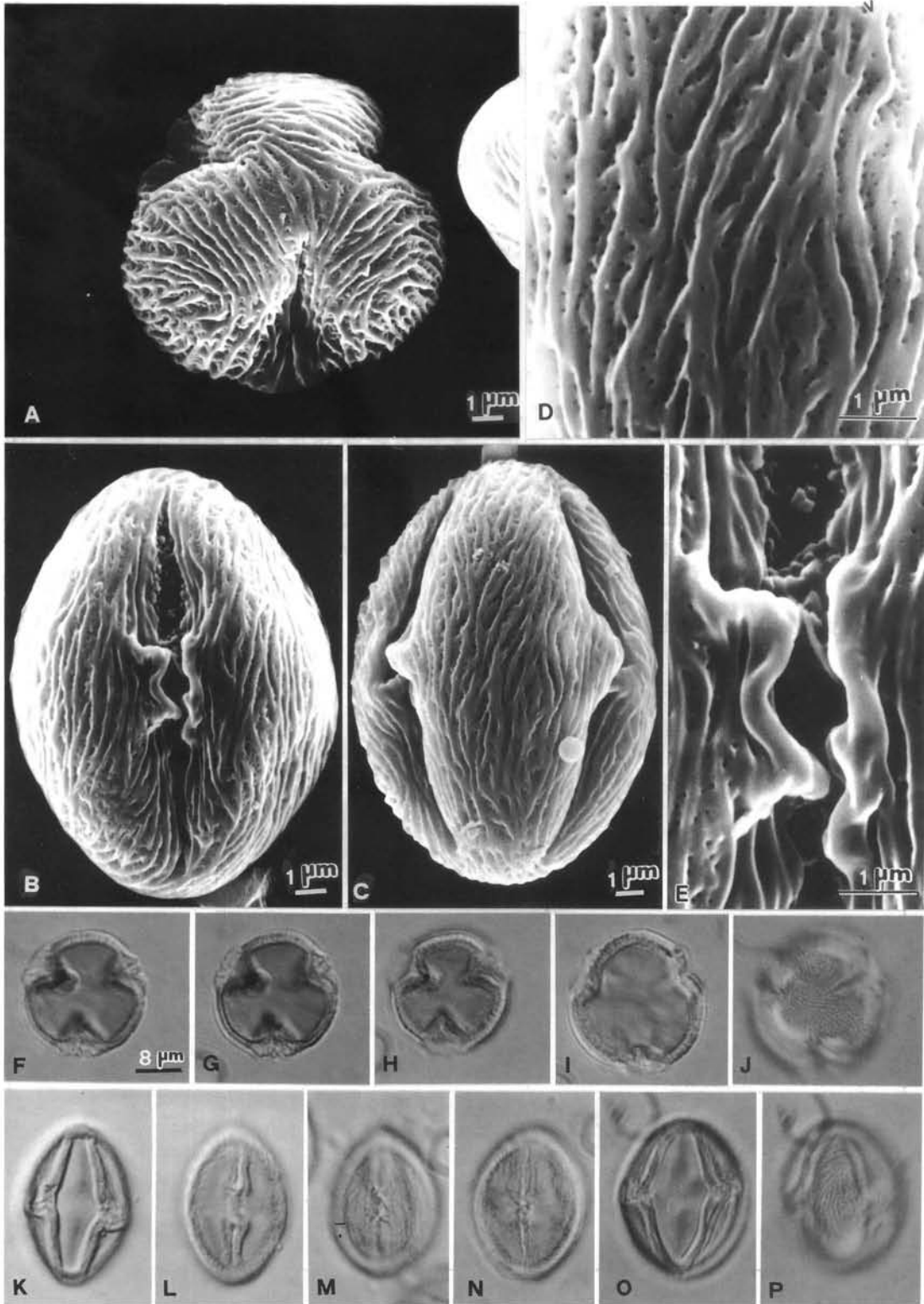


Plate 16. *Rubus sumatranus* Miq. A-E, SEM; F-P, LM. A & F-J, 3-colporate grain in polar view showing prominently striate sexine with perforate grooves. B, C & K-P, grains in equatorial view showing long and crassimarginate colpi constricted in the equator, dumbbell-shaped ora and pore flaps. D, detail of prominent striate sexine with irregularly distributed and moderately concealed perforations in the grooves in mesocolpium. E, detail of pore flap showing no connection in the equator.

## 台灣鴛鴦湖自然保留區花粉誌 (III)

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### 摘 要

本研究為連續研究(Chen and Wang, 1999; Wang and Chen, 2001)之第三篇。鴛鴦湖為酸性湖泊，位於台灣北部的自然保留區內。本研究採集該區隸屬四科十六種植物的新鮮花粉，經處理後，以光學顯微鏡和掃描式電子顯微鏡觀察這些花粉的形態。依花粉萌芽口的不同，分為三群：散孔、三溝孔和四至七溝孔的花粉。這些結果可作為研究鴛鴦湖湖積物內之花粉，並進而作為重建鴛鴦湖周邊植群史的基本資料。

關鍵詞：花粉誌、鴛鴦湖自然保留區、台灣。

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