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Pollen Flora of Yuenyang Lake Nature Preserve, Taiwan (II)

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ABSTRACT: This study is a supplement to previous report (Chen and Wang, 1999). Yuanyang Lake is an acidic lake situated within a nature preserve in northern Taiwan. The pollen morphology of twenty taxa belonging to eleven families collected from this nature preserve was studied under light microscope and scanning electron microscope in the present study. A total of eight pollen classes was grouped on the basis of the aperture on the pollen wall. They were inaperturate, 3-6-porate, pantoporate, 3-colpate, 4-7- colpate, 3-colporate, heterocolpate and tetrad pollen with monads 3-porate pollen.

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

INTRODUCTION

The pollen flora of Yuenyang Lake has facilitated the reconstruction of the paleoecology of the terrestrial vegetation around Yuenyang Lake (YYL) (Chen and Wu, 1999). Based on the preliminary study of 224 pollen species collected from Yuenyang Lake Nature Preserve, the pollen grains fall into 17 classes: saccate (Class I), inaperturate (Class II), leptomatal (Class III), 1-porate (Class IV), 2-porate (Class V), 3-6-porate (Class VI), pantoporate (Class VII), spiraperturate (VIII), fenestrate (Class IX), 1-sulcate (Class X), 3-colpate (Class XI), 4-7-colpate (Class XII), 3-colporate (Class XIII), 4-7-colporate (Class XIV), heterocolpate (Class XV), tetrad with monads 3-porate (Class XVI) or tetrad with monads 3-colporate (Class XVII) (Wang, 1996). In previous paper we have reported fifty species of pollen from the area of Yuenyang Lake Nature Preserve (Chen and Wang, 1999). In the present study, twenty species of pollen were described as a supplement. It included pollen of Illiciaceae, Labiatae, Lardizabalaceae, Lauraceae, Melastomataceae, Myricaceae, Myrsinaceae, Oleaceae, Onagraceae, Oxaliaceae and Polygonaceae. Both the light microscope (LM) and scanning electron microscope (SEM) were used to study the morphological features and fine structures of them.

MATERIALS AND METHODS

The fresh pollen grains of 20 species belonging to 11 families of angiosperms (Tab. 1) were collected from the Yuenyang Lake Nature Preserve. The treated specimens were studied as the previous study (Chen and Wang, 1999). Voucher specimens are deposited in the Palynological Laboratory, Department of Botany, National Taiwan University. All of LM photographs were 1,000 x. The magnification of all SEM micrographs is shown in plates.

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Table 1. Specimens used for the present study.

Family	Scientific name	specimen	Collection date
Illiciaceae	*Illicium anisatum* L.	*Wang 709*	21 Jun 1993
Labiatae	*Clinopodium chinense (*Benth.) Kuntze	*Wang 779*	2 Aug 1993
	Clinopodium gracile (Benth.) Kuntze	*Wang 634*	26 Apr 1993
	Melissa axillaris Bakh. f.	*Wang 1120*	13 Jul 1994
	Salvia formosana (Murata) Yamazaki var. *formosana*	*Wang 735*	2 Aug 1993
Lardizabalaceae	*Stauntonia purpurea* Y. C. Liu & F. Y. Lu	*Wang 638*	26 Apr 1993
Lauraceae	*Lindera thunbergii* (Sieb. & Zucc.) Makino	*Wang 934*	7 Mar 1994
	Litsea cubeba (Lour.) Persoon	*Wang 603*	22 Mar 1993
	Litsea elongata (Wall. ex Nees) Benth. & Hook. f. var. *mushaensis* (Hayata) J. C. Liao	*Wang 792*	2 Aug 1993
	Neolitsea acuminatissima (Hayata) Kanehira & Sasaki	*Wang 948*	21 Mar 1994
Melastomataceae	*Barthea barthei* (Hance) Krass	*Wang 668*	21 May 1993
	Sarcopyramis napalensis Wall. var. *delicata* (C. B. Robinson) S. F. Huang & T. C. Huang	*Wang 690*	21 Jun 1993
Myricaceae	*Myrica rubra* (Lour.) Sieb. & Zucc.	*Wang 920*	16 Feb 1994
Myrsinaceae	*Ardisia japonica* (Hornsted) Blume	*Wang 745*	2 Aug 1993
	Myrsine stolonifera (Koidz.) Walker	*Wang 710*	21 Jun 1993
Oleaceae	*Ligustrum liukiuense* Koidz.	*Wang 713*	21 Jun 1993
Onagraceae	*Epilobium amurense* Hausskn.	*Wang 785*	2 Aug 1993
Oxalidaceae	*Oxalis acetocella* L. ssp. *griffithii* (Edgew. & Hook. f.) Hara var. *formosana* (Terao) Huang & Huang	*Wang 946*	21 Mar 1994
Polygonaceae	*Polygonum sagittatum* L.	*Wang 773*	2 Aug 1993
	Polygonum thunbergii Sieb. & Zucc.	*Wang 746*	2 Aug 1993

RESULTS

The pollen morphology of 20 species was described alphabetically by family. The habitat of each taxon was given after the description of the pollen morphology so that it could be used for future pollen analysis.

Description of pollen morphology

Illiciaceae

Illicium anisatum L. (Plate 1. A-G)

Pollen grains 3-colpate, isopolar, oblate to oblate-spheroidal in equatorial view, 19.5-29.5 × 27.5-33 μm (P/E = 0.62-0.96), circular to slightly circulate-oblate in polar view, 26.5-39.0 μm in diameter.

Colpi relatively long, extending nearly to the poles, ends acute, 0.5 μm wide. Aperture common type.

Exine 1.5-2 μm thick. Columellae distinct. Sexine reticulate. Muri keeled/perforated, 1.2 μm wide, perforations distributed on the margins of the muri, irregularly shaped, less than 3 μm wide. Lumina irregularly shaped, gradually decreasing in size towards the colpus margins, 0.8-1.7 μm in dimension.

Evergreen medium-sized trees; at 1,400-2,400 m in mountain areas; dominant in the middle layer of mesophytic forest community on the slopes around the Yuenyang Lake.

Labiatae

Clinopodium chinense (Benth.) Kuntze (Plate 2. E-G)

Pollen grains 6-colpate (rarely 7,8-colpate), isopolar, suboblate to subprolate in equatorial view, 26.5-34.5 × 29-36 μm (P/E = 0.85-1.17), circular or hexagonal in polar view, 24-36 × 26-41.5 μm in diameter.

Colpi long, ends acuminate.

Exine 2 μm thick. Columellae distinct. Sexine finely reticulate, muri simpli-columellate, 0.2-0.6 μm wide, lumina circular to elliptical, 0.1-0.5 μm in dimension. Nexine as thick as sexine.

Perennial herbs; at low altitudes to 2,500 m in central mountains, on open roadsides; on forest floors around the Yuanyang Lake.

Clinopodium gracile (Benth.) Kuntze (Plate 2. A-D)

Pollen grains 6-colpate (rarely 5,7,8-colpate), isopolar, suboblate to subprolate in equatorial view, 19-29 × 16-31 μm (P/E = 0.84-1.25), circular or hexagonal in polar view, 20-31 μm in diameter.

Colpi shape variable, sometimes long and irregularly shaped, or short and ellpitical, or zonally distributed, or unsymmetrically distributed; ends obtuse-circular or acuminate; colpus membranes rugulate, rugulae densely distributed, 0.26 μm wide.

Exine 1.5-2 μm thick. Columellae distinct. Sexine finely reticulate, muri simpli-columellate, 0.3 μm wide, lumina circular or rounded angular, 0.15-0.9 μm in dimension. Nexine as thick as sexine.

Perennial herbs; at low altitudes in mountain areas, in champaign and on open roadsides; on forest floors around the Yuenyang Lake.

Pollen morphology was not easily distinguished between *C. chinense* and *C. gracile* under LM as well as under SEM.

Melissa axillaris Bakh. f. (Plate 3. A-C)

Pollen grains 6-colpate, isopolar, oblate-spheroidal to prolate in equatorial view, 18.5-41.5 × 20-35.5 μm (P/E = 0.93-1.38), circular or circular-lobate in polar view, 18-46.5 μm in diameter.

Colpi long, 1.3 μm wide, ends acuminate, colpus membranes verrucate, verrucae distributed compactly, 0.2-0.5 μm in dimension.

Exine 1.5-2 μm thick. Columellae distinct. Sexine perforated, perforations densely spaced in cluster densely and irregularly distributed, less than 0.8 μm in dimension. Nexine as thick as sexine.

Herbs; on the forest floors around the Yuenyang Lake.

Salvia formosana (Murata) Yamazaki var. formosana (Plate 3. D-G)

Pollen grains 6-colpate, isopolar, suboblate to oblate-spheroidal in equatorial view, 23.5-35.5 × 27-36 μm (P/E = 0.83-0.97), elliptical with 2 larger lateral mesocolpia and 4 smaller medial mesocolpia in polar view, 23.5-38 × 31-46.5 μm in diameter.

Colpi long, 0.8-1.7 μm wide, ends acuminate, colpus membranes verrucate, verrucae distributed compactly, less than 0.5 μm in dimension.

Exine 2-2.5 μm thick. Columellae distinct. Sexine doubly reticulate, primary muri simpli-columellate, slightly undulate, 0.2-0.5 μm wide, primary lumina rounded angular, 0.8-1.8 μm in dimension, decreasing in size towards the colpi and in apocolpia. Secondary reticulae in primary lumina, secondary muri 0.15-0.2 μm wide, secondary lumina 0.15-0.6 μm in dimension.

Perennial herbs; in northern Taiwan; on forest floors around the Yuenyang Lake.

Lardizabalaceae

Stauntonia purpurea Y. C. Liu & F. Y. Lu (Plate 4. G-M)

Pollen grains 3-colporate, isopolar, oblate-spheroidal to subprolate (P/E = 0.94-1.2) in equatorial view, 14.5-22 × 14-22 μm, circular or circular-lobate in polar view, 14-19.5 μm in diameter.

Colpi long, extending nearly to the poles, crassimarginate, ends acuminate, margins not entire, colpus membranes compactly verrucate, verrucae less than 0.4 μm in dimension. Ora transversally parallel.

Exine 2 μm thick. Columellae distinct. Sexine striato-reticulate, striae interwoven, 0.15-0.35 μm wide, lumina less than 0.15 μm in dimension. Nexine as thick as sexine.

Climbing shrubs; in Chilanshan; in mesophytic forest community on the slopes around the Yuenyang Lake.

Lauraceae

Lindera thunbergii (Sieb. & Zucc.) Makino (Plate 5. A-B)

Pollen grains inaperturate, apolar, spheroidal, 24.5-31.5 μm in diameter, broken after acetolysis.

Sexine spinulate, spinules cone-shaped, regularly distributed, less than 1.1 μm high, composed of longitudinal strands, with small cushion-like bases, surrounded by a ring of densely distributed verrucae, rings less than 1.75 μm in diameter, densely distributed with verrucae between spinules, verrucae less than 0.2 μm in dimension.

Deciduous small trees; at 1,000-1,800 m in northern Taiwan; understory in mesophytic forest community on the slopes around the Yuenyang Lake.

Litsea cubeba (Lour.) Persoon (Plate 5. C-D)

Pollen grains inaperturate, apolar, spheroidal, 20-22 μm in diameter, broken after acetolysis.

Sexine spinulate, spinules cone-shaped, regularly distributed, less than 1.8 μm high, composed of longitudinal strands, with small cushion-like bases, surrounded by a ring of densely distributed verrucae, rings less than 1.8 μm in diameter, densely distributed with verrucae between spinules, verrucae less than 0.25 μm in dimension.

Deciduous small trees; at 1,500-2,300 m in broad-leaved forests; understory in mesophytic forest community on the slopes around the Yuenyang Lake.

Litsea elongata (Wall. ex Nees) Benth. & Hook. f. var. mushaensis (Hayata) J. C. Liao (Plate 6. A-B)

Pollen grains inaperturate, apolar, spheroidal, 24-25.5 μm in diameter, broken after acetolysis.

Sexine spinulate, spinules cone-shaped, regularly distributed, less than 1 μm high, composed of longitudinal strands, with small cushion-like bases, surrounded by a ring of densely distributed verrucae, rings less than 1.75 μm in diameter, densely distributed with verrucae between spinules, verrucae less than 0.25 μm in dimension.

Evergreen medium-sized trees; in 1,500-2,300 m throughout the island; understory in mesophytic forest community on the slopes around the Yuenyang Lake.

Neolitsea acuminatissima (Hayata) Kanehira & Sasaki (Plate 6. C-D)

Pollen grains inaperturate, apolar, spheroidal, 16.5-20.5 μm in diameter.

Sexine spinulate, spinules cone-shaped, regularly distributed, less than 1.4 μm high, composed of longitudinal strands, with small cushion-like bases, surrounded by a ring of densely distributed verrucae, rings less than 1.5 μm in diameter, densely distributed with verrucae between spinules, verrucae less than 0.2 μm in dimension.

Small to medium-sized trees; at 1,800-2,600 m in primitive forests, broad-leaved and coniferous mixed forests and secondary forests, associated in *Tsuga* forests and *Chmaecyparis* forests, forming the second or third broad-leaved forest layer; understory in mesophytic forest community on the slopes around the Yuenyang Lake.

It is difficult to distinguish the pollen among *Lindera*, *Litsea* and *Neolitsea* under LM and SEM.

Melastomataceae

Barthea barthei (Hance) Krass (Plate 7. A-E)

Pollen grains 6-heterocolpate (3-colporate with 3 intercolpar concavities), isopolar; prolate-spheroidal to prolate (P/E = 1.06-1.38) in equatorial view, 14.5-22 × 12.5-17 μm; hexagonal with concave sides and obtuse angles in polar view, 13-18.5 μm in diameter.

Colpi long, slightly crassimarginate, constricted in the equator; colpus membranes scabrate. Intercolpar concavities elliptical, thin-walled, depressed, 6.5 × 2.5 μm. Ora dumbbell-shaped. Aperture fastigium type.

Exine 1-1.5 μm thick in mesocolpia, thicker towards the colpi. Sexine striato-reticulate; ridges short, interwoven, 0.1-0.25 μm wide; compactly verrucate to rugulate in the intercolpar concavities, verrucae less than 0.4 μm in dimension.

Evergreen trees; at medium altitudes in forests; undergrowths in mesophytic forest community on the slopes around the Yuenyang Lake.

Sarcopyramis napalensis Wall. var. delicata (C. B. Robinson) S. F. Huang & T. C. Huang (Plate 7. F-I)

Pollen grains 6-heterocolpate (3-colporate with 3-intercolpar concavities), isopolar; oblate-spheroidal to subprolate (P/E = 0.89-1.2) in equatorial view, 20.5-29.5 × 19-28 μm; hexagonal in polar view, 19.5-29.5 μm in diameter.

Colpi long, extending nearly to the poles, crassimarginate, constricted in the equator, ends obtuse, colpus margins ragged, colpus membranes finely granulate. Intercolpar concavities elliptical, thin-walled, depressed, 15.3 × 7.3 μm. Ora rounded-rectangular. Aperture fastigium type.

Exine 1.5-2 μm thick in mesocolpia, thicker towards the colpi. Sexine striate/perforated, ridges short, interwoven, less than 0.15 μm wide, irregularly distributed with perforations and fossula between the ridges; compactly verrucate in the intercolpar concavities, verrucae less than 0.6 μm in dimension.

Herbs; at low to medium altitudes (300-2,600 m) on primitive forest floors, typical on *Chamaecyparis* and broad-leaved forest floors; growing in humid and cool environments, dominant on forest floors around the Yuenyang Lake.

Myricaceae

Myrica rubra (Lour.) Sieb. & Zucc. (Plate 4. A-F)

Pollen grains 3-porate, distinctly aspidate, isopolar, oblate to oblate-spheroidal in equatorial view, 13.5-21 × 16-24.5 μm (P/E = 0.74-0.94), semiangular with slightly convex sides in polar view, 15-24.5 μm in diameter.

Pores circular or slightly longitudinally elliptic, 1.2-2.4 μm in diameter, surrounded by annulus, annulus 2-3.6 μm wide. Inner surface at the base of the aspides roughened, ribbed, or jagged. Pore membranes spinulate, easily keeled off after acetolysis.

Exine 1.5-2 μm thick. Sexine spinulate/perforated, sexine thickened and nexine absent near the pores.

Evergreen trees; at 300-2,000 m in mountain areas; understory in mesophytic forest community on the slopes around the Yuenyang Lake.

Myrsinaceae

Ardisia japonica (Hornsted) Blume (Plate 8. A-G)

Pollen grains 3-colporate (rarely 4-colporate), isopolar, oblate-spheroidal to prolate-spheroidal (P/E = 0.91-1.14) in equatorial view, 12-15 × 12-13.5 μm, circular or semiangular in polar view, 12-15 μm in diameter.

Colpi long, crassimarginate, thickened towards the ora, ends acuminate, colpus margins ragged, colpus membranes verrucate, verrucae less than 0.4 μm in dimension. Ora rectangular or transversally parallel.

Exine 1-1.5 μm thick. Columellae distinct. Sexine reticulate, muri keeled, 0.3-0.4 μm wide, lumina polygonal, less than 0.5 μm in dimension. Nexine as thick as sexine.

Evergreen small shrubs; in northern Taiwan, mostly in cool and humid *Chamaecyparis* forests; undergrowths in mesophytic forest community in the slopes around the Yuenyang Lake.

Myrsine stolonifera (Koidz.) Walker (Plate 8. H-N)

Pollen grains 3-colporate, isopolar; spheroidal to prolate-spheroidal (P/E = 1-1.11) in equatorial view, 10-16 × 9.5-15 μm; circular or circular-lobate in polar view, 10-15 μm in diameter.

Colpi long, ends acumiante, colpus membranes scabrate to finely granulate, sexine extended over the ora forming rectangular bridges. Ora rectangular or transversally parallel.

Exine 1-1.5 μm thick. Sexine compactly rugulate; rugulae 0.2-0.4 μm wide, distributed more compactly towards the colpus margins, perforated between the rugulae. Nexine as thick as sexine.

Shrubs; at 1,600-2,500 m in forests, common in humid *Chamaecyparis* forests; undergrowths in mesophytic forest community in the slopes around the Yuenyang Lake.

Pollen of *Ardisia japonica* differed from that of *Myrsine stolonifera* in having reticulate sexine. The later had rugulate sexine.

Oleaceae

Ligustrum liukiuense Koidz. (Plate 9. A-F)

Pollen grains 3-colporate, isopolar, oblate-spheroidal to prolate-spheroidal (P/E = 0.93-1.11) in equatorial view, 24.5-39 × 24-39 μm, circular or slightly circular-lobate in polar view, 26-39 μm in diameter.

Colpi long, ends acuminate, colpus membranes scabrate to granulate. Ora transversally parallel, distributed densely with granules on the os membranes, granules 0.2-0.8 μm in dimension.

Exine 4 μm thick, thinner towards the colpi. Columellae distinct. Sexine reticulate, muri simpli-columellate, 0.65-0.85 μm wide, lumina polygonal, variable in size, decreasing in size towards the colpus margins, 2.3-5.8 μm in dimension, distributed with verrucae and bacules in the lumina, verrucae less than 1 μm in dimension. Nexine thinner than sexine.

Deciduous shrubs to small trees; at 1,000-3,000 m in mountain areas in northern and central parts of the island; undergrounds in mesophyic forest community on the slopes around the Yeunyang Lake.

Onagraceae

Epilobium amurense Hausskn. (Plate 10. A-F)

Pollen grains tetrads tetrahedral, easily separated into monads, tetrads formed by the fusion of exinous fingers arranged at the base of the pore along the annuli of the pore, tetrads 76.5-113 μm, monads 3-porate, isopolar, 56.5-80.5 μm in diameter.

Pores circular, protruding, annulate. Aperture vestibulum type.

Exine 3.5-5 μm thick. Columellae distinct, less than 0.5 μm thick. Sexine finely rugulate/verrucate, rugulae short, less than 0.25 μm wide, compactly and irregularly distributed with verrucae, verrucae less than 0.35 μm in dimension, perforated between the rugulae. Visin strands arising from proximal view, tightly-compound twisted, less than 1.4 μm wide. Nexine thinner than sexine.

Perennial herbs; above medium altitudes in central mountains, along roadsides, in grasslands, on gravel hillsides; on forest floors around the Yuenyang Lake.

Oxalidaceae

Oxalis acetocella L. ssp. griffithii (Edgew. & Hook. f.) Hara var. formosana (Terao) Huang & Huang (Plate 11. A-F)

Pollen grains 4-colpate (rarely 3- or 5-colpate), isopolar, prolate-spheroidal to subprolate in equatorial view (P/E = 1.04-1.17), 31.5-54 × 29.5-49 μm, quadrangular with convex sides and obtuse angles in polar view, 29.5-58.5 μm in diameter.

Colpi of medium size, colpus margins tattered. Colpus membranes granulate, easily destroyed after acetolysis.

Exine 2-3 μm thick. Columellae distinct. Sexine granulate/rugulo-reticulate; granules polygonal-shaped, irregularly distributed, 0.8-1.5 μm wide, 0.9-1.5 μm high, with 2-3 inconspicuous ridges. Muri simpli-columellate, often cracked or ruptured as rugulae, up to 0.4 μm wide. Lumina various in size, decreasing in size towards the colpi. Nexine thinner than sexine.

Perennial herbs; at 900-3,300 m in cool places and under the shades of the trees.

Polygonaceae

Polygonum sagittatum L. (Plate 12. A-B)

Pollen grains pantoporate, apolar, spheroidal, 49.5-66 μm in diameter.

Pores circular, situated in the lumina, 3.3-5 μm in diameter.

Exine 5-7 μm thick. Columellae distinct. Sexine reticulate, muri wedge-shaped, 0.75-0.95 μm wide, supported with double to triple pilae, pilae 0.7-1 μm wide; lumina polygonal, sunken, 4.3-8.3 μm in dimension, usually forming tetra- to heptagon, compactly distributed verrucae in the lumina, verrucae 0.4-1 μm in dimension. Nexine thinner than sexine.

Hygrophytic annual herbs; common in roadside wetlands, along river banks and in ditches; mixed with *Polygonum thunbergii* in *Schoeoplectus mucronatus* consocies in the marsh around the Yuenyang Lake.

Polygonum thunbergii Sieb. & Zucc. (Plate 12. C-F)

Pollen grains pantoporate, apolar, spheroidal, 34-75.5 μm in diameter.

Pores circular, situated in the lumina, 2.8-4.3 μm in diameter..

Exine 5.5-7.5 μm thick. Columellae distinct. Sexine reticulate, muri wedge-shaped, 0.8-1.3 μm wide, supported with double to triple pilae, pilae 0.55-1.2 μm wide; lumina polygonal, sunken, 7.3-11.3 μm in dimension, usually forming penta- to heptagons, compactly distributed verrucae in the lumina, verrucae 0.45-1.2 μm in dimension. Nexine thinner than sexine.

Annual herbs; at low to medium altitudes in mountain areas and shady wetlands; mixed with *Polygonum sagittatum* in *Schoeoplectus mucronatu* consocies, in shrub community margins in the marsh and on froest floors around the Yuenyang Lake.

It is difficult to distinguish between pollen of *Polygonum sagittatum* and that of *P. thunbergii*.

DISCUSSION

In this study, the pollen morphology of 20 species could be categorized on the basis of aperture types into eight pollen classes: inaperturate (Class II), 3-6-porate (Class VI), pantoporate (ClassVII), 3-colpate (Class XI), 4-7- colpate (Classs XII), 3-colporate (Class XIII), heterocolpate (Class XV) and tetrad with monads 3-porate pollen (Class XVI).

In Taiwan, Wang (1969) and Huang (1972) have observed 46 and 37 species of lauraceous pollen, respectively, by using LM and described them as inaperturate, spheroidal to subspheroidal grains. In the present study, three genera and four species (*Lindera*

thunbergii, *Litsea cubeba*, *Litsea elongata* var. *mushaensis*, *Neolitsea acuminatissima*) of lauraceous pollen were studied by LM and SEM, and they were grouped to inaperturate pollen grains (class II). These three genera belong to pollen type A of Kostermans's proposal (Kostermans, 1957) on the basis of mainly spheroidal shape, apolar, and exine spinulate sculpture. Pollen of *Lindera subumbelliflora* (van der Merwe *et al.*, 1990), *L. benzoin* (Lieux, 1980a) and neoptropical Lauraceae (Raj and van der Werff, 1988) have circular cushion-like form at the base of sexine spinules. This structure was also observed in all four species of this study. However, it was not present in Chinese lauraceous pollen (Tang and Shang, 1995). Pollen of *Litsea caliclris* have closely distributed verrucae between sexine spinules (Moar, 1993).This character was also observed in all four species of this study. However, verrucae are not present between spinules in Chinese lauraceous pollen (Tang and Shang, 1995).

The pollen of Lauraceae have distinctly thin exine (Erdtman, 1966; Raj and van der Werff, 1988). They are easily shriveled or ruptured after acetolysis. There are about 60 species of Lauraceae in Taiwan (Liao, 1996), which are the main forest components at low mountain areas in Taiwan. Unfortunately, the lauraceous pollen can hardly exist after acetolysis. The interpretation of pollen diagram at lowland in Taiwan is therefore more difficult than that in higher altitude (Chen, unpublished data).

In this study, *Myrica rubra* is the only species belonging to 3-6-porate pollen grains (class VI). The pollen morphology of Taiwanese *M. rubra* was studied previously by Chen (1988). The pollen of this species are characterized by thickening of sexine and absence of nexine in the vicinity of the pores, which is the same as the results of Sundberg (1985). These characters can contribute to the taxonomy and fossil records of the *Myrica* (Ferguson, 1998). The structure of spinulate supratectal islands on sexine was observed by Chen (1988) in *M. rubra* and by Lieux (1980b) in *M. inodora*. This structure, however, was not observed in the samples of the present study, which showed homogeneously distributed spinulae on sexine and was more or less similar to the type of *M. cerifera* pollen described by Lieux (1980b) as well as that of *M. gale* by Nillson *et al.* (1977). The results of the present study suggest that the morphological differences within this species might be some variations among different populations. To ascertain this, a further study should be done.

There are two species of Polygonaceae belonging to pantoporate pollen grains (class VII), namely *Polygonum sagittatum* and *P. thunbergii*. Based on the pollen morphological characteristics, they belong to *Persicaria*-type category (Zhang and Zhou, 1998; Wang and Feng, 1994; van Leeuwen *et al.*, 1988).

Illicium anisatum (Illiciaceae) is the only species belonging to 3-colpate pollen (class XI). The morphology of colpi of this species is similar to other species of *Illicium* (Lieux, 1980a; Kurosawa, 1991; Takahashi, 1994). Their colpi extend nearly to the poles and forming syncolpi.

Of the class XII of 4-7-colpate pollen there are five species belonging to two families in the present study: *Clinopodium gracile*, *C. chinense*, *Melissa axillaris*, *Salvia formosana* var. *formosana* (Labiatae) and *Oxalis acetocella* ssp. *griffithii* var. *formosana* (Oxalidaceae). Pollen of *Oxalis* is 4-colpate and easily distinguished from other pollen of Labiatae, which are 6-colpate. Most species of *Oxalis* have reticulate sexine (Kurosawa, 1991; Crompton and Wojtas, 1993; Moar, 1993; Xi and Ning, 1994) except *O. magellanica* which has rugulate sexine (Heusser, 1971). There exist some variations of sexine sculpture in *Oxalis* pollen. *Salvia* pollen has two larger lateral mesocolpia and four smaller medial mesocolpia (Trudel and Korton, 1992). It can be easily distinguished from pollen of *Clinopodium* and *Melissa*. The majority of *Clinopodium* pollen are 6-colpate. However, 5-, 7-, or 8-colpate pollen often

occurred in the same sample. The shape of these pollen colpi sometimes varies from long and irregularly-shaped, short and elliptical, zonally distributed to unequidistantly placed. Abnormal pollen are observed in *Clinopodium gracile* and *C. chinense* in the present study and also found in *Salvia leucantha* by Gupta and Sharma (1990). A further cytological study of Taiwanese *Clinopodium* is necessary in order to investigate the pollen fertility of these species.

In the present study, all of 3-colporate pollen belong to the class XIII which have reticulate wall sculpturing. Among them, the pollen of *Ligustrum liukiuense* (Oleaceae) can be easily distinguished from those of *Ardisia japonica* and *Myrsine stolonifera* (Myrsinaceae), and *Stauntonia purpurea* (Lardizabalaceae) by its larger grain size (more than 23 μm in diameter). It has coarsely reticulate sexine like other species in other countries (Zhang, 1982; Kiew, 1984; Punt *et al.*, 1991; Guo *et al.*, 1994). *Stauntonia purpurea* differs from *Ardisia japonica* and *Myrsine stolonifera* in having thicker exine (more than 1.5 μm). The pollen of *Ardisia japonica* has reticulate sculpturing with keeled muri, whereas that of *Myrsine stolonifera* has compactly rugulate sculpturing. These species are thus different from each other significantly.

Pollen of *Stauntonia* from China (Wang *et al.*,1997) and from Taiwan in previous report (Huang, 1972) has a verrucate, granulate/reticulate, or finely-reticulate sexine under LM. In this study, however, the pollen of this genus is finely-reticulate sexine under LM and striato-reticulate sexine under SEM. Presumably it is an intraspecific variation.

Two species of Melastomataceae belong to heterocolpate pollen (class XV): *Sarcopyramis napalensis* var. *delicata* and *Barthea barthei*. The former species has larger pollen size than the latter, although they have similar length of their intercolpar concavities (*i.e.* similar length of polar axis). This is similar to that reported by Chantaranothai (1997). There are three types of pollen in Melastomataceae: heterocolpate with pseudocolpi, heterocolpate with intercolpar concavities, and tricolporate (Patel *et al.*, 1984). Both the *Barthea* and *Sarcopyramis* pollen grains belong to heterocolpate group with intercolpar concavities.

Pollen of *Epilobium amurense* (Onagraceae) belong to the of class XVI of tetrads with 3-porate monads. The pollen of *Epilobium* in the present study is a combination of finely rugulae and verrucae rather than finely reticulate reported for Chinese species (Wang *et al.*, 1997). The viscin threads are evident in Onagraceae and some Ericaceae (Skvarla *et al.*, 1978). Moreover, the viscin threads of Onagraceae pollen have four surface patterns: smooth, segmented, tightly compound-twisted and incised-compound (Patel *et al.*, 1984). The viscin threads of *Epilobium* pollen are of tightly compound-twisted surface patterns which are possibly originated from exine bridges connecting adjacent members of tetrads, unlike those observed in *Rhododendron formosanum* and *R. mariesii* (Ericaceae) pollen grains of our previous study (Chen and Wang, 1999).

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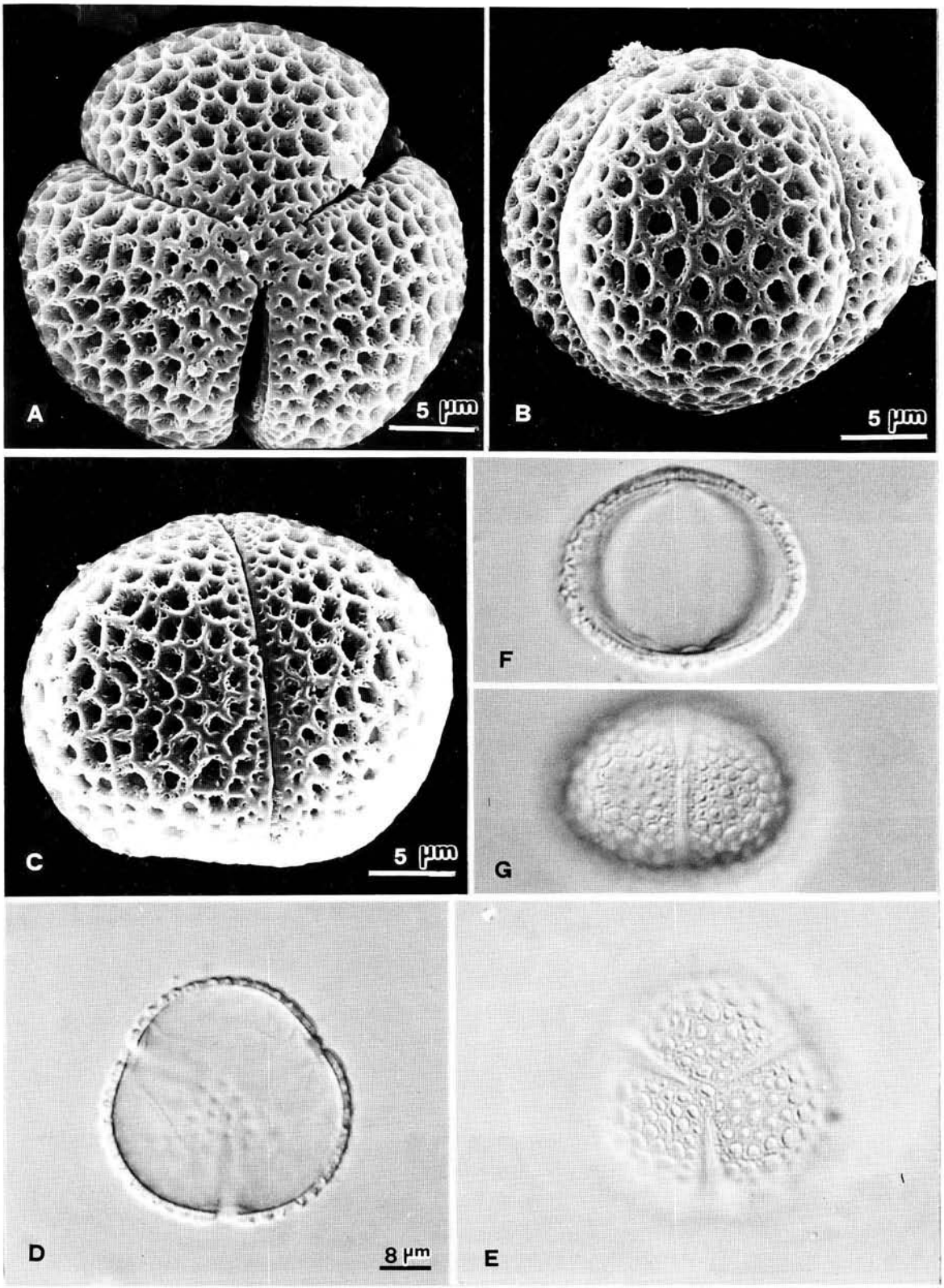

Plate 1. A-G: *Illicium anisatum* L. A-C, SEM; D-G, LM. A, D & E, 3-colpoate grains in polar view showing reticulate sexine. B, C, F & G, grains in equatorial view showing relatively long colpi and irregularly shaped lumina gradually decreasing in size towards the colpus regions.

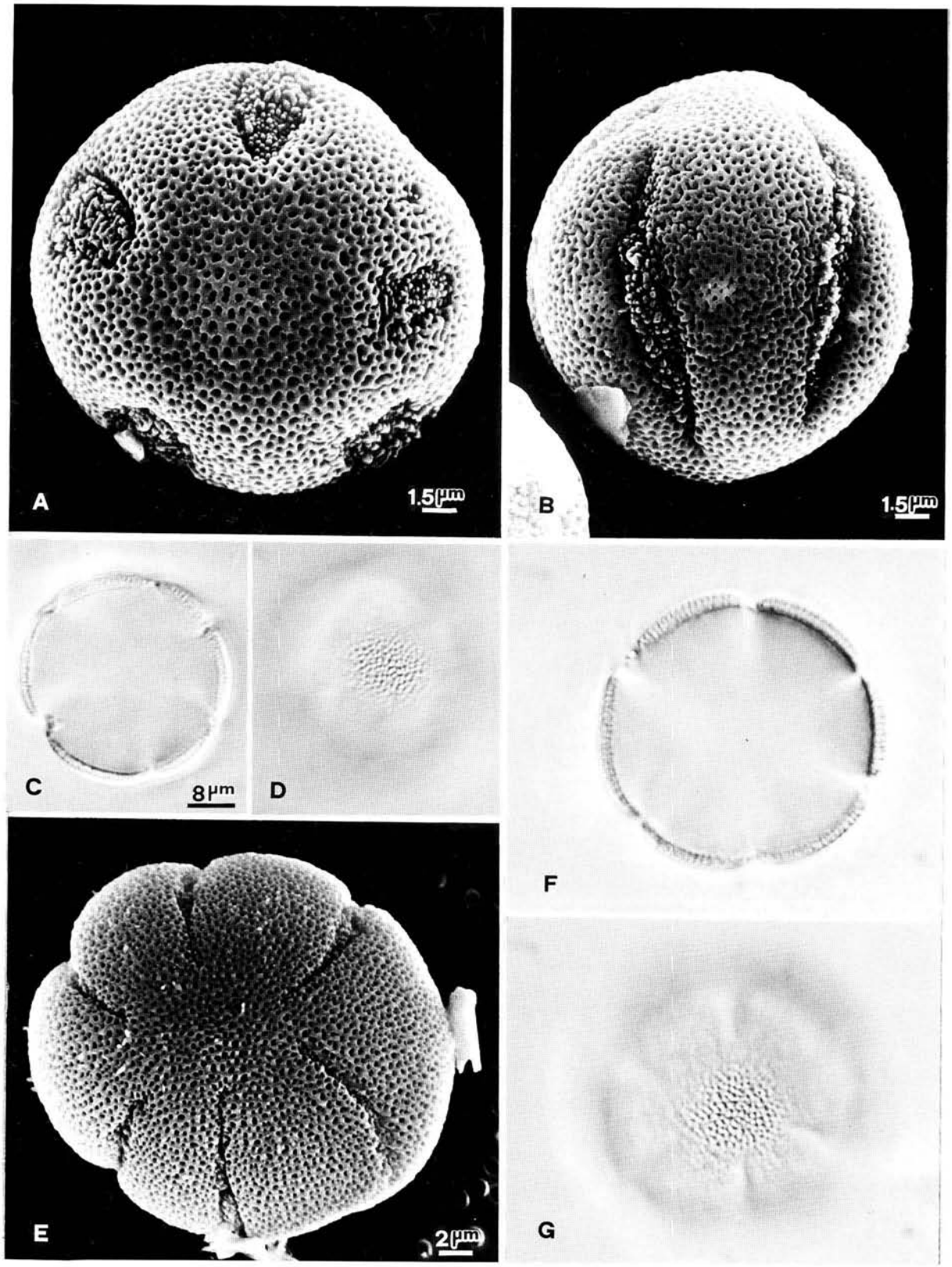

Plate 2. A-D: *Clinopodium gracile* (Benth.) Kuntze. A & B, SEM; C & D, LM. A, C & D, 6-colpate grains in polar view showing finely reticulate sexine. B, grain in equatorial view. E-G: *Clinopodium chinense* (Benth.) Kuntze. E, SEM; F & G, LM. E-G, 6-colpate grains in polar view showing finely reticulate sexine.

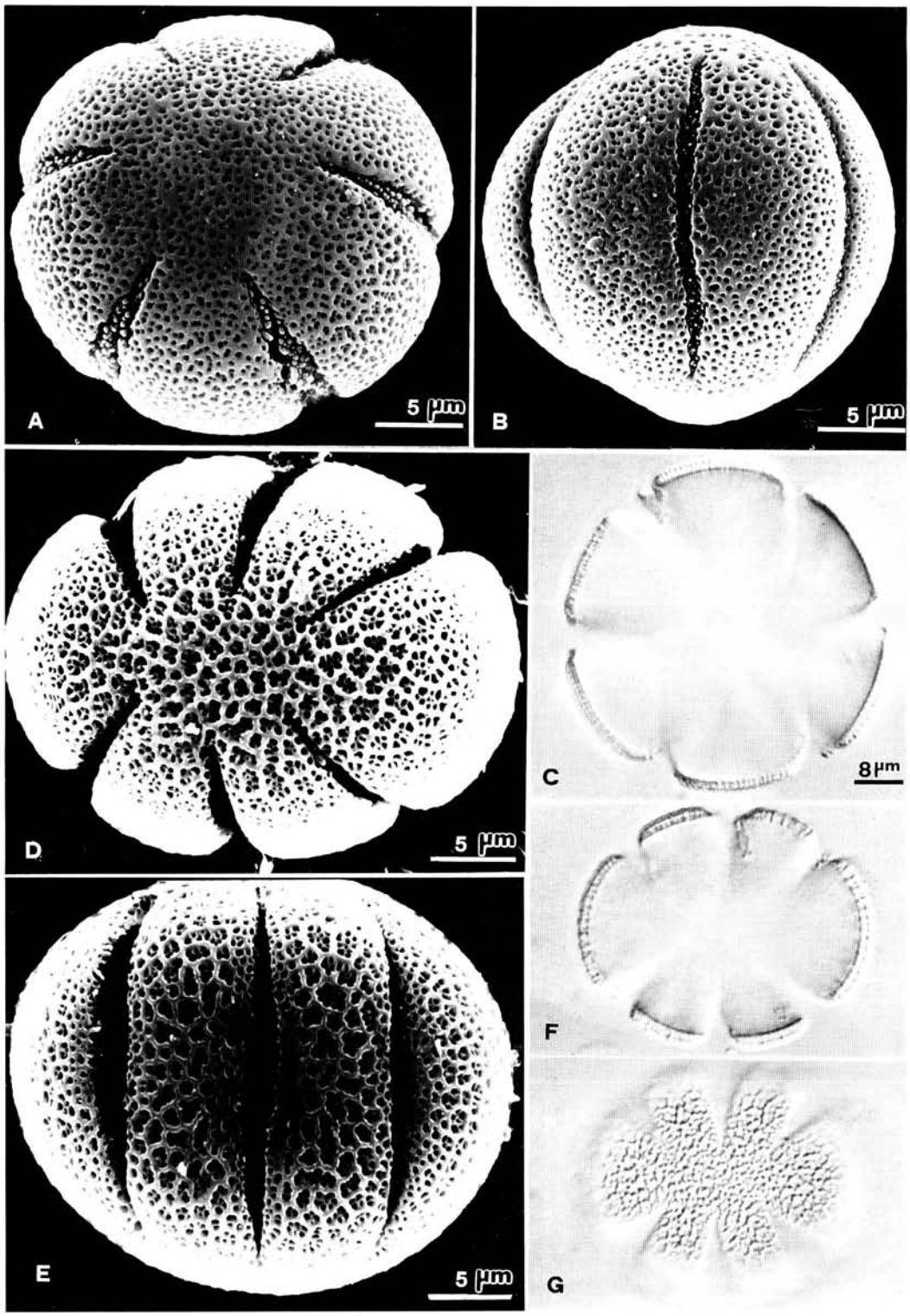

Plate 3. A-C: *Melissa axillaris* Bakh. f. A & B, SEM. C, LM. A & C, 6-colpate grains in polar view showing perforated sexine. B, grain in equatorial view showing long colpus and verrucate colpus membrane. D-G: *Salvia formosana* (Murata) Yamazaki var. *formosana*. D & E, SEM; F & G, LM. D, F & G, 6-colpate grains in polar view showing double reticulate sexine. E, grain in equatorial view.

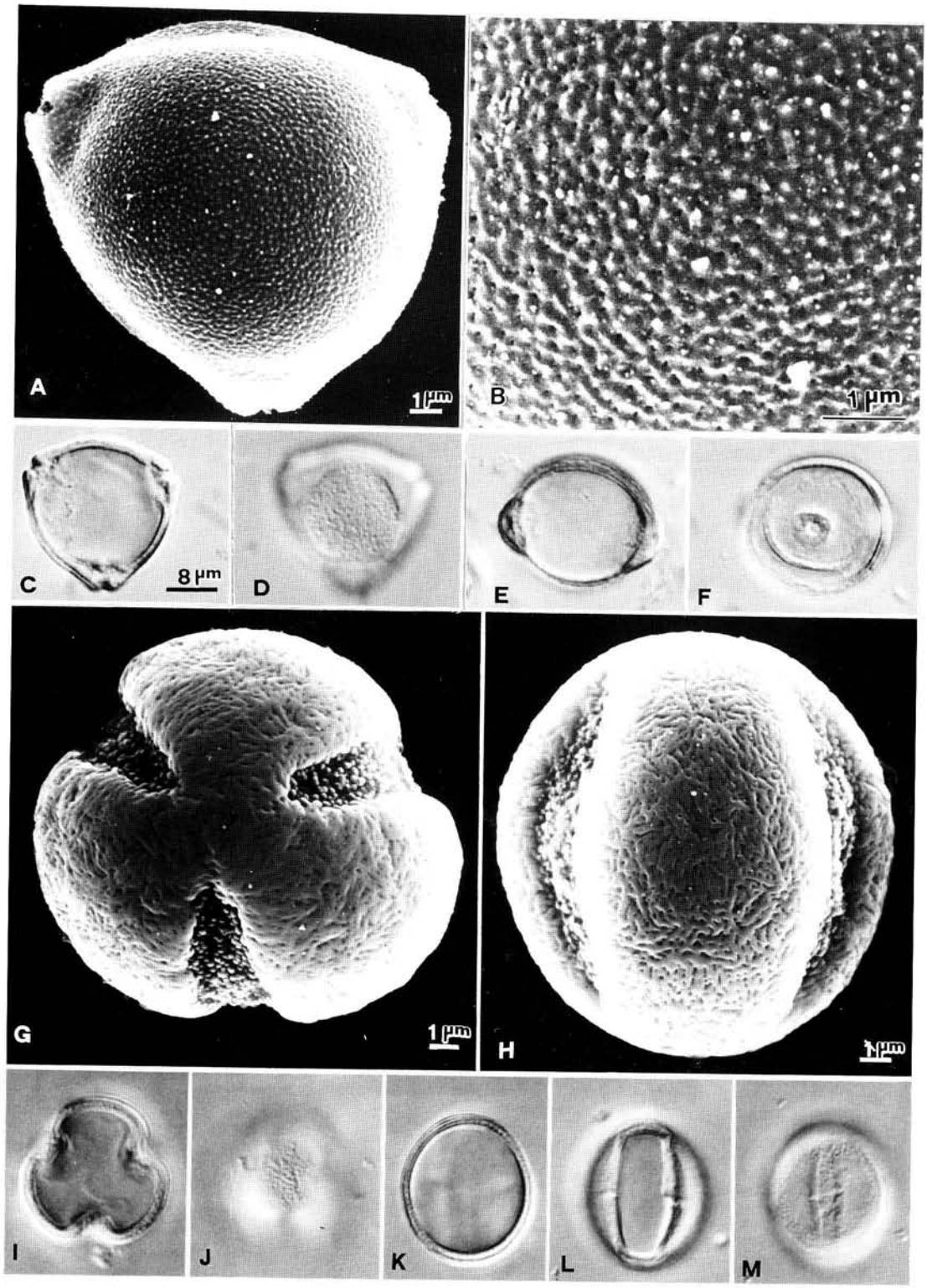

Plate 4. A-F: *Myrica rubra* (Lour.) Sieb. & Zucc. A & B, SEM; C-F, LM. A, C & D, 3-porate grains in polar view showing spinulate/perforated sexine. B, detail of spinulate/perforated sexine. E & F, grains in equatorial view showing circular pores and annulus surrounding the pores. G-M: *Stauntonia purpurea* Y. C. Liu & F. Y. Lu. G & H, SEM; I-M, LM. G, I & J, 3-colporate grain in polar view showing striato-reticulate sexine. H, K-M, grains in equatorial view showing verrucate colpus membranes and transversally parallel ora.

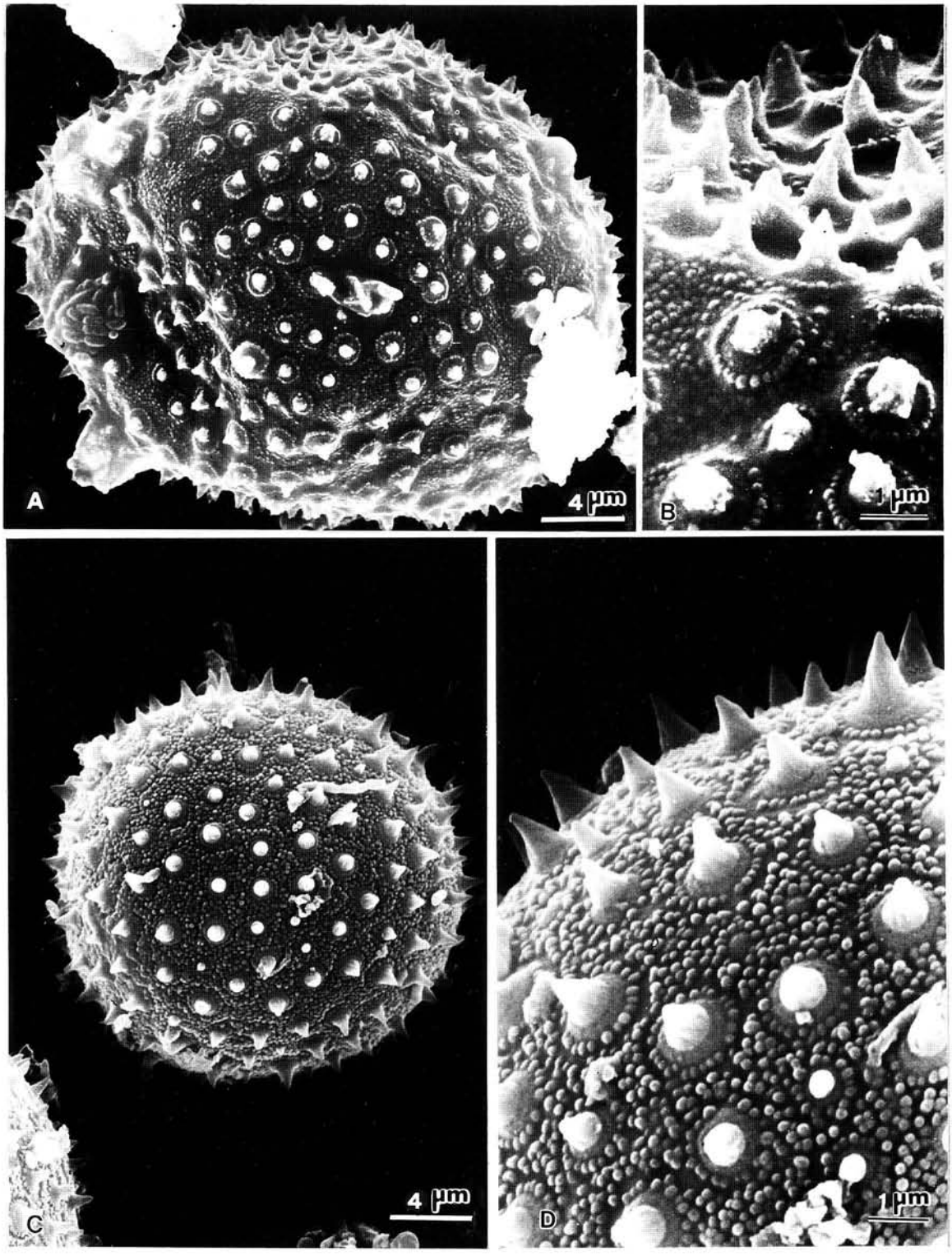

Plate 5. A & B: *Lindera thunbergii* (Sieb. & Zucc.) Makino, SEM. A, inaperturate grain showing spinulate sexine. B, detail of spinulate sexine showing cone-shaped spinules, small cushion-like bases and a ring of densely distributed verrucae surrounding the base. C & D: *Litsea cubeba* (Lour.) Persoon, SEM. C, inaperturate grain showing spinulate sexine. D, detail of spinulate sexine showing cone-shaped spinules, small cushion-like bases and a ring of densely distributed verrucae surrounding the base.

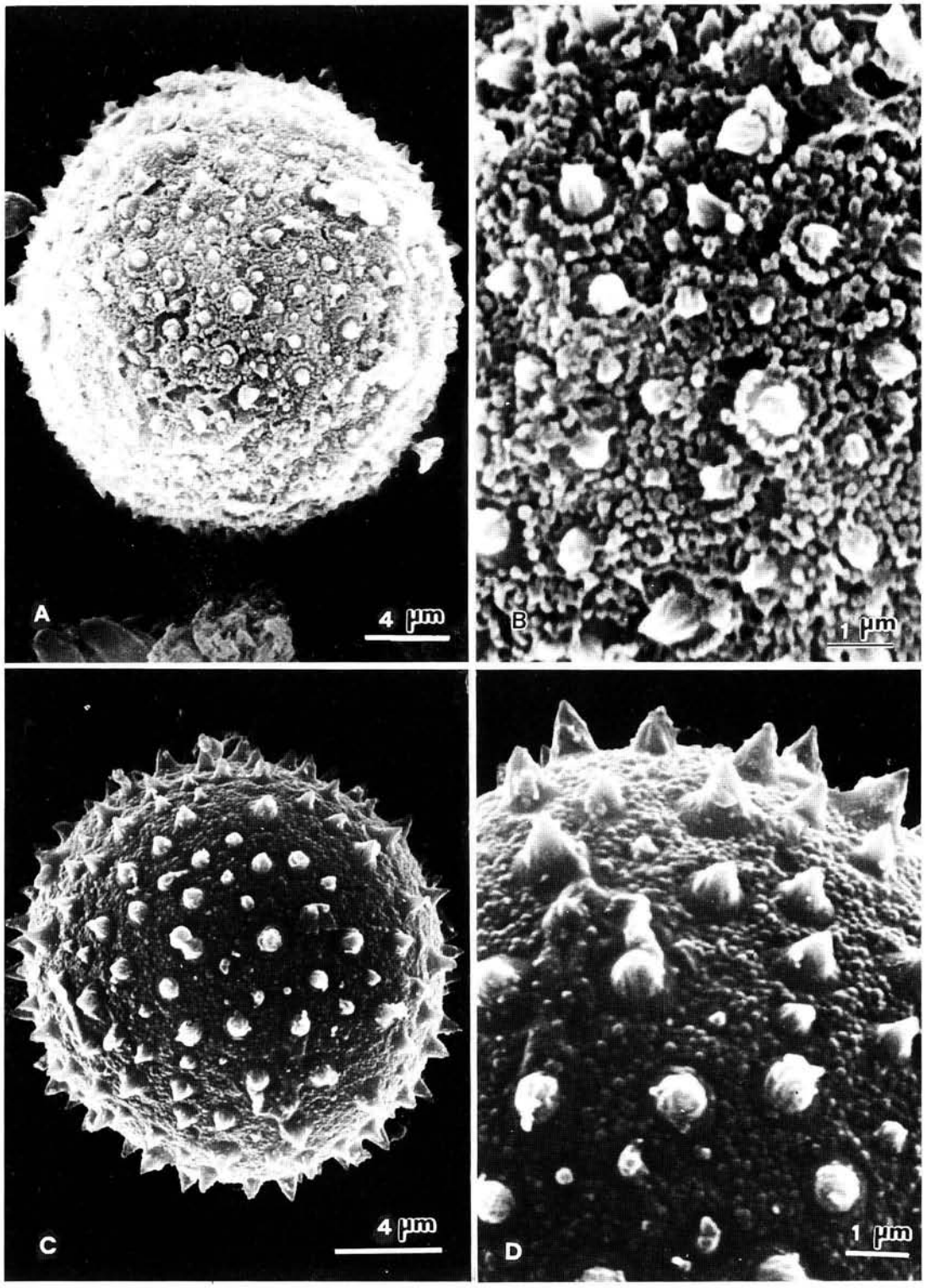

Plate 6. A-B: *Litsea elongata* (Wall. ex Nees) Benth. & Hook. f. var. *mushaensis* (Hayata) J. C. Liao, SEM. A, inaperturate grain showing spinulate sexine. B, detail of spinulate sexine showing cone-shaped spinules, small cushion-like bases and a ring of densely distributed verrucae surrounding the base. C-D: *Neolitsea acuminatissima* (Hayata) Kanehira & Sasaki, SEM. C, inaperturate grain showing spinulate sexine. D, detail of spinulate sexine showing cone-shaped spinules, small cushion-like bases and a ring of densely distributed verrucae surrounding the base.

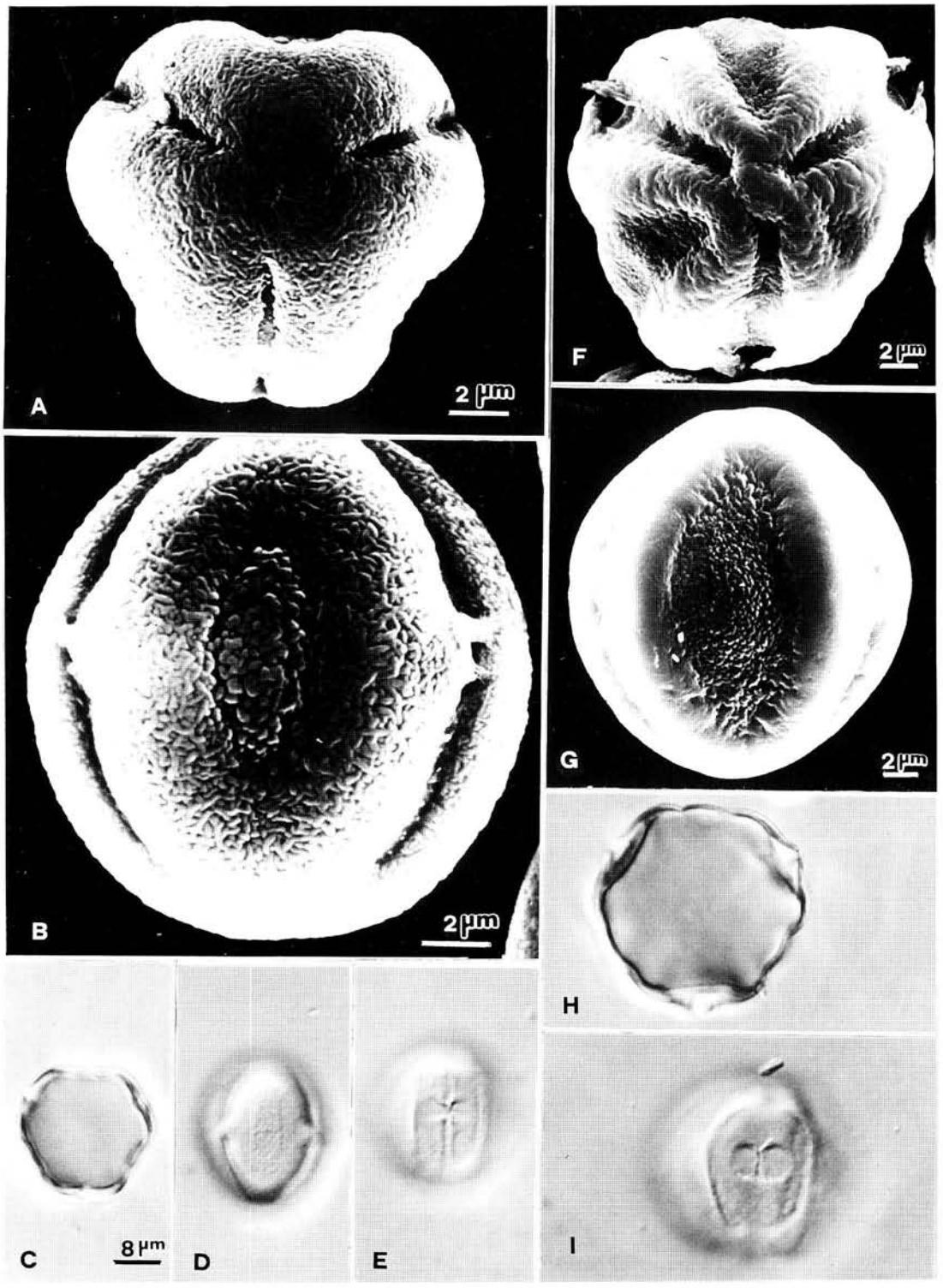

Plate 7. A-E: *Barthea barthei* (Hance) Krass. A & B, SEM; C-E, LM. A & C, 6-heterocolpate grains in polar view showing striato-reticulate sexine. B, D & E, grains in equatorial view showing intercolpar concavity and dumbbell-shaped os. F-I: *Sarcopyramis napalensis* Wall. var. *delicata* (C. B. Robinson) S. F. Huang & T. C. Huang. F & G, SEM; H & I, LM. F & H, 6-heterocolpate grains in polar view showing striate/perforated sexine. G & I, grains in equatorial view showing intercolpar concavity and rounded-rectangular os.

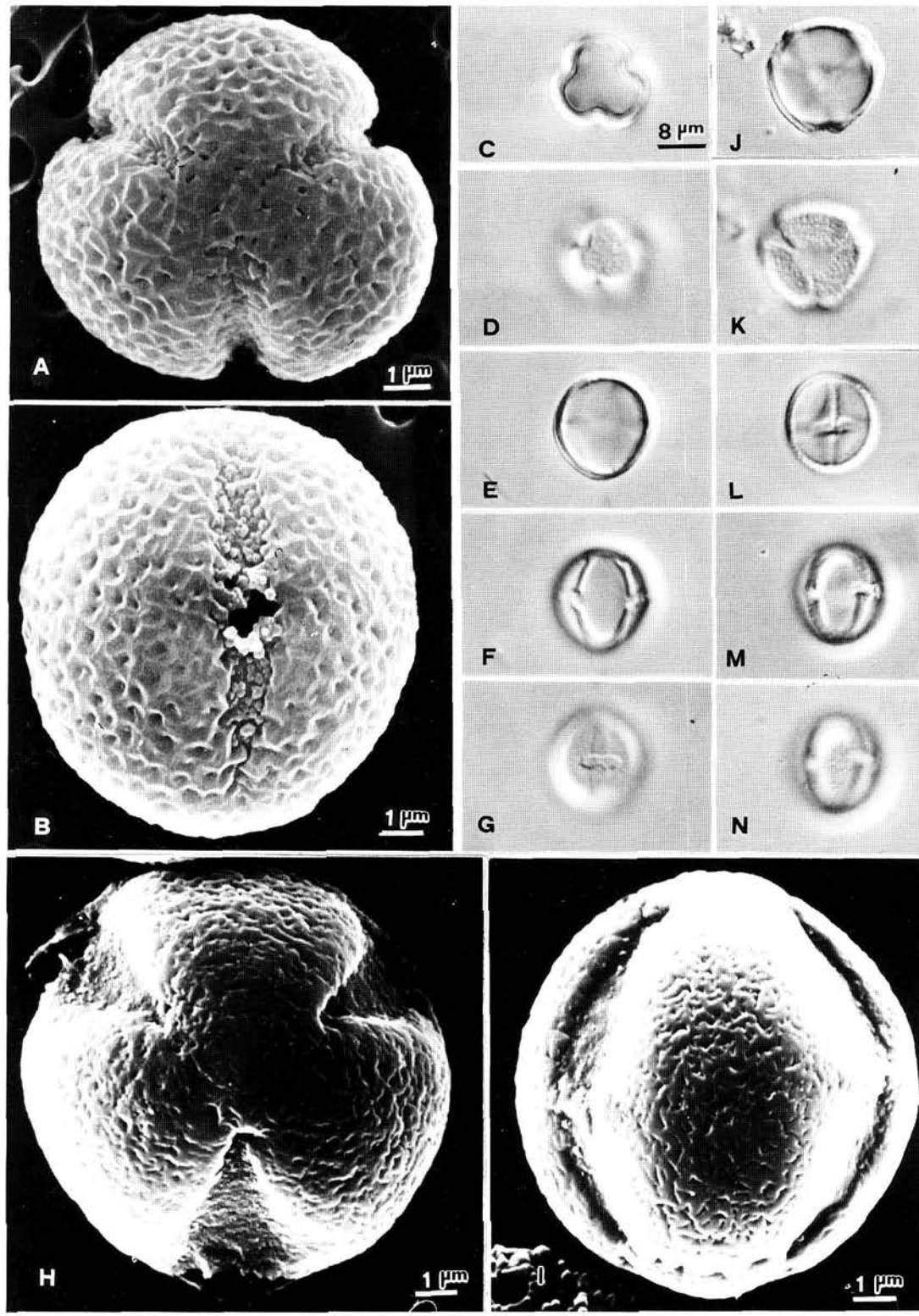

Plate 8. A-G: *Ardisia japonica* (Hornsted) Blume. A & B, SEM; C-G, LM. A, C & D, 3-colporate grains in polar view showing reticulate sexine. B & E-G, grains in equatorial view showing rectangular ora and verrucate colpus membrane. H-N: *Myrsine stolonifera* (Koidz.) Walker. H-I, SEM; J-N, LM. H, J & K, 3-colporate grains in polar view showing compactly rugulate sexine. I & L-N, grains in equatorial view. showing rectangular ora.

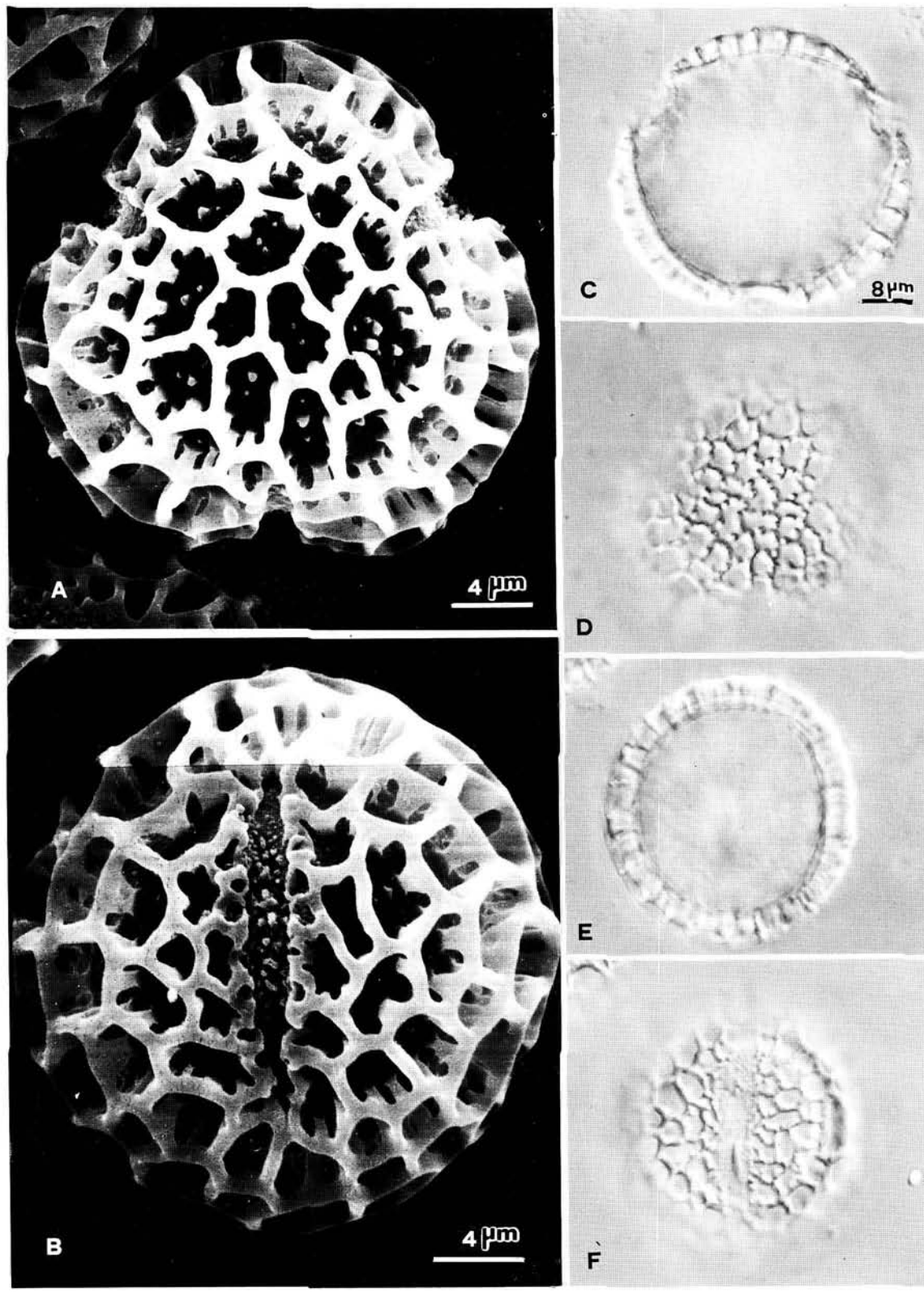

Plate 9. A-F: *Ligustrum liukiuense* Koidz. A & B, SEM; C-F, LM. A, C & D, 3-colporate grains in polar view showing reticulate sexine and simpli-columellate muri. B, E & F, grains in equatorial view showing transversally parallel ora and granulate colpus membranes.

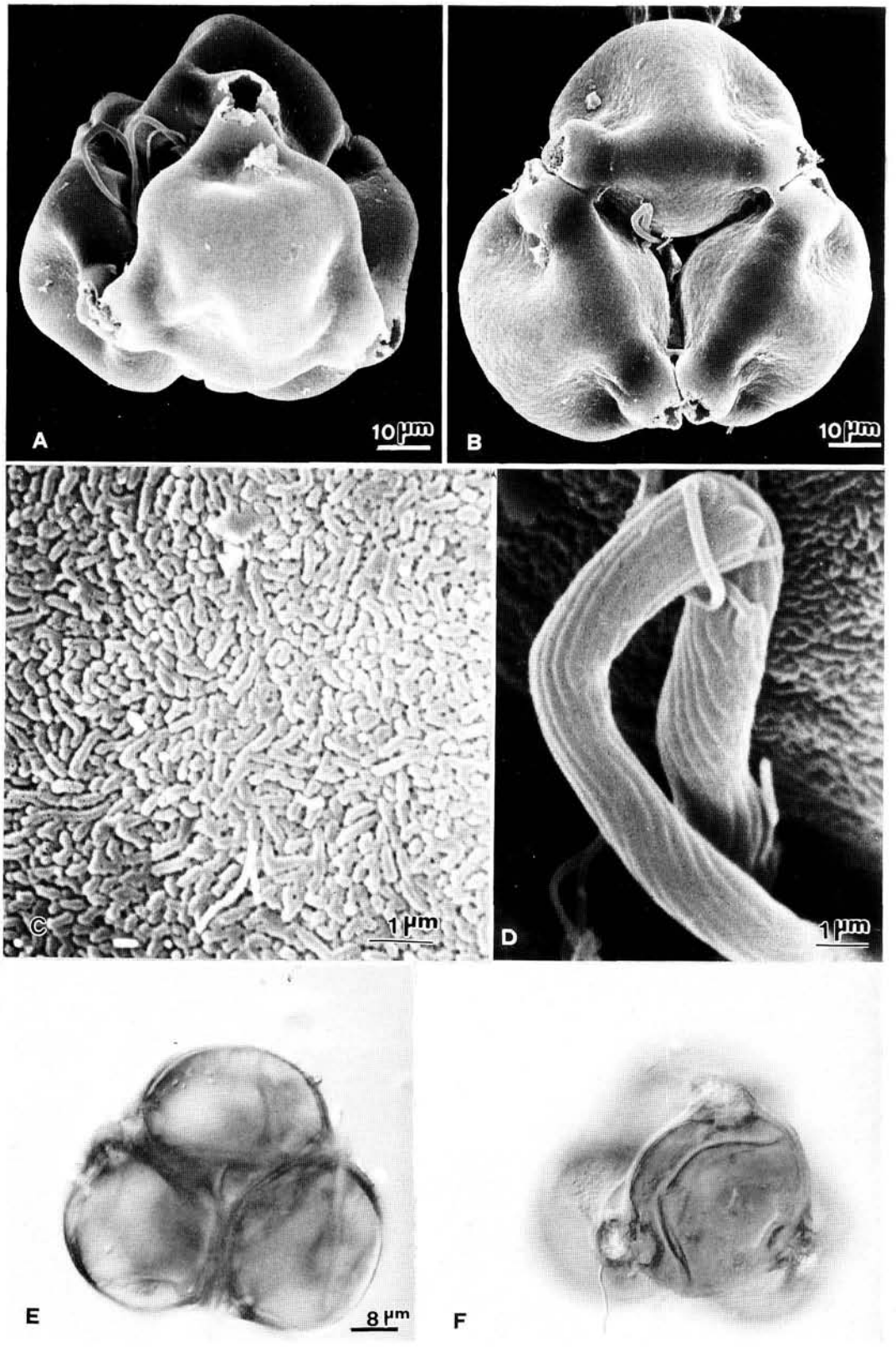

Plate 10. A-F: *Epilobium amurense* Hausskn. A-D, SEM; E & F, LM. A, E & F, tetrahedral tetrad grains in polar view. B, tetrads in equatorial view showing equatorial bridges between the apertural protrusions . C, detail of finely rugulate/verrucate sexine. D, detail of tightly-compound twisted viscin strands.

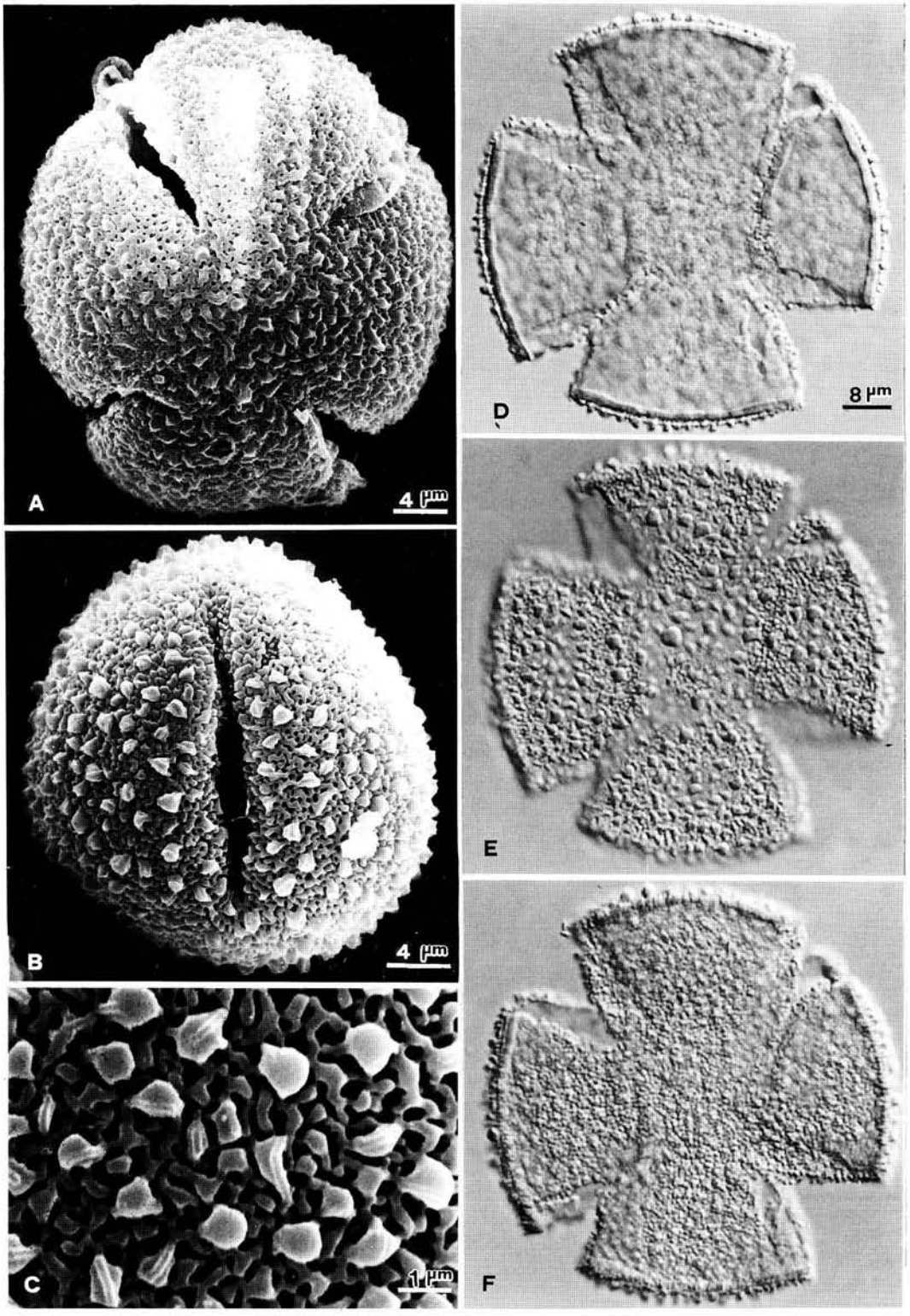

Plate 11. A-F: *Oxalis acetocella* L. ssp. *griffithii* (Edgew. & Hook. f.) Hara var. *formosana* (Terao) Huang & Huang. A-C, SEM; D-F, LM. A & D-F, 4-colpate grains in polar view showing granulate/rugulo-reticulate sexine. B, grain in equatorial view showing destroyed colpus membrane. C, detail of granulate/rugulo-reticulate sexine showing polygonal-shaped granules and cracked or ruptured muri.

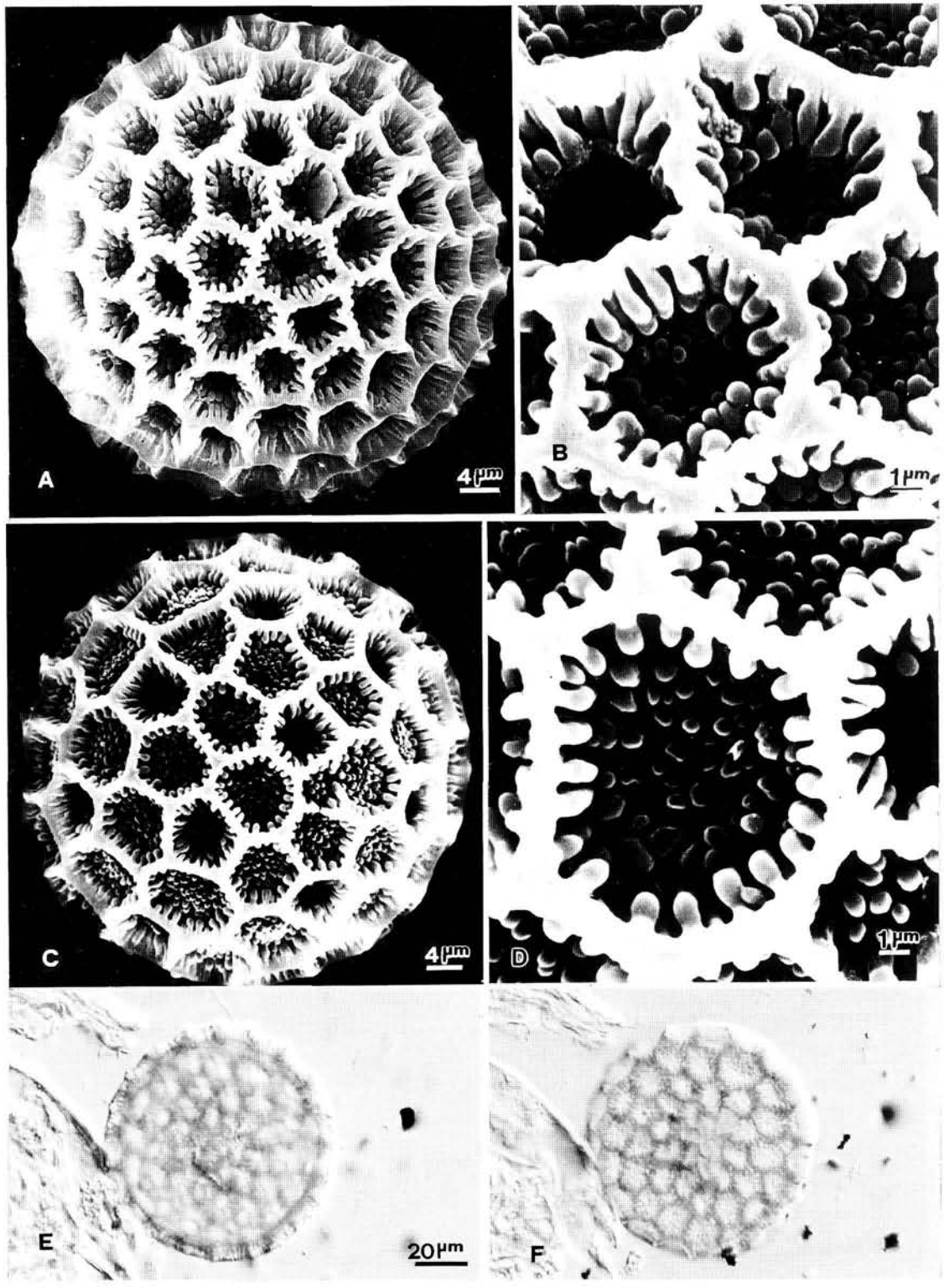

Plate 12. A-B: *Polygonum sagittatum* L. SEM. A, pantoportae grain showing reticulate sexine. B, detail of reticulate sexine showing circular pore situated in the lumen, wedged-shaped muri and compactly distributed verrucae in polygonal lumina. C-F: *Polygonum thunbergii* Sieb. & Zucc. C & D, SEM; E & F, LM. C, E & F, pantoportae grains showing reticulate sexine. D, detail of reticulate sexine showing wedged-shaped muri and compactly distributed verrucae in polygonal lumina.

台灣鴛鴦湖自然保留區花粉誌（II）

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摘　　要

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十一科二十種植物的新鮮花粉，經處理後，以光學顯微鏡和掃瞄式電子顯微鏡觀察這些花粉的形態。依花粉萌芽口的不同，分為八群：無萌發孔、三至六孔、散孔、三溝、四至七溝、三溝孔、異溝孔和四分體具三孔的花粉。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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