Taiwania, **44**(1): 82-136, 1999

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

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(Manuscript received 8 February, 1999; accepted 26 February, 1999)

ABSTRACT: Yuenyang Lake is an acidic lake situated within a nature preserve in northern Taiwan. This lake is unique for the study of the succession of *Chamaecyparis*, one of the most important woods in Taiwan, which grows well in the area surrounding this lake. The pollen of fifty taxa belonging to thirty families collected from this nature preserve were investigated under light and scanning electron microscopes and described in the present study. A total of 11 pollen classes grouped on the basis of the aperture on the pollen wall were obtained: saccate, leptomatal, 3-6 porate, pantoporate, spiraperturate, fenestrate, 3-colpate, 4-7 colpate, 3-colporate, heterocolpate, and tetrad with monads 3-colporate pollen. The present data provide a basis for further study on changes in the environment of the terrestrial vegetation surrounding the Yuenyang Lake.

KEY WORDS: Pollen flora, Pollen morphology, Yuenyang Lake Nature Preserve, Taiwan.

INTRODUCTION

Yuenyang Lake (121°24'E latitude, 24°35'N longitude, altitude 1,670 m) is one of several acidic lakes (Wu and Chang, 1996) situated within a nature preserve (about 374 ha, 1700~2100 m alt.) in northern Taiwan. The acid environment provides a unique condition for the preservation of pollen grains in the sediments of the lake, from which changes in the surrounding vegetation can be traced (Chen and Wu, 1999). This lake is particularly suitable for the study of the succession of *Chamaecyparis*, one of the most important woods in Taiwan, which grows well in the area surrounding this lake.

Information on pollen morphology can be used in the analysis of fossil pollen (Erdtman, 1954; Tschudy and Scott, 1969; Birks and Gordon, 1985; Behre, 1986; Faegri and Iversen, 1989; Moore *et al.*, 1991), airborne pollen (Nilsson *et al.*, 1977; Basett, 1978; Lewis and Vinay, 1983) or honey pollen (Crompton and Wojtas, 1993). In the last two decades, scanning (SEM) and transmission electron microscopes (TEM) have been used as an aid in the identification and ultrastructural study of pollen (Heusser, 1971; Iwanami *et al.*, 1988; Hesse and Ehrendorfer, 1990; Dajoz *et al.*, 1991; Kurosawa, 1991; Scotand, 1992; Trudel and Gibby, 1992; Argue, 1993: Moar, 1993; Kurmann, 1994).

In Taiwan, the morphology of pollen and fern spores using light microscopy (LM) was the basis of the flora of pollen and spores (Huang, 1972 , 1981). Chen (1986, 1988) and honey pollen observed under SEM. These results have been used in the study of fossil pollen

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(Shaw, 1995, 1997 and 1998; Shaw and Huang, 1995), airborne pollen (Chen, 1984; Chen and Chien, 1986; Peng and Chen, 1996 and 1997; Yang and Chen, 1998; Huang, 1998), honey pollen (Chen *et al.*, 1984; Lin *et al.*, 1993), or as taxonomical characteristics (Hsiao and Kuoh, 1995; Hsieh and Huang, 1995, 1996, 1997 and 1998; Huang, 1996). However, little attention was given to other groups of pollen. In this study, the pollen flora around Yuenyang Lake was studied. The aim was to provide basic information for the reconstruction of the paleoecology of the terrestrial vegetation surrounding Yuenyang Lake.

CLIMATIC CONDITIONS AND VEGETATION OF THE YUENYANG LAKE NATURE PRESERVE

The Yuenyang Lake Nature Preserve combines the effects of high relative humidity (RH >80%) in the prevailing fog zone, cool temperatures (5-20°C), moderately high annual precipitation (2500-4500 mm), and the influence of prevailing typhoons. These typhoons bring abundant rainfall during late summer and fall. The northeasterly monsoon from January to April is associated with the wet season. This area is therefore classified as a temperate heavy moist climate (Liu & Hsu, 1973).

The Yuenyang Lake Nature Preserve is about 374 ha, with the lake area 3.6 ha and the swamp area 2.2 ha (Liu & Hsu, 1973). The terrestrial vegetation is mesophytic cypress forest, including *Chamaecyparis formosensis* Matsum. and *C. obtusa* Sieb. & Zucc. var. *formosana* (Hay.) Rehder. They are among the most important woods in Taiwan. These trees grow well in the area surrounding the lake. The hydrophytic plants in the swamp are *Miscanthus transmorrisonensis - Baeothryon subcapitatum - Schoeoplectus mucronatus* subsp. *robustus* Associes and *Rhododendron mariseii - Rhamnus crenata* Associes. The hydrophytic plants in the lake are *Potamogeton octandra* Consocies, *Sparganium fallax* Consocies and *Baeothryon subcapitatum* Consocies (Liu and Hsu, 1973). The soil was formed possibly through podzolization and gleization on the slope and in the swamp, respectively (Liu and Hsu, 1973).

The ecology and plant composition of terrestrial ecosystems have been reported by Liu and Hsu (1973), and the limnological conditions was described by Wu and Chang (1996).

A total of 224 pollen species belonging to 77 families has been collected from the Yuenyang Lake Nature Preserve. Some of them have been studied using LM and SEM (Wang, 1996). Fifty species of pollen belonging to 3 families of gymnosperms and 27 families of angiosperms are described in this article. The pollen of other species will be published in subsequent articles.

MATERIALS AND METHODS

The fresh pollen grains of 50 species belonging to 3 families of gymnosperms and 27 families of angiosperms (Tab. 1) were collected from the Yuenyang Lake Nature Preserve.

Table 1. Specimens used for study of pollen morphology

Family	Scientific name	Specimen No.	Collection date
Gymnospermae			
Cupressaceae	*Chamaecyparis formosensis* Matsum.	*Wang 961*	21 Mar 1994
	Chamaecyparis obtusa Sieb. & Zucc. var. *formosana* (Hayata) Rehder	*Wang 930*	16 Feb 1994
Pinaceae	*Pinus taiwanensis* Hayata	*Wang 1078*	24 May 1994
Taxodiaceae	*Cryptomeria japonica* (L. f.) D. Don	*Wang 627*	27 Apr 1994
	Cunninghamia konishii Hayata	*Wang 954*	21 Mar 1994
Dicotyledoneae			
Acanthaceae	*Parachampionella rankanensis* (Hayata) Bremek.	*Wang 915*	16 Feb 1994
Aceraceae	*Acer serrulatum* Hayata	*Wang 962*	21 Mar 1994
Actinidiaceae	*Actinidia arisanensis* Hayata	*Wang 659*	21 May 1993
Anacardiaceae	*Rhus ambigua* Lav. Ex Dipped.	*Wang 1025*	26 Apr 1994
Apocynaceae	*Trachelospermum formosanum* Liu & Ou	*Wang 1090*	20 Jun 1994
Aquifoliaceae	*Ilex hayataiana* Loes.	*Wang 945*	21 Mar 1994
	Ilex sugeroki Maxim. var. *brevipedunculata* (Maxim.) S. Y. Hu	*Wang 1128*	15 Jul 1994
Araliaceae	*Aralia decaisneana* Hance	*Wang 762*	2 Aug 1993
	Dendropanax dentiger (Harms ex Diels) Merr.	*Wang 828*	15 Sep 1993
	Hedera rhombea (Miq.) Bean var. *formosana* (Nakai) Li	*Wang 1161*	13 Sep 1994
	Pentapanax castanopsisicola Hayata	*Wang 856*	18 Oct 1993
	Schefflera taiwaniana (Nakai) Kanehira	*Wang 1170*	5 Oct 1994
Aristolochiaceae	*Asarum crassusepalum* S. F. Huang, T. H. Hsieh & T. C. Huang	*Wang 923*	16 Feb 1994
Balsaminaceae	*Impatiens uniflora* Hayata	*Wang 841*	18 Oct 1993
Begoniaceae	*Begonia formosana* (Hayata) Masamune	*Wang 1145*	22 Aug 1994
Berberidaceae	*Berberis kawakamii* Hayata	*Wang 949*	21 May 1994
Betulaceae	*Alnus formosana* (Burk.) Makino	*Wang 1155*	13 Sep 1994
Boraginaceae	*Trigonotis elevato-venosa* Hayata	*Wang 995*	30 Mar 1994
Campanulaceae	*Peracarpa carnosa* (Wall.) Hook. f. & Thoms.	*Wang 977*	30 Mar 1994
	Pratia nummularia (Lam.) A. Br. & Asch.	*Wang 877*	15 Nov 1993
Caprifoliaceae	*Lonicera acuminata* Wall.	*Wang 702*	21 Jun 1993
	Viburnum furcatum Blume ex Maxim.	*Wang 609*	24 Mar 1993
	Viburnum integrifolium Hayata	*Wang 681*	21 Jun 1993
	Viburnum luzonicum Rolfe. var. *formosanum (Hance) Rehder*	*Wang 617*	27 Apr 1993
	Viburnum taiwanianum Hayata	*Wang 674*	21 May 1993
Caryophyllaceae	*Cucubalus baccifer* L.	*Wang 775*	2 Aug 1993
	*Stellaria arisanensis (*Hayata) Hayata	*Wang 916*	16 Feb 1994
Celastraceae	*Celastrus hindsii* Benth.	*Wang 1023*	26 Apr 1994
	Euonymus spraguei Hayata	*Wang 1091*	20 Jun 1994
	Perrottetia arisanensis Hayata	*Wang 1151*	22 Aug 1994
Compositae	*Eupatorium formosanum* Hayata	*Wang 1151*	22 Aug 1994
	Sonchus arvensis L.	*Wang 1112*	13 Jul 1994
Cruciferae	*Cardamine flexuosa* With.	*Wang 914*	16 Feb 1994
Daphniphyllaceae	*Daphniphyllum himalaense* (Benth.) Muell.-Arg. Subsp. *macropodum* (Miq.) Huang	*Wang 1002*	30 Mar 1994
Diapensiaceae	*Shortia exappendiculata* Hayata	*Wang 618*	27 Apr 1993
Elaeocarpaceae	*Elaeocarpus japonicus* Sieb. & Zucc.	*Wang 675*	21 May 1993

Table. 1. Continued

Family	Scientific name	Specimen No.	Collection date
Ericaceae	*Pieris taiwanensis* Hayata	*Wang 607*	24 Mar 1993
	Rhododendron formosanum Hemsl.	*Wang 624*	27 Apr 1993
	Rhododendron mariesii Hemsl. & Wilson	*Wang 670*	21 May 1993
Fagaceae	*Pasania kawakamii* (Hayata) Schott.	*Wang 1113*	13 Jul 1994
Flacourtiaceae	*Idesia polycarpa* Maxim.	*Wang 1076*	24 May 1994
Gentianaceae	*Gentiana atkinsonii* Burk. var. *formosana* (Hayata) Yamamoto	*Wang 687*	21 Jun 1993
	Gentiana flavo-maculata Hayata	*Wang 970*	20 Mar 1994
	Tripterospermum lanceolatum (Hayata) Hara ex Satake	*Wang 880*	15 Nov 1993
Gesneriaceae	*Hemiboea bicornuta* (Hayata) Ohwi	*Wang 862*	18 Oct 1993

They were acetolyzed according to Erdtman (1952), then washed in distilled water. A part of the acetolyzed material was embedded in glycerin gelatin and then observed and photographed using a Leitz DM RB LM with Normaski optics. The rest of the sample was fixed in glutaraldehyde and osmium tetraoxide, dehydrated in an alcohol series, critical point dried, and coated with gold (Chen, 1986). The pollen was then examined with Hitachi S-520 and S-2400 SEM.

The nomenclature of the taxa examined follow the Flora of Taiwan (Li *et al.*, 1979). The pollen morphology is described following Erdtman (1966) and Huang (1972). The size and wall thickness of the pollen grains are based on 25 measurements made with the use of a light microscope. Voucher specimens are deposited in the Palynological Laboratory, Department of Botany, National Taiwan University.

RESULTS

The pollen morphology of 50 species is described alphabetically by family. The habitat of each taxon is given after the description of the pollen morphology so that it can be used for future pollen analysis.

Gymnospermae

1. Cupressaceae

Chamaecyparis formosensis Matsum. (Plate 1. A-E)

Pollen grains leptomatal, spheroidal, heteropolar, 23.2-34.5 μm in diam., folded, split in "V" shape or halves, spindle-like after acetolysis.

Leptoma pore-like, circular, on the distal face of the pollen, 1.8-2.2 μm in diam.

Exine 1 μm thick. Sexine microspinulate, detachable, easily wrinkled; spinulate orbicules (0.25-0.65 μm in diam.)situated on the surface of microspinulate sexine, deciduous, distributed irregularly or sometimes in clusters.

Large evergreen trees, in forests at 1,000-3,000 m, usually forming pure stands or mixed with *Chamaecyparis obtusa* Sieb. & Zucc. var. *formosana* (Hayata) Rehder, upper story in mesophytic forests on slopes around Yuenyang Lake.

Chamaecyparis obtusa Sieb. & Zucc. var. formosana (Hayata) Rehder (Plate 1. F-J)

Pollen grains leptomatal, spheroidal, heteropolar, 19.5-32 μm in diam., folded, split in "V" shape or halves with a ruptured tear, spindle-like after acetolysis.

Leptoma pore-like, on distal face of pollen, 0.9-1.2 μm in diam.

Exine 1-1.5 μm thick. Sexine microspinulate, detachable, easily wrinkled; spinulate orbicules (0.2-0.6 μm in diam.) situated on surface of microspinulate sexine, deciduous, distributed irregularly or sometimes in clusters.

Large evergreen trees, in forests at 1,300-2,800 m, usually forming pure stands or mixed with *Chamaecyparis formosensis* Matsum, upper story in mesophytic forests on slopes around Yuenyang Lake.

The pollen morphology of *Chamaecyparis formosensis* and *C. obtusa* var. *formosana* is difficult to distinguish.

2. Pinaceae

Pinus taiwanensis Hayata (Plate 2. A-E)

Pollen grains 2-saccate, 1-colpate, bilaterally symmetrical, heteropolar. Corpus elliptical in polar view, plano-convex in lateral view, 36-68 × 27-61 × 21-51 μm, sacci elliptical in polar view, biconvex in lateral view, 25.5-53.5 × 18-46.5 × 11-22 μm.

Colpus represented by a thinned area on distal side of corpus.

Exine 1.5-2 μm thick at proximal face of corpus, more thickened toward sacci attachment, 2.5-3 μm thick. Columellae distinct at corpus. Sexine of corpus compactly rugulate at proximal face, rugulae short, 0.3-0.7 μm wide; psilate or sparsely perforated at distal face, with a marginal frill near sacci attachment, frill compactly rugulate. Sexine of sacci roughened and sparsely perforated under SEM, internally 3-dimensionally reticulate under LM.

Evergreen trees, 1,000-3,000 m in mountainous areas, light demanding tree, rather common in openings such as in alpine grasslands, landslides and burned areas.

3. Taxodiaceae

Cryptomeria japonica (L. f.) D. Don (Plate 3. A-C)

Pollen grains leptomatal, spheroidal, heteropolar, 21.5-34.5 μm in diam., easily wrinkled, folded after acetolysis.

Leptoma slightly curved or hooked papillate, 2.8-5 μm high, 2.7-4 μm in diam.

Exine 1.5-2 μm thick. Sexine microspinulate, detachable, easily wrinkled; spinulate orbicules (0.25-0.5 μm in diam.) situated on surface of microspinulate sexine, deciduous, distributed irregularly or at leptoma and toward its circumference.

Evergreen trees, at 800-2,200 m in forests, plantation trees outside Yuenyang Lake Nature Preserve.

Cunninghamia konishii Hayata (Plate 3. D-G)

Pollen grains leptomatal, spheroidal, heteropolar, 21-32 μm in diam., folded, split in "V" shape after acetolysis.

Leptoma pore-like, circular, on distal face of pollen, 1.4-1.8 μm in diam., annulus distinct, 0.2-0.7 μm wide.

Exine 1.5-2 μm thick. Sexine microspinulate, detachable, easily peeled and wrinkled; orbicules spinulate (0.25-0.4 μm in diam.) situated on surface of microspinulate sexine, deciduous, distributed irregularly or sparsely or sometimes spaced in clusters.

Large evergreen trees, 1300-2400 m in forests, in understory of mesophytic forest community on slopes around Yuenyang Lake.

Cryptomeria differs from *Cunninghamia* by having a slightly curved or hooked papillate leptoma and an easily peeled sexine after acetolysis. The later has a pore-like leptoma and an easily peeled sexine after acetolysis.

Dicotyledoneae

4. Acanthaceae

Parachampionella rankanensis (Hayata) Bremek. (Plate 4. A-D)

Pollen grains 15-23 heterocolpate, (or 3-colporate, aperture alternate with 12-20 pseudocolpi), isopolar, prolate to perprolate in equatorial view, 56-97.5 × 22.5-58.5 μm (P/E=1.45-2.48).

Colpi and pseudocolpi long from pole to pole, narrow, sunken, colpi protruding over ora, forming atriums. Ora rectangular, 4-7 × 6-11 μm.

Exine 4-6.5 μm thick. Columellae distinct. Sexine reticulate, pseudocolpi and colpi dividing sexine into longitudinal strips, strips 3.6-4.9 μm wide, each sexine strip having scalariform reticula. Muri simpli-collumellate, undulate, 0.7-1.5 μm wide. Lumina angular, decreasing in size toward poles, with spinules in lumina, spinules less than 0.5 μm high and 0.4 μm wide. Nexine thinner than sexine.

Herbs, at medium altitudes in forests and at forest edges in mountainous areas, in small colonies on forest floor around Yuenyang Lake.

5. Aceraceae

Acer serrulatum Hayata (Plate 5. A-F)

Pollen grains 3-colporate, isopolar, spheroidal to prolate in equatorial view, 17-32 × 14.5-27 μm (P/E=1-1.44), circular to slightly circular-lobate in polar view, 17-29.5 μm in diam.

Colpi very long, extending nearly to poles, ends acute, 1.7-2.4 μm wide, colpus membranes granulate, granulae less than 0.3 μm wide. Ora circular.

Exine 1-3 μm thick. Columellae distinct. Sexine striate under SEM, reticulo-striate under LM, striae simple, parallel-sided, variously forked and anastomosing, arranged longitudinally, elongated, densely spaced, 0.2-0.5 μm wide; grooves completely obscured by

densely spaced striae in mesocolpia, scattered perforations in grooves in apocolpia and near colpus region, perforations less than 0.15 μm wide.

Medium-sized, deciduous trees, in forests, at 1000-2000 m, in understory of mesophytic forests on slopes.

6. Actinidiaceae

Actinidia arisanensis Hayata (Plate 5. G-L)

Pollen grains 3-colporate (rarely 4-colporate), isopolar, spheroidal to subprolate in equatorial view, 14.5-21 × 12-18.5 μm (P/E=1-1.33), circular or semi-angular in polar view (rarely quadrangular), 14.5-19.5 μm in diam.

Colpi long, crassimarginate, constricted toward ora, ends obtuse, colpus membranes scabrate to verrucate, 2.4-2.7 μm wide. Ora transversally parallel. Aperture labrum type.

Exine 1.5-2 μm thick. Sexine rugulate, with fine striae on rugulae, rugulae less than 0.5 μm wide, comprising verrucae, rugulae congested in mesocolpia, less dense in apocolpia. Nexine as thick as sexine.

Climbing shrubs at 500-1700 m, in northern and central mountainous areas in warm, humid environments in mesophytic forests on slopes around Yuenyang Lake.

7. Anacardiaceae

Rhus ambigua Lav. ex Dipped. (Plate 6. A-F)

Pollen grains 3-colporate, isopolar, subprolate to prolate in equatorial view, 20-34.5 × 14-23 μm (P/E=1.22-1.65), circular in polar view, 14-25.5 μm in diam.

Colpi slit-shaped, crassimarginate, as long as P axis, somewhat constricted at equator, less than 1 μm wide. Ora transversally elongate, with parallel costae.

Exine 2-2.5 μm thick. Columellae distinct, of uniform size, regularly distributed. Sexine reticulato-striate, with long parallel striae, running meridionally, sometimes branched, anastomosing, diving under one another, 0.2-0.8 μm wide. Grooves less than 0.5 μm wide. Lumina in single rows between striae.

Climbing shrubs, at 1,800-2,500 m in primary and secondary forests and along forest edges throughout the island; one of the indicator epiphytes in the *Chamaecyparis* forest zone; in mesophytic forests on slopes around Yuenyang Lake.

8. Apocynaceae

Trachelospermum formosanum Liu & Ou (Plate 6. G and H)

Pollen grains 16-40-porate, apolar, spheroidal to subspheroidal, 27.5-63.5 × 27.5-53.5 μm in diam.

Pores circular, crassimarginate, irregularly distributed on sexine surface, 1-2.5 μm in diam., annuli 1-2 μm wide, opercula 1-2 μm wide, easily peeled off after acetolysis.

Exine 1 μm thick. Ektexine psilate, infratectum granulate (Huang, 1989).

Climbing shrubs, in mesophytic forests on slopes around Yuenyang Lake.

9. Aquifoliaceae

Ilex hayataiana Loes. (Plate 7. A-D)

Pollen grains 3-colporate (rarely 4-colporate), isopolar, prolate spheroidal to prolate in equatorial view, 34-39 × 26.5-34.5μm (P/E=1.11-1.48), circular (rarely quadrangular) in polar view, 29-35.5 μm in diam.

Colpi long, sunken, sexine slightly raised over ora, forming a constricted colpus near equator, ends subacute, colpus membrane densely distributed small granules. Ora transversally parallel or circular.

Exine 3.5-4 μm thick (including clavae). Sexine clavate, clavae 3-3.5 μm high, 0.4-3 μm wide, varying in size and shape, fairly uniform in height, irregularly arranged, clavae smaller in mesocolpia than in apocolpia, sparsely spaced, gradually decreasing in size toward colpi, intermixed with scattered granulae of far smaller size (0.15-0.3 μm in diam.). Nexine thinner than sexine, nexine less than 0.5 μm thick.

Small evergreen trees, at 1,000-2,500 m in mountainous areas in the northern and central parts of the island; understory in mesophytic forests on slopes around Yuenyang Lake.

Ilex sugeroki Maxim. var. brevipedunculata (Maxim.) S. Y. Hu (Plate 7. E-G)

Pollen grains 3-colporate, isopolar, spheroidal to subprolate in equatorial view, 20.5-36 × 20.5-32 μm (P/E=1-1.32), circular in polar view, 19.5-36 μm in diam.

Colpi long and broad, deeply sunken, sexine slightly raised over ora, forming a constricted colpus near equator, ends obtuse, colpus membrane uneven. Ora circular.

Exine 3.5-5 μm thick (including clavae). Sexine clavate, clavae 2.3-3 μm high and 0.6-1.8 μm wide, varying in size and shape, evenly and densely spaced, abruptly decreasing in size toward colpi; granulae 0.2 μm in diam., scattered between clavae. Nexine thinner than sexine.

Small evergreen shrubs or small trees, at about 2,200 m; in forests along ridge crests in the northern and central parts of the central mountains; understory in mesophytic forests on slopes around Yuenyang Lake.

The pollen morphology is not easy to distinguish between *I. hayataiana* and *I. sugeroki* var. *brevipedunculata* using LM. But under SEM, the former differs from the later by having clavae more sparsely spaced and gradually decreasing in size near the colpi and smaller granulae intermixed between the clavae.

10. Araliaceae

Aralia decaisneana Hance (Plate 8. A-E)

Pollen grains 3-colporate, isopolar, prolate-spheroidal to subprolate (P/E=1.04-1.33) in equatorial view, 20.5-30.5 × 17.5-28 μm, angular with obtuse angles and slightly concave or straight sides in polar view, 19.5-28 μm in diam.

Colpi long, narrow, slit-like, crassimarginate, constricted at equator, nexine thickened toward ora. Ora lalongate or transversally parallel, protruding. Aperture fastigium type.

Exine 2-3 μm thick. Columellae distinct. Sexine reticulate, muri slightly undulate in mesocolpia, 0.2-0.6 μm wide, lumina polygonal in apocolpia, elongated or polygonal in mesocolpia, decreasing in size toward colpus margins, 0.3-1.2 μm in diam. Nexine as thick as sexine.

Small deciduous trees, from low altitudes to 1,800 m in mountain areas and on grasslands and in secondary forests; understory in mesophytic forest community on slopes around Yuenyang Lake.

Dendropanax dentiger (Harms ex Diels) Merr. (Plate 8. F-I)

Pollen grains 3-colporate, isopolar, prolate-spheroidal or subprolate (P/E=1.04-1.33) in equatorial view, 30-41.5 × 24-35μm, angular, angles obtuse with slightly concave or straight sides in polar view, 24-36 μm in diam.

Colpi long, narrow, slit-like, crassimarginate, constricted at equator, nexine thickened toward ora. Ora transversely parallel or lalongate, protruding. Aperture fastigium type.

Exine 1.5-2 μm thick. Columellae distinct. Sexine finely reticulate, muri slightly undulate in mesocolpia, 0.2-1 μm wide in apocolpia, 0.2-0.6 μm wide in mesocolpia, lumina perforated in apocolpia, irregularly elongate and undulate in mesocolpia, decreasing in size or disappearing toward colpus margins, less than 0.5 μm in diam. in apocolpia. Nexine as thick as sexine.

Evergreen shrubs and small trees, at high altitudes in broad-leaved forests throughout the island, slightly shade tolerant, in warm and humid environments; in understory mesophytic forests on slopes around Yuenyang Lake.

Hedera rhombea (Miq.) Bean var. formosana (Nakai) Li (Plate 9. A-D)

Pollen grains 3-colporate, isopolar, subprolate to prolate (P/E=1.17-1.4) in equatorial view, 21.5-39 × 17-28 μm; angular with obtuse angles and slightly concave or straight sides in polar view, 18.5-27 μm in diam.

Colpi long, narrow, slit-like, crassimarginate, nexine thickened toward ora. Ora transversally parallel, protruding. Aperture fastigium type.

Exine 2.5-3 μm thick. Columellae distinct. Sexine reticulate, muri 0.3-0.6 μm wide; lumina polygonal, elongate or perforate, larger in apocolpia than in mesocolpia, decreasing in size or disappearing toward colpus margins, less than 1.5 μm in diam. Nexine as thick as sexine.

Epiphytic shrub between *Chamaecyparis* upper story and secondary broad-leaved forest layer, at 600-2,500 m; in primary broad-leaved forests and coniferous and broad-leaved mixed forests throughout the island.

Pentapanax castanopsisicola Hayata (Plate 9. E-H)

Pollen grains 3-colporate, isopolar, subprolate to prolate (P/E=1.14-1.37) in equatorial view, 21-34.5 × 17-29.5 μm, semiangular or angular with obtuse angles and slightly concave or straight sides in polar view, 18-28 μm in diam.

Colpi long, narrow, slit-like, crassimarginate, nexine thickened toward ora. Ora transversally parallel, protruding. Aperture fastigium type.

Exine 2-3 μm thick. Columellae distinct. Sexine reticulate, muri slightly undulate, 0.25-0.9 μm wide, lumina polygonal to elongated in mesocolpia, decreasing in size or disappearing toward colpus margins and in apocolpia, 0.2-1.9 μm in diam. Nexine as thick as or thinner than sexine.

Epiphytic shrubs, at 800-2,600 m.

Schefflera taiwaniana (Nakai) Kanehira (Plate 10. A-C)

Pollen grains 3-colporate, isopolar, oblate-spheroidal to prolate-spheroidal (P/E=0.92-1.02) in equatorial view, 23-37 × 23.5-39 μm, circular or semiangular in polar view, 25-40 μm in diam.

Colpi long, narrow, slit-like, crassimarginate, nexine thickened toward ora. Ora lalongate, protruding. Aperture fastigium type.

Exine 2-4 μm thick. Columellae distinct. Sexine reticulate, muri irregular in width, undulate in mesocolpia, with a few perforations on muri, 0.2-0.4 μm wide, lumina polygonal, less than 1.2 μm in diam. in apocolpia, irregularly elongate in mesocolpia, decreasing in size or disappearing toward colpus margins. Nexine as thick as sexine.

Small evergreen trees, at 1,800-3,000 m in alpine forests, rather common in coniferous forests and broad-leaved and coniferous mixed forests; understory in mesophytic forests on slopes around Yuenyang Lake.

Key to 5 taxa of Araliaceae

1a. Pollen semiangular or circular in polar view ..... *Schefflera*
1b. Pollen angular with obtuse angles and slightly concave or straight sides in polar view 2
2a. Sexine finely-reticulate ..... *Dendropanax*
2b. Sexine reticulate ..... *Aralia, Hedera, Pentapanax*

11. Aristolochiaceae

Asarum crassusepalum S. F. Huang, T. H. Hsieh & T. C. Huang (Plate 10. D-G)

Pollen grains 4-porate, isopolar, spheroidal, 26.5-45.0 μm in diam.

Pores more or less circular, slightly invaginated, 3-3.3 μm in diam., undelimited margins merging with sculpturing, pore membrane with densely granulate elements, easily destroyed by acetolysis.

Exine 2 μm wide. Sexine incompletely rugulo-reticulate. Muri simpli-columellate, 0.25-0.4 μm wide, often cracked or irregularly ruptured as rugulae, 0.8-1.5 μm wide, 0.9-1.5 μm high, supratectal granulae irregularly distributed on muri. Lumina variable in size, smooth or sparsely granulate, gradually decreasing in size toward pore and elongating in mesocolpia and apocolpia, 0.4-1.1 μm in diam.

Perennial herbs, at 1,600-1,700 m; on forest floor around Yuenyang Lake.

Asarum crassusepalum was considered by Huang *et al.* (1995) to have 4-6-colpoidate pollen with a rugulate sexine.

12. Balsaminaceae

Impatiens uniflora Hayata (Plate 11. A-C)

Pollen grains 4-colpate, bilateral, rectangular with convex sides and acute angles in polar and equatorial view, flattened, 20.5-34 × 35-51 μm .

Colpi slit-like, short, located at corners of rectangular grains in polar view.

Exine 1-1.5 μm wide. Columellae distinct. Sexine reticulate. Muri simpli-collumellate, 0.25-0.4 μm wide. Lumina variously polygonal, gradually decreasing in size near colpi, 0.8-2 μm in diam., filled with densely spaced verrucae, verrucae less than 0.25 μm in diam.

Annual herbs, at medium altitudes, roadsides and forest edges; on forest floor around Yuenyang Lake.

13. Begonicaeae

Begonia formosana (Hayata) Masamune (Plate 12. A-F)

Pollen grains 3-colporate, isopolar, perprolate in equatorial view, 16.5-30 × 7.5-13 μm (P/E=2.11-2.5), circular-lobate in polar view, 8 μm in diam.

Colpi long, crassimarginate, thickened toward ora, constricted at equator, colpus membranes granulate, granulae angular, less than 0.4 μm in diam. Ora lalongate.

Exine 1 μm thick. Sexine striate, striae parallel, less than 0.3 μm wide, perforated in grooves, perforations sparsely and irregularly distributed, less than 0.15 μm in diam.

Creeping perennial herbs, forest edges in mountainous areas throughout the island; on forest floor in mesophytic forests on slopes around Yuenyang Lake.

14. Berberidaceae

Berberis kawakamii Hayata (Plate 11. D-F)

Pollen grains spiraperturate, 4-5-colpate, easily breaking at spiral aperture after acetolysis, apolar, spheroidal to prolate in equatorial view, 25.5-57.5 × 23.5-48 μm (P/E=1-1.34).

Colpi long, crassimarginate, colpus margins ragged.

Exine 2-3 μm thick. Columellae distinct. Sexine perforated/fossulate, of varying density, sexine sometimes cracking in apocolpia and mesocolpia.

Deciduous shrubs, at 2,300-3,700 m, grasslands and sparse woodlands in the central mountains; understory in mesophytic forests on slopes around Yuenyang Lake.

15. Betulaceae

Alnus formosana (Burk.) Makino (Plate 12. G-J)

Pollen grains 4-5-porate (rarely 6-porate), isopolar, aspidate, oblate to suboblate in equatorial view, 13-22 × 16.5-29.5 μm (P/E=0.67-0.86); tetragonal or pentagonal with obtuse angles in polar view, 17-27 μm in diam.

Pores elliptical, protruding, 2-4 × 1 μm, with thick annulus. Aperture vestibulate type.

Exine 1 μm thick. Sexine with supratectal ridges bearing spinules. Nexine as thick as sexine. Neighboring pores connected by exinous thickening arci, arci 2-4 μm wide.

Deciduous trees, from low elevations to 2,500 m; throughout the island, usually on river banks, near streams, in waste places and in exposed areas; understory in mesophytic forests on slopes around Yuenyang Lake.

16. Boraginaceae

Trigonotis elevato-venosa Hayata (Plate 13. A-D)

Pollen grains 6-heterocolpate, (or 3-colporate, aperture alternate with 3 pseudocolpi); isopolar, dumbbell shaped in equatorial view, constricted at equatorial region, slightly concave in polar region, 8-9 × 4.5-5.5 μm in diam., P/E=1.5-1.9; hexagonal in polar view, angles rounded, 5-5.4 μm in diam.

Colpi wider and shorter than pseudocolpi, rhomboidal (0.7-1 × 2.8-3.4μm in diam.), colpus margins regularly or irregularly tooth-like, colpus membranes granulate. Pseudocolpi 4.1-4.8 μm long. Ora lalongate under LM, rectangular under SEM, 0.2-0.3 × 0.4-0.9 μm in diam.

Exine very thin, less than 1 μm wide. Sexine perforated in polar region and adjacent to polar region, rib-like ridges near equatorial region, and perpendicular to colpi, 0.1-0.2 μm wide.

Small, creeping, perennial herbs; on forest floor around Yuenyang Lake.

17. Campanulaceae

Peracarpa carnosa (Wall.) Hook. f. & Thoms. (Plate 13. E-H)

Pollen grains 4-5-porate (rarely 3,6-porate), isopolar, oblate to oblate-spheroidal in equatorial view, 19.0-29.5 × 22.5-34.5 μm (P/E=0.72-0.95), circular in polar view, 23-35.5 μm in diam.

Pores circular to elliptic, sunken, 2.8-6 × 3-7.5 μm in diam., margins merging with sculpturing, pore membranes with verrucate elements, easily destroyed by acetolysis. Annulus 1-2 μm wide. Aperture club type.

Exine 1.5-2 μm thick. Columellae distinct. Sexine spinulate, spinules conical, basally ramifying, regularly distributed, 0.3-0.8 μm high and 0.4-0.75 μm wide, reticulo-striate between spinules, congested toward pores, striae interwoven, 0.1-0.2 μm wide. Nexine as thick as sexine.

Perennial herbs, medium to high elevations in mountainous areas; forest floor in mesophytic forests on slopes.

Pratia nummularia (Lam.) A. Br. & Asch. (Plate 14. A-E)

Pollen grains 3-colporate, isopolar, spheroidal to subprolate in equatorial view, 15.5-24.5 × 14.5-23.5 μm (P/E=1-1.25), circular or slightly circular-lobate or semiangular in polar view, 16-24.5 μm in diam.

Colpi long, crassimarginate, slightly constricted at equator, 1.6 μm wide, ends acuminate, colpus membranes granulate, granulae less than 0.3 μm in diam. Ora circular or transversally parallel.

Exine 1-2 μm thick. Columellae distinct. Sexine striate under SEM and reticulato-striate

under LM, striae variously anastomosing and diving under one another, elongate, densely spaced, sometimes parallel to colpi, or perpendicular to colpi, 0.2-0.45 μm wide. Nexine as thick as sexine.

Perennial herbs, at 500-3,000 m, wet places and roadsides; on forest floor in mesophytic forests on slopes.

18. Caprifoliaceae

Lonicera acuminata Wall. (Plate 14. F-I)

Pollen grains 3-colporate, isopolar; suboblate to oblate-spheroidal in equatorial view, 35.5-57.6 × 45-75.4 μm (P/E=0.76-0.89); semiangular or subangular in polar view, 47.5-87.5 μm in diam.

Colpi brevicolpate, end acute, sunken, 10.6-15 μm long, 1.6 μm wide, colpus margins tattered, colpus membranes granulate, granulae 0.6-1.3 μm in diam. Ora indistinct.

Exine 3-4 μm thick in mesocolpia (excluding spinules), 2.5-3 μm thick toward colpus margins (excluding spinules). Columella distinct. Sexine spinulate, spinules conical with broaden bases and tapered apical portions, 0.7-3.4 μm high and 0.8-2.5 μm wide, sparsely spaced, rugulo-perforate between spinules, rugulae less than 0.5 μm wide, perforations less than 0.3 μm in diam. Nexine thinner than sexine.

Evergreen woody vines, at 1,800-3,000 m, open fields and sparse woodlands in the central mountains.

Viburnum furcatum Blume ex Maxim. (Plate 15. A-F)

Pollen grains 3-colporate (rarely 4-colporate), isopolar, oblate-spheroidal to subprolate (P/E=0.95-1.24) in equatorial view, 16-27 × 16-24 μm, semiangular or angular with convex sides and obtuse angles in polar view, 17-25.5 μm in diam.

Colpi long, extending nearly to poles, crassimarginate, ends acuminate, colpus membranes scabrate. Ora circular or transversally parallel. Aperture fastigium type.

Exine 2-2.5 μm thick. Columellae distinct. Sexine reticulate, muri simpli-columellate, 0.25-0.4 μm wide, lumina irregularly polygonal, decreasing in size toward colpus margins, less than 1.6 μm in diam., colpus margins psilate, lumina with verrucae. Nexine as thick as sexine.

Deciduous shrubs, at 1,300-3,000 m, broad-leaved forests; understory in mesophytic forests on slopes around Yuenyang Lake.

Viburnum integrifolium Hayata (Plate 15. G-L)

Pollen grains 3-colporate, isopolar, oblate-spheroidal to prolate-spheroidal (P/E=0.94-1.06) in equatorial view, 17.5-22 × 18-22 μm, angular with convex sides and obtuse angles in polar view, 18-23 μm in diam.

Colpi long, extending nearly to poles, crassimarginate, constricted at equator, nexine thickened toward ora, ends acuminate, colpus membranes scabrate to finely granulate. Ora lalongate or dumbbell-shaped. Aperture fastigium type.

Exine 2-3 μm thick. Columellae distinct. Sexine reticulate, muri simpli-columellate, 0.35 μm wide, lumina irregularly polygonal, decreasing in size toward colpus margins, less than 2.2 μm in diam., psilate on colpus margins; verrucae densely distributed in lumina, less than 0.45 μm in diam. Nexine as thick as sexine.

Evergreen shrubs, at 700-2,000 m, throughout the island; understory in mesophytic forests on slopes around Yuenyang Lake.

Viburnum luzonicum Rolfe. var. formosanum (Hance) Rehder (Plate 16. A-B)

Pollen grains 3-colporate (rarely 4-colporate), isopolar, oblate-spheroidal to subprolate (P/E=0.89-1.24) in equatorial view, 17.5-27 × 17.5-24 μm, circular, semiangular or angular with convex sides and obtuse angles in polar view, 18-25.5 μm in diam.

Colpi long, extending nearly to poles, crassimarginate, narrow, constricted at equator, colpus membranes finely granulate, less than 0.3 μm in diam. Ora dumbbell-shaped or lalongate. Aperture fastigium type.

Exine 3 μm thick. Columellae distinct. Sexine reticulate, muri simpli-columellate, 0.25-0.4 μm wide, lumina irregularly polygonal, decreasing in size toward colpus margins, less than 2.2 μm in diam., colpus margins psilate, lumina with verrucae, verrucae 0.2-0.45 μm in diam. Nexine as thick as sexine.

Deciduous shrubs or small trees, at 360-2,000 m, forests and shrub thickets; understory in mesophytic forests on slopes around Yuenyang Lake.

Viburnum taiwanianum Hayata (Plate 16. C-G)

Pollen grains 3-colporate (rarely 4-colporate), isopolar, prolate-spheroidal to subprolate (P/E=1.04-1.32) in equatorial view, 21.5-35.5 × 18.5-29.5 μm, circular or circular-lobate in polar view, 18.5-33 μm in diam.

Colpi long, extending nearly to poles, crassimarginate, nexine thickened toward ora, ends acute, colpus membranes finely granulate. Ora lalongate or circular. Aperture fastigium type.

Exine 2-3 μm thick. Columellae distinct. Sexine reticulate, muri simpli-columellate, 0.4-0.6 μm wide, lumina irregularly polygonal, decreasing in size toward colpus margins, less than 2.2 μm in diam., lumina with dense verrucae, verrucae less than 0.5 μm in diam. Nexine as thick as sexine.

Small deciduous shrubs, at 1,600-2,600 m; mountains; common in the *Chamaecyparis* forest zone of Tai-ping Mountain, Hsi-shih Mountain; understory in mesophytic forests on slopes around Yuenyang Lake.

It is difficult to distinguish between the pollen of *Viburnum furcatum*, *V. integrifolium* and *V. luzonicum* var. *formosanum*. The pollen of *V. taiwanianum* differs from the above species by having wider muri (0.4-0.6 μm); the three species above have muri less than 0.4 μm wide.

19. Caryophyllaceae

Cucubalus baccifer L. (Plate 17. E-H)

Pollen grains pantoporate, 26-34 porate, apolar, spheroidal, 29-43.5 μm in diam.

Pores circular, invaginated, 2.4-4.9 μm in diam., margins distinct and regular, distances between adjacent pores larger than pore diam., capped by an operculum studded with 2-5 irregularly distributed spinules, operculum easily peeled off after acetolysis.

Exine 2.4-3.6 μm thick, crassisexinous. Columellae distinct, broader at apex than at base.

Sexine spinulate/perforated, spinules cone-shaped, irregularly distributed, increasing in number toward pores, less than 0.5 μm wide and high; perforations irregularly distributed, less than 0.4 μm in diam.

Scandent perennial herbs, at 1,000-3,000 m, forest edges and roadsides; on forest floor around Yuenyang Lake.

Stellaria arisanensis (Hayata) Hayata (Plate 17. A-D)

Pollen grains pantoporate, 14-18-porate, apolar, polyhedral, 29-41.5 μm in diam. Pores circular and invaginated, 3.3-4.9 μm in diam., capped by an operculum densely studded 10-12 cone-shaped spinules, 0.5-1.1 μm in diam., opercula sometimes peeling off after acetolysis.

Exine 2.5-4 μm thick, crassisexinous. Columellae distinct, broader at apex than at base. Sexine spinulate/perforate; spinules on raised interporal zone, 0.4-0.5 μm wide; perforations less than 0.2 μm in diam.

Creeping perennial herbs, at medium elevations at forest edges and slightly moist roadsides, clustered; on forest floor around Yuenyang Lake.

20. Celastraceae

Celastrus hindsii Benth. (Plate 18. A-D)

Pollen grains 3-colporate, isopolar, prolate-spheroidal to subprolate (P/E=1.05-.122) in equatorial view; 18-33 × 17-27 μm, circular or semiangular in polar view, 18-33 μm in diam.

Colpi long, extending nearly to poles, slightly constricted at equator, crassimarginate, nexine thickened toward ora, ends acuminate, colpus membrane scabrate to finely-granulate. Ora circular or lolongate.

Exine 2-2.5 μm thick in mesocolpia, gradually thinning to colpus margins. Columellae distinct. Sexine reticulate, muri simpli-columellate, slightly keeled, 0.3-0.6 μm wide; lumina polygonal, decreasing in size toward colpus margins, 0.1-0.9 μm in diam. Nexine thinner than sexine.

Climbing shrubs, at 300-2,500 m, in thickets.

Euonymus spraguei Hayata (Plate 18. E-H)

Pollen grains 3-colporate (rarely 4-colporate), isopolar, suboblate to subprolate (P/E=0.85-1.18) in equatorial view, 25.5-38 × 25-38 μm, circular or semiangular or angular in polar view, 24.5-41.2 μm in diam.

Colpi long, crassimarginate, nexine thickened toward ora, ends acute. Ora circular or transversally parallel, opercula often ruptured after acetolysis. Aperture atrium type.

Exine 4 μm thick in mesocolpia, gradually thinning to colpus margins. Columellae distinct. Sexine reticulate, muri simpli-columellate, 0.3-0.5 μm wide; lumina rounded angular, decreasing in size toward colpus margins, 0.5-1.6 μm in diam. Nexine thinner than sexine.

Evergreen shrubs, at 2,000-3,000 m, mountainous areas; understory in mesophytic forests on slopes around Yuenyang Lake.

Perrottetia arisanensis Hayata (Plate 19. A-G)

Pollen grains 3-colporate, isopolar, suboblate to prolate (P/E=0.83-1.44) in equatorial view, 12-17 × 10-17 μm; circular, semiangular or angular in polar view, 11.5-16 μm in diam. Colpi relatively long, extending nearly to poles, constricted at equator, ends acuminate, colpus membranes finely granulate, granulae less than 0.1 μm in diam. Ora transversally parallel.

Exine 1 μm thick. Columellae distinct. Sexine reticulate, muri 0.2-0.5 μm in diam., with some verrucae on muri, verrucae less than 0.35 μm in diam., lumina circular to elliptic, decreasing in size toward colpus margins, less than 0.35 μm in diam.

Evergreen shrubs or small trees, above 1,200 m, broad-leaved forests in the central mountains; understory in mesophytic forests on slopes around Yuenyang Lake.

21. Compositae

Eupatorium formosanum Hayata (Plate 20. A-F)

Pollen grains 3-colporate, isopolar, oblate-spheroidal to subprolate (P/E=0.89-1.17) in equatorial view, 19-28 × 21.5-27 μm; circular-lobate in polar view, 20-28 μm in diam.

Colpi long, ends obtuse, colpus membranes granulate. Ora circular.

Exine 1-2 μm thick (exclude echini). Columellae distinct, taller at echini bases. Sexine echinate, echini conical, with broadened bases and tapering apices, well separated, 3-4 μm tall, 3-3.5 μm wide, perforated at base, perforations less than 0.3 μm in diam. Nexine thinner than sexine.

Perennial erect herbs, at low to medium elevations in mountainous areas, rather common in waste lands and on roadsides; forest floor around Yuenyang Lake.

Sonchus arvensis L. (Plate 20. G-I)

Pollen grains fenestrate (3-colporate), isopolar, suboblate to oblate spheroidal (P/E=0.85-0.94) in equatorial view, 18-36 × 20-39 μm, inter-hexagonal in polar view, 21.5-39 μm in diam.

Colpi long, divided by two pairs of sexine ridges into three lacunae, lacunae interconnected by narrow interlacunar gaps, colpus membrane scabrate. Ora circular.

Exine 3.5-5 μm thick (exclude echini). Columellae distinct. Sexine echinolophate, with 15 lacunae, 6 abporal, 3 poral, 6 paraporal, lacunae 3-6 × 5-7.5 μm; echini conical, with broadened base and tapering apex, 1.5-2.5 μm tall, 0.9-2.5 μm wide, perforated at base; ridges 2.3-4 μm wide; finely reticulate between echini and in lacunae, muri less than 0.2 μm wide, lumina less than 0.2 μm in diam. Nexine thinner than sexine.

Perennial herbs, at low to medium elevations, open fields, waste land, roadsides; on forest floor around Yuenyang Lake.

22. Cruciferae

Cardamine flexuosa With. (Plate 19. H-M)

Pollen grains 3-colpate (rarely 4-colpate), isopolar, suboblate to subprolate in equatorial view, 18.5-35.5 × 19.5-35.5 μm (P/E=0.77-1.32); circular-lobate in polar view, 19.5-35.5 μm in diam.

Colpi long, narrow, crassimarginate, slightly sunken, ends acuminate, margins without clear incisions. Colpus membrane verrucate, easily ruptured after acetolysis.

Exine 2-4 μm thick, becoming thinner toward colpi. Columellae distinct. Sexine reticulate. Muri simpli-columellate, 0.3-0.4 μm wide. Lumina irregularly polygonal, open toward colpus margins, decreasing in size toward colpi and poles, less than 2.2 μm in diam. Nexine thinner than sexine.

Annual or biennial herbs, at low elevations, waste lands; on forest floor around Yuenyang Lake.

23. Daphniphyllaceae

Daphniphyllum himalaense (Benth.) Muell.-Arg. subsp. macropodum (Miq.) Huang (Plate 21. A-F)

Pollen grains 3-colporate, isopolar, suboblate to subprolate (P/E=0.85-1.19) in equatorial view, 13.5-25.5 × 14-24.5 μm, semiangular or circular in polar view, 16-25.5 μm in diam.

Colpi long, ends acute, margins tattered, colpus membranes finely granulate or spinulate. Ora indistinct.

Exine 1-1.5 μm thick. Sexine rugulate, rugulae 0.2-0.7 μm wide, sometimes with small perforations between rugulae. Nexine as thick as sexine.

Shrubs or small trees, 300-1,500 m, throughout the island, rather common in thickets and roadsides; understory in mesophytic forests on slopes around Yuenyang Lake.

24. Diapensiaceae

Shortia exappendiculata Hayata (Plate 21. G-L)

Pollen grains 3-colporate (rarely 4-colporate), isopolar, oblate-spheroidal to subprolate (P/E=0.88-1.22) in equatorial view, 18-29.5 × 18-29.5 μm, circular, circular-lobate or semiangular in polar view, 18.5-29.5 μm in diam.

Colpi long, narrow, slightly crassimarginate, constricted at equator. Ora indistinct.

Exine 2 μm thick. Columellae distinct. Sexine rugulo-reticulate, rugulae composed of several twisted and fused ridges, with blunt spinules on rugulae, rugulae less than 0.35 μm wide, lumina less than 0.25 μm in diam., ridges less than 0.12 μm wide, spinules less than 0.15 μm wide and 0.25 μm tall. Sculpturing of colpus membrane similar to that of exine surface. Nexine as thick as sexine.

Perennial herbs, medium to high elevations in mountainous areas, moist places in forests, commonly on rocks and associated with bryophytes; on forest floor around Yuenyang Lake.

25. Elaeocarpaceae

Elaeocarpus japonicus Sieb. & Zucc. (Plate 22. A-G)

Pollen grains 3-colporate, isopolar, prolate-spheroidal to subprolate (P/E=1.04-1.23) in equatorial view, 9-13 × 8.5-12 μm; circular to circular-lobate in polar view, 7.5-12.5 μm in diam.

Colpi long, extending nearly to poles, sunken, ends obtuse, margins uneven, 0.7-1.5 μm wide, slightly constricted at equator, colpus membranes uneven. Ora transversely parallel.

Exine 1 μm thick. Sexine densely spaced rugulate with perforations between rugulae in mecocolpia and in vicinity of colpi, rugulo-reticulate in apocolpia, densely covered with small granulae on rugulae. Muri 0.06-0.2 μm wide in apocolpia. Lumina less than 0.2 μm in diam. in apocolpia.

Evergreen, medium sized trees, low elevations to 2,000 m, in forests; understory in mesophytic forests on slopes around Yuenyang Lake.

26. Ericaceae

Pieris taiwanensis Hayata (Plate 22. H-L)

Pollen grain tetrads tetrahedral, tetrads circular, semiangular or slightly circular-lobate in polar view, 26.5-44 μm in diam.; monads 3-colporate, circular or semiangular in polar view, 20-35.5 μm in diam.

Colpi long, slit-like, crassimarginate, interconnected at juncture of adjacent grains. Ora lalongate. Aperture labrum type.

Exine 2.5-4 μm thick. Columellae distinct. Sexine conspicuously rugulate in middle of mesocolpia, psilate in other areas, rugulae short, compact, irregularly oriented, 0.25-0.6 μm wide. Nexine thicker than sexine.

Evergreen shrubs, at 2,000-3,000 m, open, sunny alpine areas; understory in mesophytic forests on slopes around Yuenyang Lake.

Rhododendron formosanum Hemsl. (Plate 23. A-F)

Pollen grains tetrads tetrahedral, tetrads circular-lobate in polar view, 46.5-63 μm in diam., monads 3-colporate, circular or semiangular in polar view, 38-49 μm in diam.

Colpi short, slit-like, crassimarginate, interconnected at juncture of adjacent grains. Ora lalongate. Aperture labrum type.

Exine 3.5-5 μm thick. Columellae distinct. Sexine densely verrucate, verrucae in clusters, less than 0.25 μm in diam., cracked in middle of mesocolpia. Viscin strands present. Nexine thicker than sexine.

Evergreen trees, in upper layer of broad-leaved forests in central mountains; the most dominant tree in the mid layer of mesophytic forests on slopes around Yuenyang Lake.

Rhododendron mariesii Hemsl. & Wilson (Plate 24. A-F)

Pollen grains tetrads tetrahedral, tetrads circular-lobate in polar view, 43-63.5 μm in diam., monads 3-colporate, circular or semiangular in polar view, 29-41.5 μm in diam.

Colpi medium, slit-like, crassimarginate, interconnected at juncture of adjacent grains. Ora lalongate. Aperture labrum type.

Exine 2.5-4 μm thick. Columellae distinct. Sexine densely verrucate, verrucae in clusters, less than 0.25 μm in diam., conspicuously cracked in middle of mesocolpia. Viscin strands present. Nexine thicker than sexine.

Deciduous shrubs or small trees, at 1,600-1,900 m in forests in northern and central parts of the island; dominant in marshes and in understory of mesophytic forests on slopes around Yuenyang Lake.

27. Fagaceae

Pasania kawakamii (Hayata) Schott. (Plate 25. A-G)

Pollen grains 3-colporate, isopolar, subprolate to prolate in equatorial view, 13-21 × 8-13.5 μm (P/E=1.27-1.88); circular to circular-lobate in polar view, 8-12.5 μm in diam.

Colpi relatively long and narrow, ends acute, 0.7-1.4 μm wide. Ora crassimarginate, transversally parallel, 1.3-2 × 4-7 μm.

Exine 1-1.5 μm thick. Sexine striato-rugulate under SEM, mainly limited to longitudinal mesocolpia, distribution of ridges irregular, ridges 0.2-0.4 μm wide, indistinct near colpus margins in apocolpia.

Medium-sized evergreen trees, 700-1,600 m, in broad-leaved forests; understory in mesophytic forests on slopes around Yuenyang Lake.

28. Flacourtiaceae

Idesia polycarpa Maxim. (Plate 25. H-N)

Pollen grains 3-colporate, isopolar, subprolate to prolate in equatorial view, 14.5-23.5 × 12-18.5 μm (P/E=1.2-1.36), circular to slightly circular-lobate in polar view, 13-22 μm in diam.

Colpi long, crassimarginate, more thickened near ora, sunken, to 1 μm wide, ends acuminate, margins uneven. Colpus membranes granulate. Ora circular or lolongate.

Exine 1.5-2 μm thick. Columellae distinct. Sexine reticulate. Muri simpli-columellate, with columellae at corners and along sides, 0.3-0.5 μm wide. Lumina rounded-angular, wider than separating muri, intermixed with much smaller lumina, decreasing in size near colpi, absent toward colpus margins, less than 1.2 μm wide. Nexine as thick as or thinner than sexine.

Deciduous trees, at 100-2,100 m, in secondary forests; understory in mesophytic forests on slopes around Yuenyang Lake.

29. Gentianaceae

Gentiana atkinsonii Burk. var. formosana (Hayata) Yamamoto (Plate 26. A-E)

Pollen grains 3-colporate, isopolar, oblate-spheroidal to subprolate (P/E=0.88-1.2) in equatorial view, 25-34 × 22-29.5 μm, semiangular in polar view, 21-32 μm in diam.

Colpi long, crassimarginate, exine thickened toward ora, ends acuminate, colpus membranes finely granulate. Ora circular.

Exine 2-2.5 μm thick. Columellae distinct. Sexine reticulato-striate, muri sometimes forked or anastomosing, 0.25-0.7 μm wide, lumina 0.15-0.6 μm in diam., decreasing in size toward colpus margins. Nexine as thick as sexine.

Perennial herbs, at 1,000-3,000 m in central mountains, roadsides and grasslands; on forest floor around Yuenyang Lake.

Gentiana flavo-maculata Hayata (Plate 26. F-J)

Pollen grains 3-colporate (rarely 4-colporate), isopolar, oblate-spheroidal to subprolate (P/E=0.93-1.19) in equatorial view, 22-34.5 × 18.5-34.5 μm, circular or semiangular in polar view, 24-32 μm in diam.

Colpi long, extending nearly to poles, crassimarginate, exine thickened toward ora, colpus ends obtuse, colpus membranes scabrate. Ora circular.

Exine 2-2.5 μm thick. Columellae distinct. Sexine reticulo-striate with perforations in grooves, striae meridionally distributed, parallel, sometimes forking or anastomosing, 0.35-0.6 μm wide, perforations 0.2-0.7 μm in diam., grooves decreasing in width toward colpus margins. Nexine as thick as sexine.

Perennial herbs, at 2,000-3,500 m in central mountains, roadsides and rocky places; on forest floor around Yuenyang Lake.

Tripterospermum lanceolatum (Hayata) Hara ex Satake (Plate 27. A-C)

Pollen grains 3-colporate, isopolar, subprolate to prolate (P/E=1.22-1.53) in equatorial view, 31-49 × 21-34.5 μm; semiangular or circular in polar view, 21-44 μm in diam.

Colpi long, crassimarginate, constricted at equator, colpus membranes verrucate. Ora circular.

Exine 2 μm thick. Columellae distinct. Sexine striate under SEM, reticulato-striate under LM, striae compact, not wavy, meridional, sometimes forking, dividing, anastomosing, 0.3-0.8 μm wide, with small perforations on or between ridges. Nexine as thick as or thinner than sexine.

Climbing perennial herbs, at 1,500-3,000 m in mountainous areas.

Key to 3 taxa of Gentianaceae

1a. Sexine reticulato-striate ..... *Gentiana atkinsonii* var. *formosana*
1b. Sexine striate 2
2a. Sexine striate with perforations in grooves ..... *Gentiana flavo-maculata*
2b. Sexine striate with perforations on or between compact ridges ..... *Tripterospermum lanceolatum*

30. Gesneriaceae

Hemiboea bicornuta (Hayata) Ohwi (Plate 27. D-G)

Pollen grains 3-colporate, isopolar, oblate-spheroidal to subprolate in equatorial view, 15-27 × 15-22 μm (P/E=0.97-1.25), circular or semiangular in polar view, 15.5-27 μm in diam.

Colpi long, crassimarginate, constricted at equator, 2.6-3.2 μm wide, ends obtuse, colpus membranes rugulate, protruding toward ora, easily broken during acetolysis, rugulae 0.35-0.5 μm wide. Ora circular.

Exine 1.5-2 μm thick. Columellae distinct. Sexine reticulate, muri 0.2-0.4 μm wide, lumina rounded-angular, less than 0.7 μm in diam. Nexine as thick as sexine.

Perennial herbs, at medium to high elevation in the northern and central parts of the island; on forest floor around Yuenyang Lake.

DISCUSSION

Based on the preliminary study of 224 pollen species collected from Yuengyang Lake Nature Preserve, the pollen grains fall into seventeen 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); tetrads with monads 3-porate (Class XVI); and tetrads with monads 3-colporate (Class XVII). In this article, the pollen morphology of only 50 species has been throughly investigated. These pollens are belonging to 11 pollen classes which are described and discussed as follows.

Class I: saccate pollen

Three species of plants have saccate pollen in the Yuenyang Lake Nature Reserve: *Pinus taiwanensis*, *Picea morrisonicola*, and *Tsuga chinensis* var. *formosana*. Only *Pinus taiwanensis* is discussed in this article. The length of the corpus is less than 70 μm, and the bladder width is less than 55 μm in this pollen. The pollen of *Picea morrisonicola* is similar to that of *Pinus*. The former can be distinguished from the latter by its larger corpus (>70 μm) (Huang, 1972). The pollen of *Tsuga chinensis* var. *formosana* is sac circular or ring shaped.

Class III: leptomatal pollen

Pollen of *Chamaecyparis formosensis*, *C. obtusa* var. *formosana* (Cupressaceae), *Cryptomeria japonica*, *Cunninghamia konishii* (Taxodiaceae), and some taxa of Cyperaceae belong to this group. Only the pollen of the former two families is discussed in this article. Distinguishing the pollen of *Chamaecyparis* from that of *Cryptomeria* and *Cunninghamia* is important to the pollen analysis because the former is the most dominant tree in the nature preserve.

The pollen of *Cryptomeria* differs from that of *Cunninghamia* and *Chamaecyparis* in having a slightly curved or hooked papillate leptoma. The spinulate orbicules on the pollen wall surface are denser in *Chamaecyparis* than in *Cunninghamia*. Therefore, the ornamentation of *Chamaecyparis* is coarser than *Cunninghamia*. No marked difference in the pollen morphology of two taxa of *Chamaecyparis* was observed under either LM or SEM.

The easily detachable outer layer of *Cryptomeria japonica* is the ektexine when observed under TEM (Sohma, 1985). The spinulate processes of *Cryptomeria japonica* were designated as orbicules by Praglowski (1962) and Sohma (1985). However, the spinulate orbicules of Taxodiaceae were called Ubisch bodies by Xi and Wang (1989). The correctness of the terminology can only be ascertained by the study of microsporogenesis in the future.

The germination pore is inconspicuous in Cupressaceae and Taxodiaceae. Therefore the class of pollen for these two families has been defined as inaperturate (Chaturvedi, 1979; Faegri and Iversen, 1989; Moore *et al.*, 1991;), 1-porate (Huang, 1972; Bortenschlager, 1990; Kurmann, 1994), 1-aperturate or monotreme (Nilsson *et al.*, 1977), papillate (Ho and Sziklai, 1973), or leptomatal (Erdtman, 1969). The term leptoma was used in this study because the wall of the pore-like area of this pollen is thinner than the wall around it.

Class VI: 3-6-porate pollen

Three species belong to this type: *Asarum crassusepalum* (Aristolochiaceae), *Alnus formosana* (Betulaceae), and *Peracarpa carnosa* (Campanulaceae). Pollen of *Alnus* differs from that of the other two in having protruding pores and sexinal arcoid streaks interconnecting the pores. The wall sculpture of *Asarum crassusepalum* is rugulo-reticulate, but that of *Peracarpa carnosa* is spinulate.

Class VII: pantoporate pollen

Pollen of three species belongs to this type: *Trachelospermum formosanum* (Apocynaceae), *Cucubalus baccifer* and *Stellaria arisanensis* (Caryophyllaceae). The pollen of *Trachelospermum formosanum* differs from the other two in having 16-40 pores distributed irregularly on the pollen grains. The tectum is psilate with a granulate infratectum (Huang, 1989). The pollen of the two species of Caryophyllaceae have pores (14-34) distributed regularly over the grains.

Chanda (1962) described 8 species of *Stellaria* from Scandinavia. Pores of these pollen grains are generally surrounded by an annulus. Nevertheless, Punt and Hoen (1995) observed that the annulus is usually visible as a prominent solid ring around the pore margin under LM, but not under SEM. This is because the columellae around the pore merge into a ring without causing a thickening or thinning of either the sexine or the nexine. The distinctly sunken pores and distinct polygonal outline of the pollen of *S. arisanensis* in this study correspond to the *Stellaria holostea* type (Punt and Hoen, 1995). However, the echinae in the former are distributed regularly on the pollen grains whereas in the latter they are restricted to the middle of the mesoporium.

Class VIII: spiraperturate pollen

Berberis kawakamii (Berberidaceae) is the only species belonging to this type. Pollen of this species has 4 or 5 irregularly shaped colpi before acetolysis. They form an aperture afterward because the exine is easily broken into a spiral aperture by acetolysis (Nowicke and Skvarla, 1981). The position of the furrow is variable.

Class IX: fenestrate pollen

Only *Sonchus arvensis* (Compositae) belongs to this type. The ornamentation of sexine of this genus was defined as echinolophate by Lahham and Sadeq (1992) and echinate by Singh (1992). However, the echinolophate sexine is used in the present study to distinguish it from other non-fenestrate pollen and from the echinate pollen in the Compositae.

Class XI: 3-colpate pollen

All the 3-colpate pollen from plants in the Yuenyang Lake Nature Preserve have reticulate sculpturing. Only one species, *Cardamine flexuosa* (Cruciferae), is described in this study. The colpus membranes ruptured easily after acetolysis, giving rise to a rough colpus margin.

Class XII: 4-7-colpate pollen

Ten taxa have this type of pollen. Only the pollen of *Impatiens uniflora* (Balsaminaceae) is described in this study. The pollen of this species has a characteristic rectangular shape with four short colpi at each corner.

Class XIII: 3-colporate pollen

Thirty taxa with this type of pollen are presented in the present study. There is great variation in the sculpturing of the pollen surface, ranging from spinulate, clavate, echinate, rugulate, striato-rugulate, striate, reticulato-striate, reticulate to rugulo-reticulate.

The pollen of *Lonicera acuminata* (Caprifoliaceae) can be easily distinguished from the others by its short colpi and spinulate sculpture. The pollen of *Ilex hayataiana* and *I. sugeroki* var. *brevipedunculata* (Aquifoliaceae) have clavate processes of various sizes and shapes. The pollen of *Eupatorium formosanum* (Compositae) has echinate sculpturing.

Three species of plants have rugulate pollen: *Actinidia arisanensis* (Actinidiaceae), *Daphniphyllum himalense* subsp. *macropodum* (Daphniphyllaceae) and *Elaeocarpus japonicus* (Elaeocarpaceae). The pollen of *Pasania kawakamii* (Fagaceae) has striate-rugulate sculpturing. The rugulae in all of them are obscure under LM. *Elaeocarpus japonicus* can be distinguished easily by pollen size with the P axis less than 13 μm and the other species greater than 13 μm. The ora in *Daphniphyllum* are indistinct. Therefore, Zavada and Dilcher (1986) have described the pollen of this genus as tricolpate.

Pollen of seven taxa with striate or reticulo-striate ornamentation are presented in the present study. They are *Acer serrulatum* (Aceraceae), *Rhus ambigua* (Anacardiaceae), *Begonia formosana,* (Begoniaceae), *Pratia nummularia* (Campanulaceae), *Gentiana atkinsonii* var. *formosana*, *G. flavo-maculata* and *Tripterospermum lanceolatum* (Gentianaceae). The pollen of *Begonia formosana* can be distinguished from other striate pollen by its perprolate shape in equatorial view. In addition, its sculpturing is striate under both SEM and LM. The pollen of two taxa of *Gentiana* have reticulo-striate sculpturing both under SEM and LM. However, sexine of the remaining four taxa is striate under SEM and reticulo-striate under LM.

Fifteen taxa show reticulate pollen sculpturing. They are *Aralia decaisneana*, *Dendropanax dentiger*, *Hedera rhombea* var. *formosana*, *Pentapanax castanopsisicola* and *Schefflera taiwaniana* in Araliaceae, four species of *Viburnum* (Caprifoliaceae), *Celastrus hindsii*, *Euonymus spraguei* and *Perrottetia arisanensis* (Celastraceae), *Shortia exappendiculata* (Diapensiaceae), *Idesia polycarpa* (Flacourtiaceae) and *Hemiboea bicornuta* (Gesneriaceae). The pollen of *Celastrus hindsii* and *Euonymus spraguei* (Celastraceae) fit one of the three pollen types of subfamily Cassinoideae (Archer and van Wyk, 1992) in having reticulate ornamentation. The pollen sculpturing of Araliaceae is also reticulate, but the muri are more curved than in the Celastraceae. The reticulate surface pattern of *Schefflera taiwaniana* is considered to be highly specialized and derived from the undifferentiated and imperforate surface pattern characteristic of some primitive species of *Schefflera* (Shoup and Tseng, 1977; Tseng and Shoup, 1978). Pollen of *Shortia* from the southeastern United States and from eastern Asia is foveolate-reticulate, clearly reticulate or finely reticulate (Xi and Tang, 1990). However, the pollen of *Shortia exappendiculata* in this study differs in having rugulo-reticulate sculpturing.

Class XV: heterocolpate pollen

The pollen of *Parachampionella rankanensis* (Acanthaceae) is 15-23 heterocolpate (or 3-colporate with 12-20 pseudocolpi). However, that of *Trigonotis elevato-venosa* (Boraginaceae) is 6-heterocolpate (or 3-colporate with 3-pseudocolpi).

Colpi without endoapertures are often termed pseudocolpi (Erdtman, 1952). However, Clarke (1977) used colporate apertures and simple colpi instead of pseudocolpi to describe the pollen of Boraginaceae.

Class XVII: tetrad pollen monads 3-colporate

Three species of Ericaceae belong to this type of pollen: *Pieris taiwanensis*, *Rhododendron formosanum* and *R. mariesii*. The apocolpia is psilate in *Pieris* and verrucate in two species of *Rhododendron*. The mesocolpia is rugulate in *Pieris* and cracked in *Rhododendron*.

ACKNOWLEDGEMENTS

This work was supported by a grant from the National Science Council, Taiwan (NSC 84-2311-B-002-020) to S. H. Chen. We are very grateful to Mr. Horng-Bin Chuang and Miss Ching-Yen Lin, staff members of the Electron Microscope Laboratories, National Taiwan University, for taking the SEM photographs.

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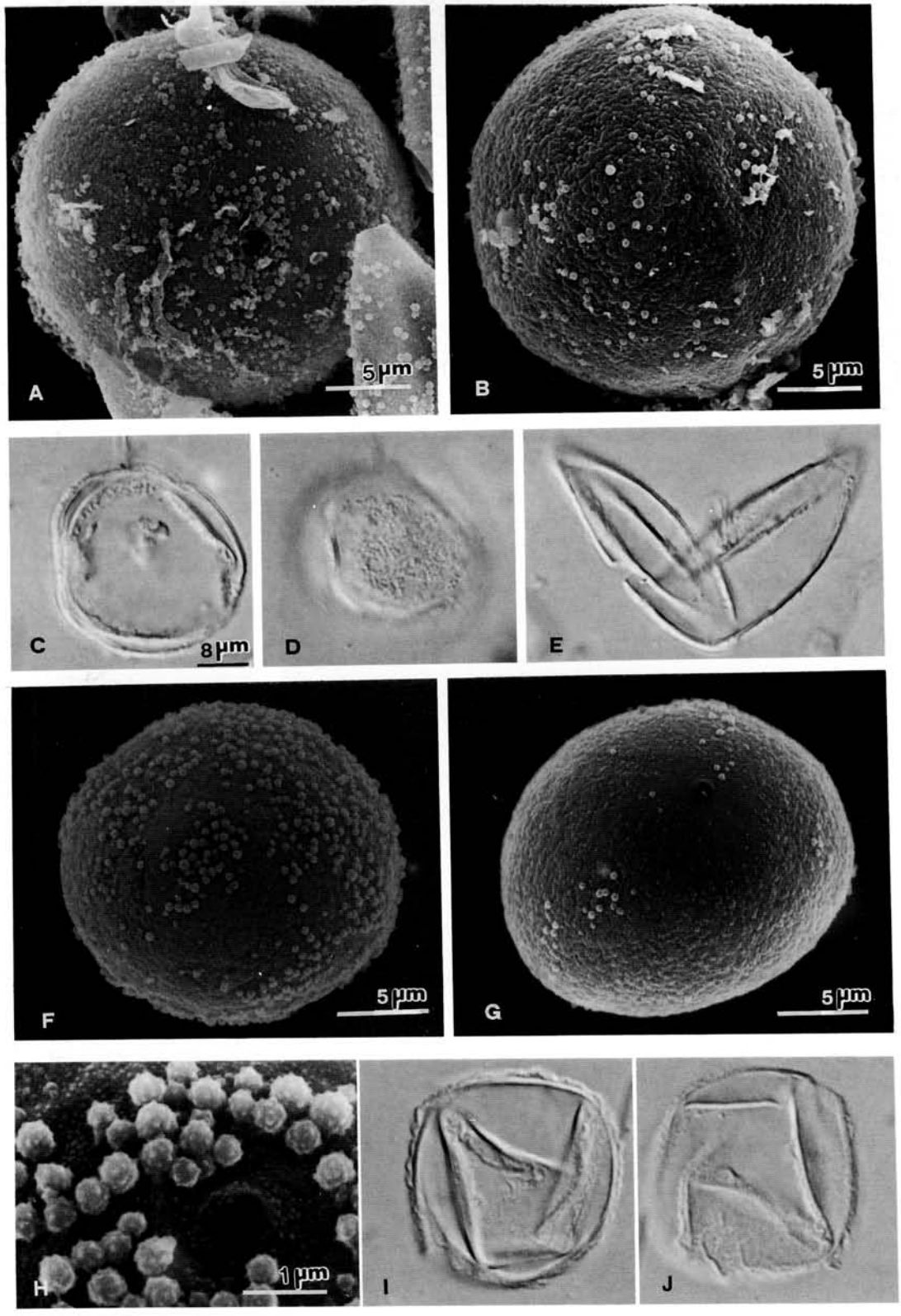

Plate 1. A-E: *Chamaecyparis formosensis* Matsum. A-B, SEM; C-E, LM. A, 1-porate grain situated at the distal pole. B, grain showing sexine and irregularly distributed orbicules. C & D, 1-porate grains with granulate sexine. E, grain with sexine showing a V-shaped opening. F-J: *Chamaecyparis obtusa* Sieb. & Zucc. var. *formosana* (Hayata) Rehder. F-H, SEM; I-J, LM. F, pollen grain showing sexine with irregularly distributed orbicules. G, 1-porate grain situated at distal pole. H, detail of circular pore and circumferential spinulate orbicules. I & J, folded grains with wrinkled sexine.

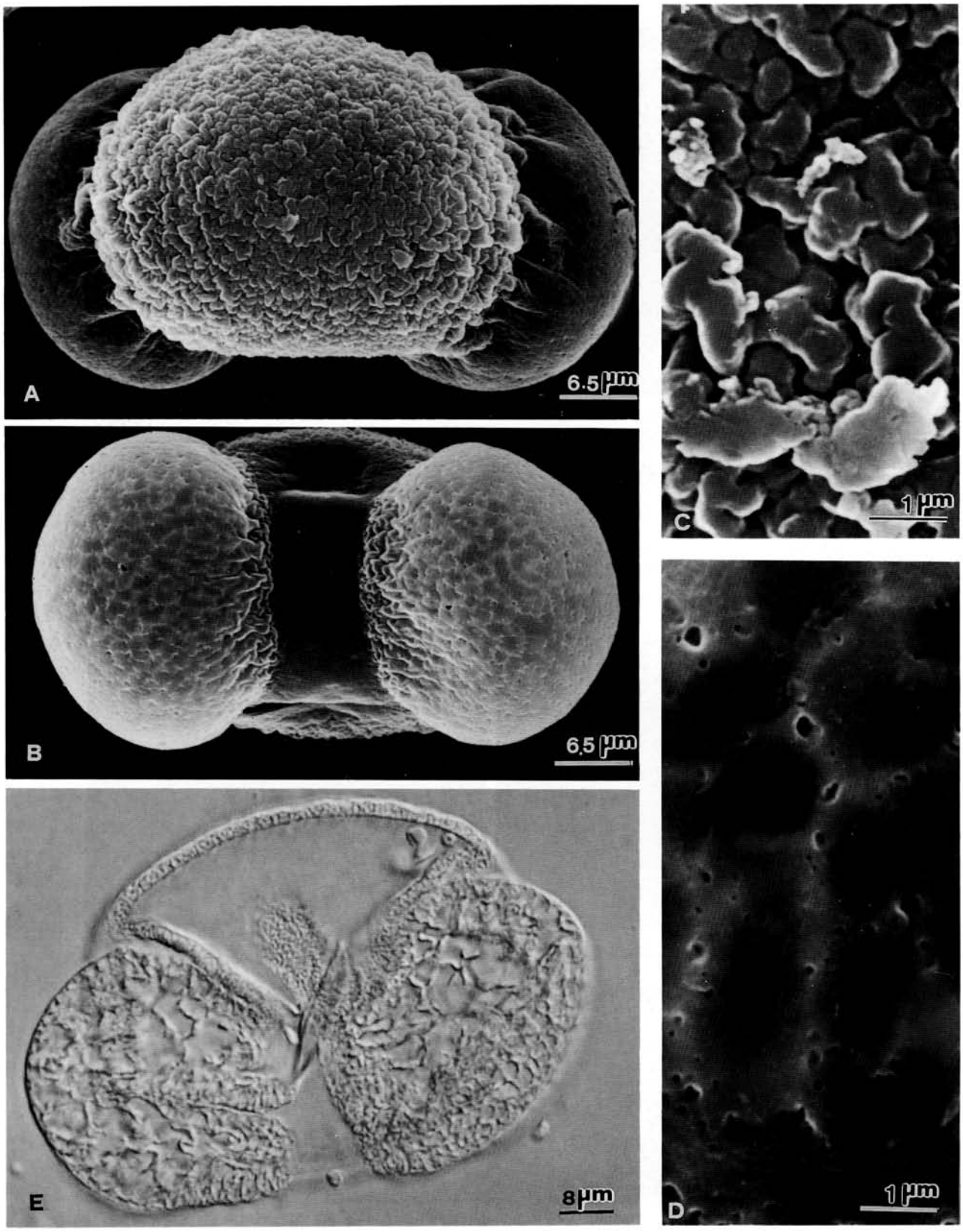

Plate 2. A-E: *Pinus taiwanensis* Hayata. A-D, SEM; E, LM. A, pollen grain in proximal view with two sacci. B, grain in distal view showing smooth or sparsely perforated distal surface and marginal rugulate frills near sacci attachment. C, detail of sexine of corpus showing congested rugulae on proximal face. D, detail of sexine of sacci roughened and sparsely perforated. E, 2-sacci grain showing internal 3-dimensional reticula.

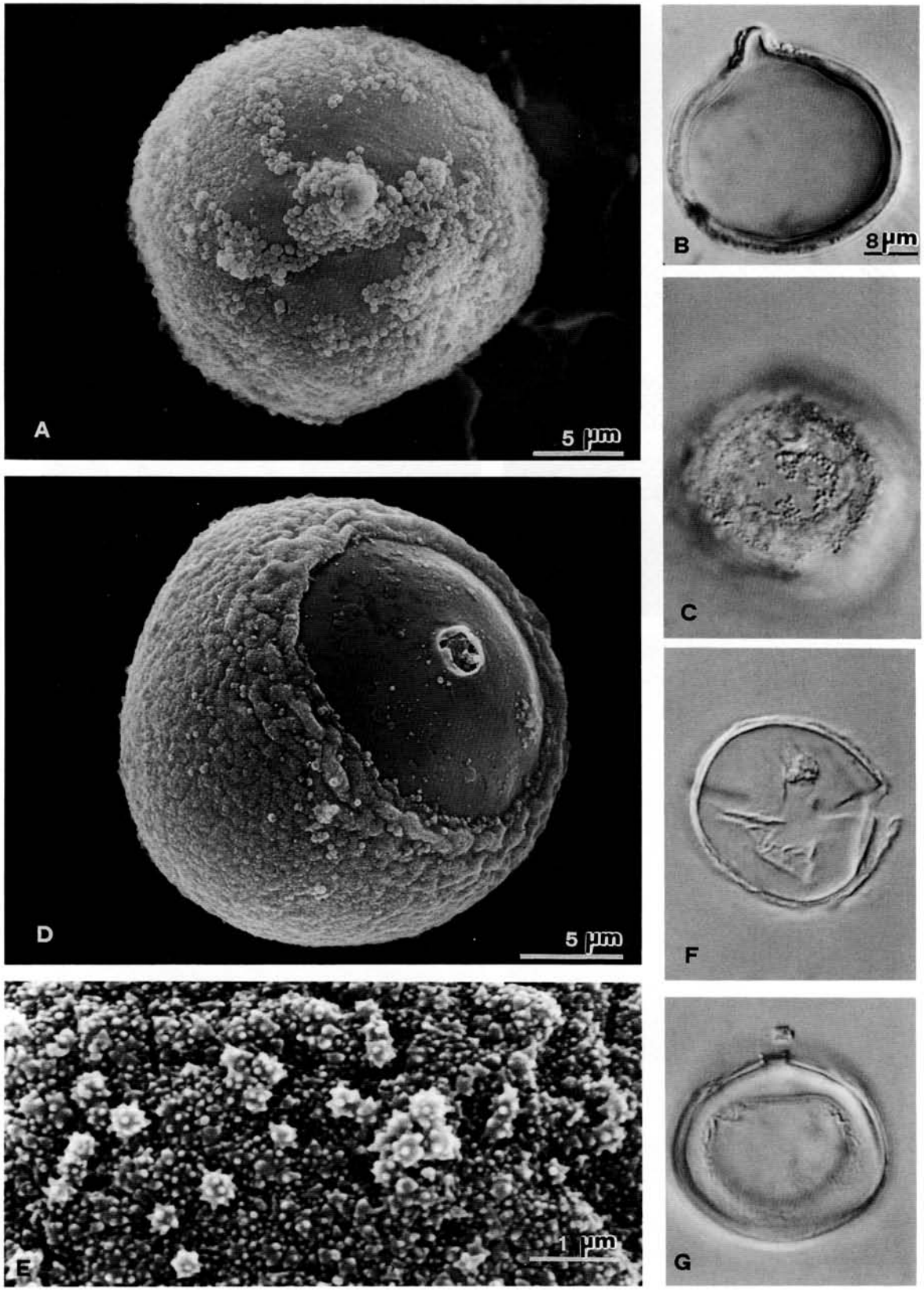

Plate 3. A-C: *Cryptomeria japonica* (L. f.) D. Don. A, SEM; B & C, LM. A & B, grains showing a hooked papillate leptoma and spinulate orbicules distributed irregularly. C, grain with granulate sexine. D-G: *Cunninghamia konishii* Hayata. D & E, SEM; F & G, LM. D, 1-porate grain showing peeled sexine. E, detail of sexine with congested spinulate oricules. F, grain showing V-shaped opening and wrinkled sexine. G, 1-porate grain.

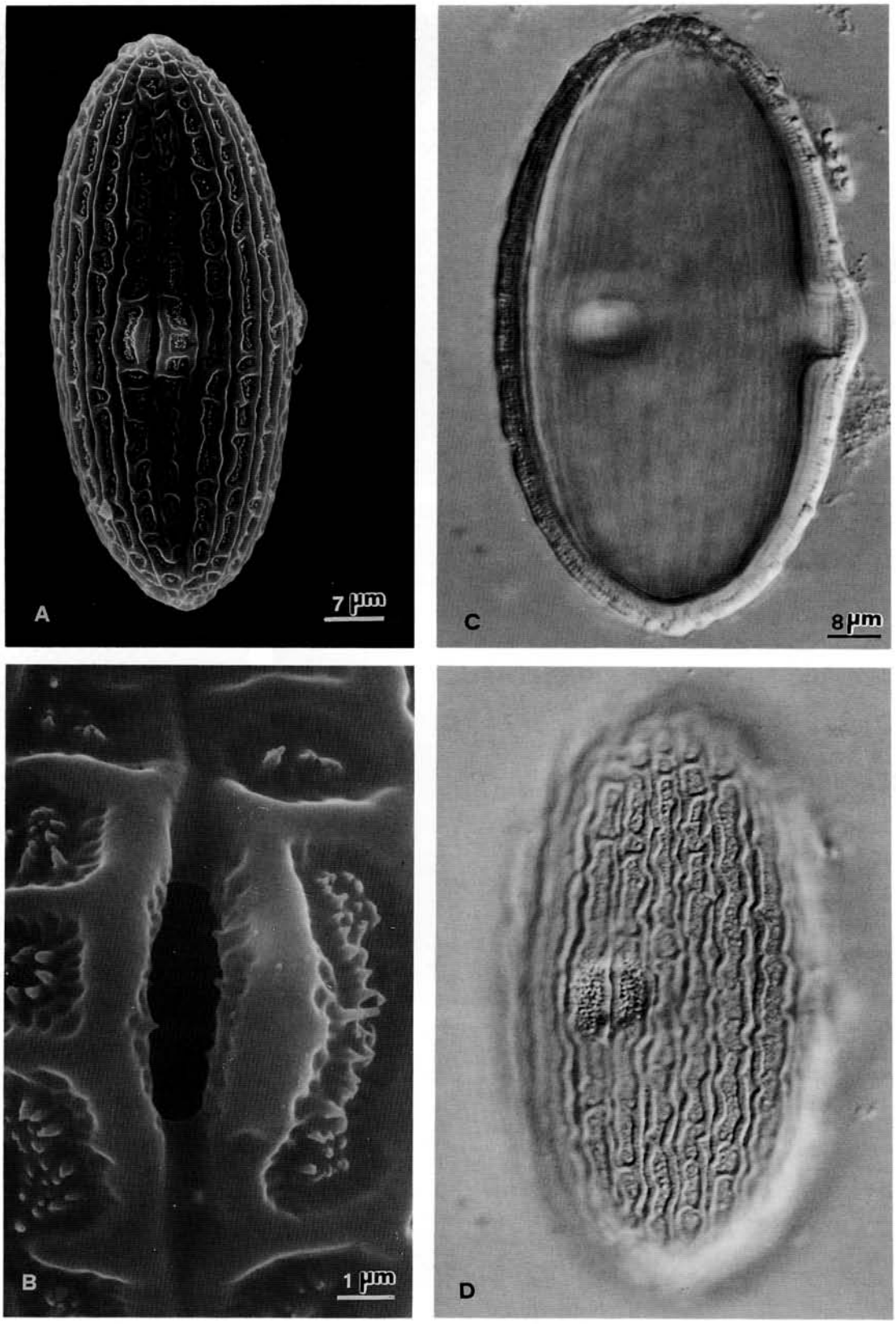

Plate 4. A-D: *Parachampionella rankanensis* (Hayata) Bremek. A & B, SEM; C & D, LM. A, heterocolpate grain with reticulate sexine showing pseudocolpi and colpi dividing sexine into longitudinal strips, each sexine strip with scalariform reticula. B, highly magnified os and spinules in angular lumina. C & D, grains in equatorial view, showing two of three colporate apertures and a rectangular os.

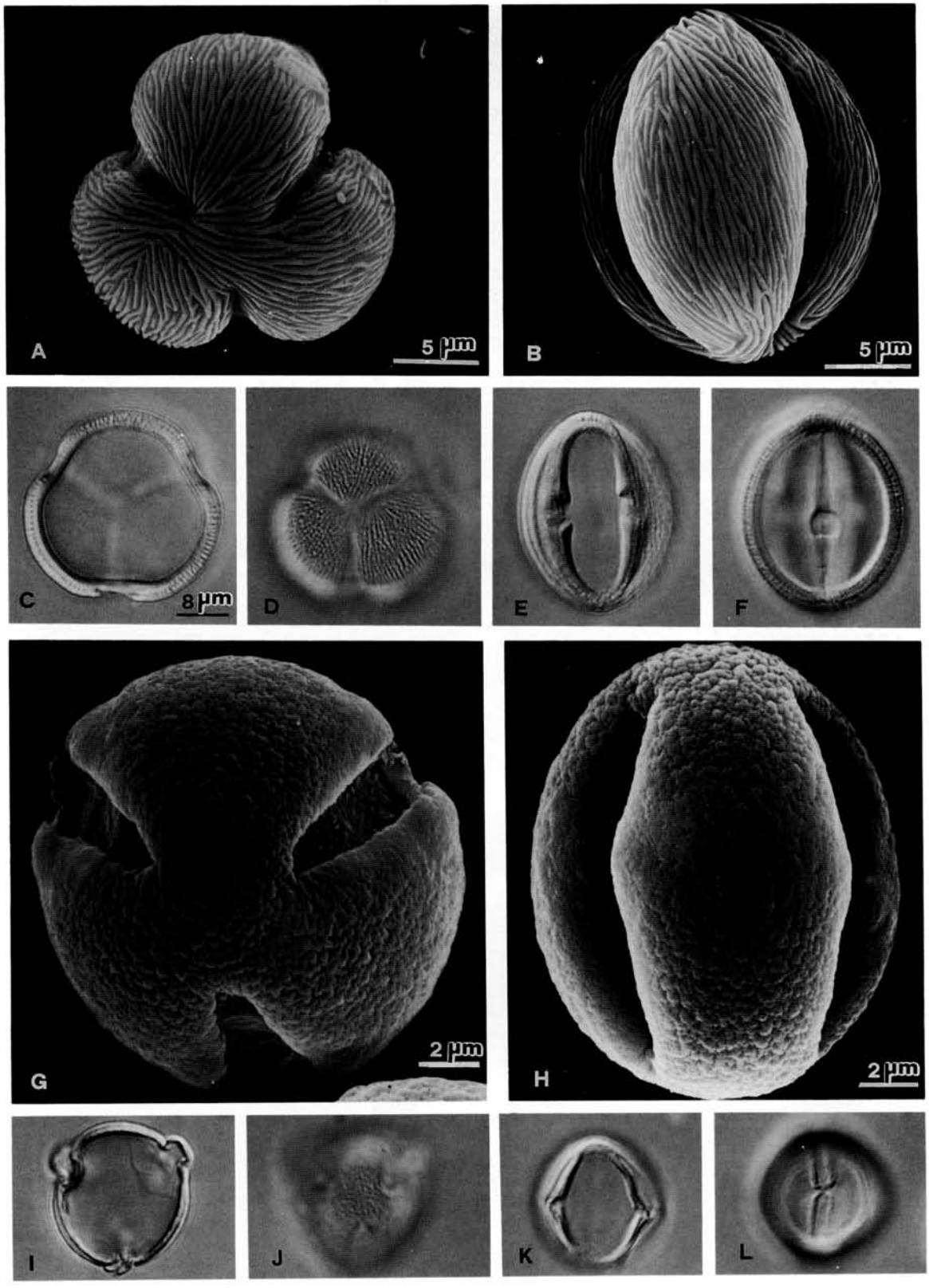

Plate 5. A-F: *Acer serrulatum* Hayata. A & B, SEM; C-F, LM. A, 3-colporate grain in polar view showing striate sexine. B, grain in equatorial view. C & D, grains in polar view showing reticulato-striate sexine. E & F, grains in equatorial view showing circular os. G-L: *Actinidia arisanensis* Hayata. G & H, SEM; I-L, LM. G, 3-colporate grain in polar view showing rugulate sexine. H, grain in equatorial view. I & J. grains in polar view, showing labrum type aperture. K & L. grains in equatorial view showing colpi constricted toward os and transversally parallel os.

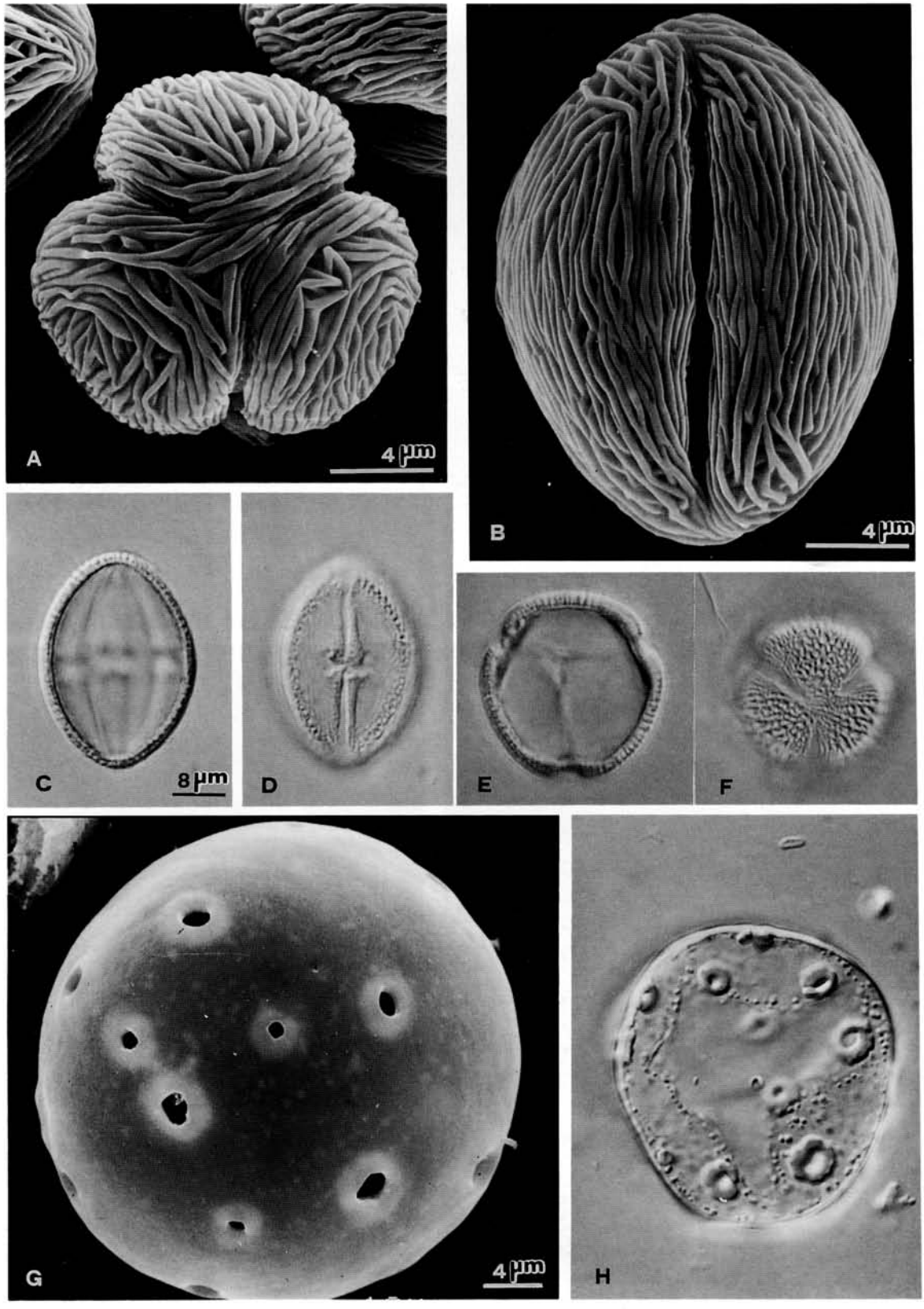

Plate 6. A-F: *Rhus ambigua* Lav. ex Dipped. A & B, SEM; C-F, LM. A, E & F, 3-colporate grains in polar view showing striate sexine in A and reticulato-striate sexine in F. B, C & D, grains in equatorial view showing slit-shaped colpus and transversally elongated os. G & H: *Trachelospermum formosanum* Liu & Ou. G, SEM; H, LM. G, pantoporate grain showing circular pores irregularly distributed on psilate sexine surface. H, grain showing the granulate infratectum and pores with conspicuous annuli.

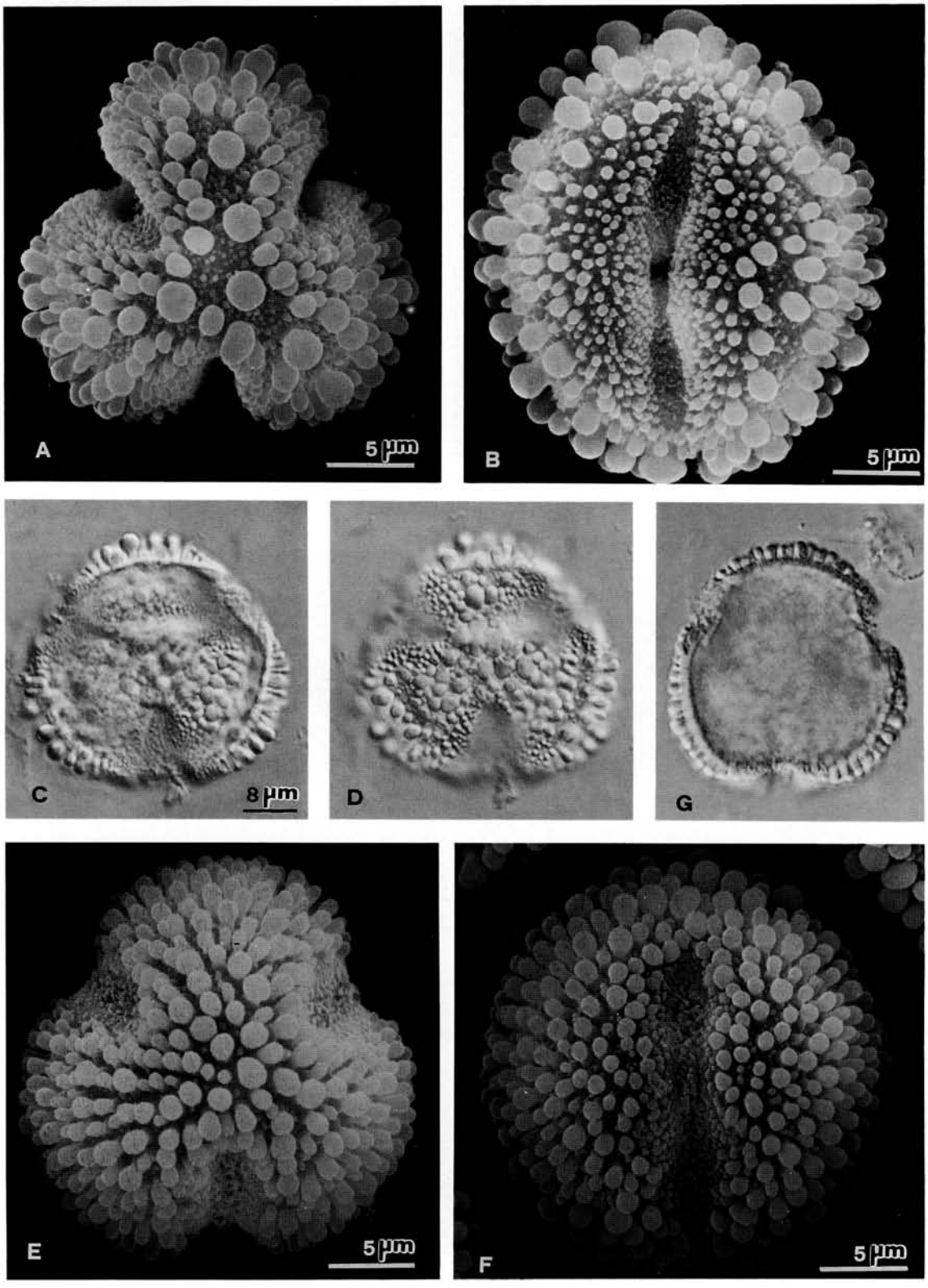

Plate 7. A-D: *Ilex hayataiana* Loes., A & B, SEM; C & D, LM. A, C & D, 3-colporate grains in polar view showing sparsely clavate sexine. B, grain in equatorial view showing calvae gradually decreasing in size toward colpus, colpus membrane densely granulate. E-G: *Ilex sugeroki* Maxim. var. *brevipedunculata* (Maxim.) S. Y. Hu. E & F, SEM; G, LM. E & G, 3-colporate grains in polar view showing more densely spaced clavate sexine. F, grain in equatorial view showing clavae abruptly decreasing in size toward colpus and uneven colpus membrane.

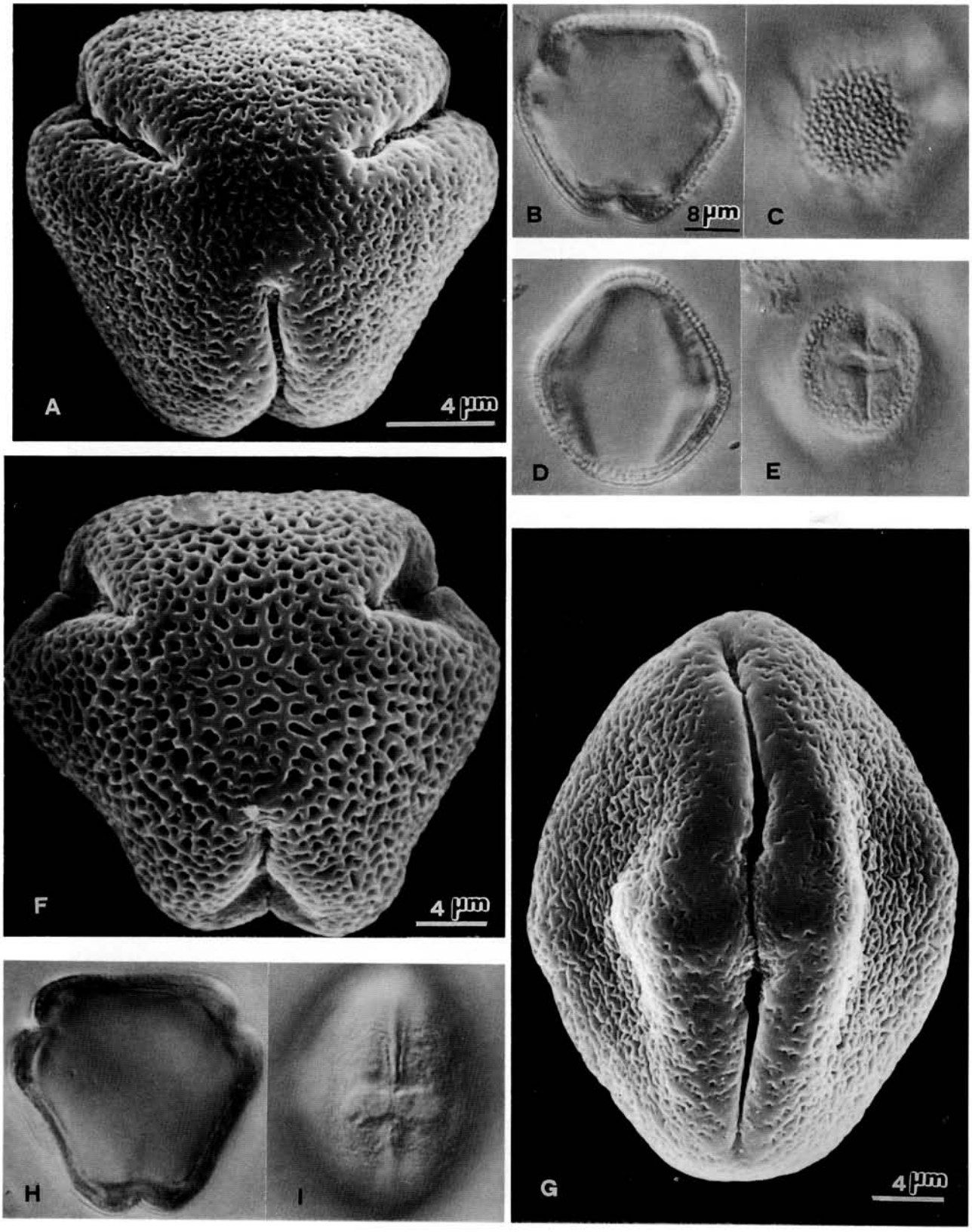

Plate 8. A-E: *Aralia decaisneana* Hance. A, SEM; B-E, LM. A-C, 3-colporate grains in polar view showing reticulate sexine. D & E, grains in equatorial view showing lalongate os. F-I: *Dendropanax dentiger* (Harms ex Diels) Merr. F & G, SEM; H & I, LM. F & H, 3-colporate grains in polar view showing reticulate sexine. G & I, grains in equatorial view showing transversally parallel os and crassimarginate colpus.

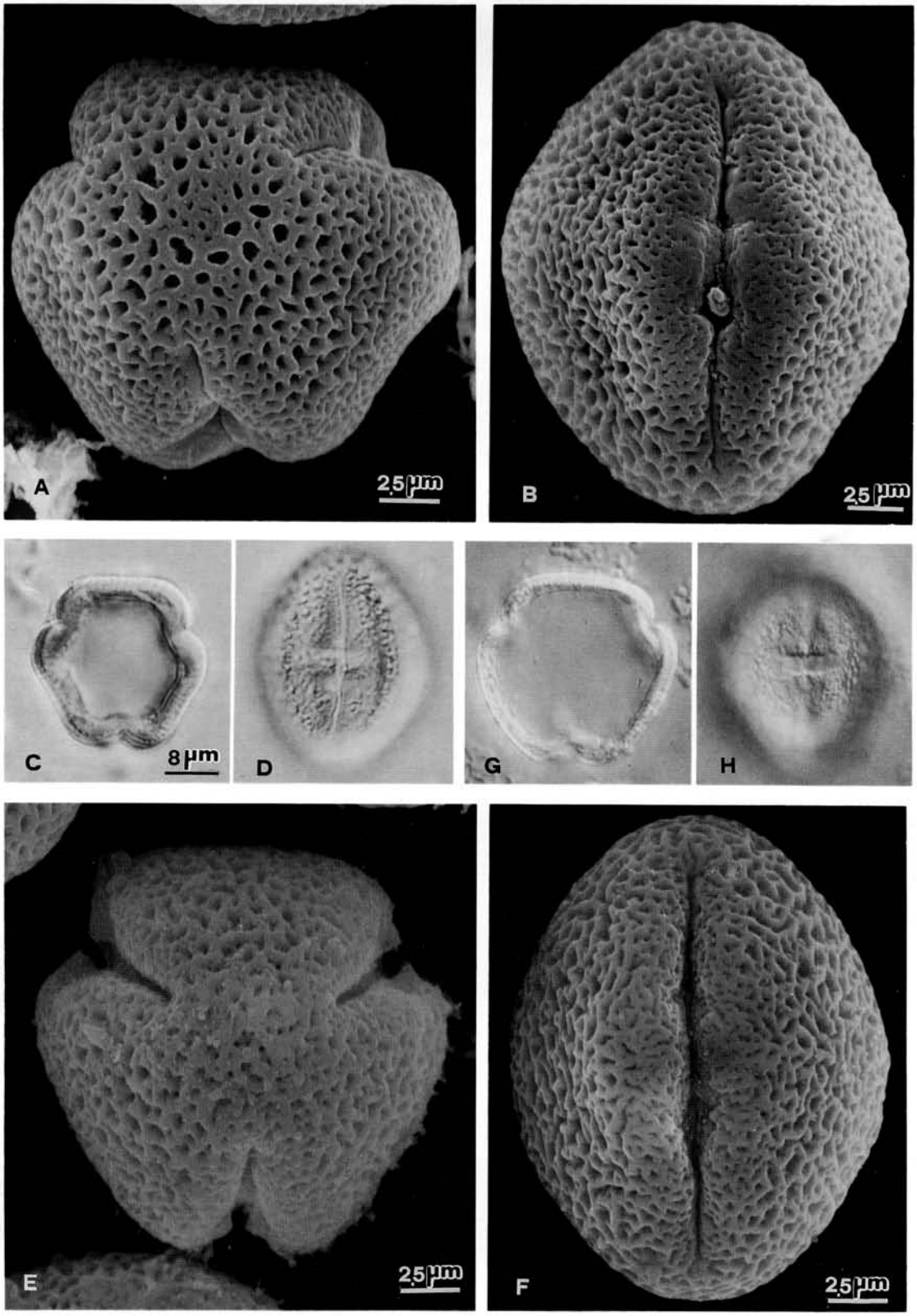

Plate 9. A-D: *Hedera rhombea* (Miq.) Bean var. *formosana* (Nakai) Li. A & B, SEM; C & D, LM. A & C. 3-colporate grains in polar view showing reticulate sexine. B & D, grains in equatorial view showing transversally parallel os and crassimarginate colpi. E-H: *Pentapanax castanopsisicola* Hayata. E & F, SEM; G & H, LM. E & G, 3-colporate grains in polar view showing reticulate sexine. F & H, grains in equatorial view showing transversally parallel os and crassimarginate colpi.

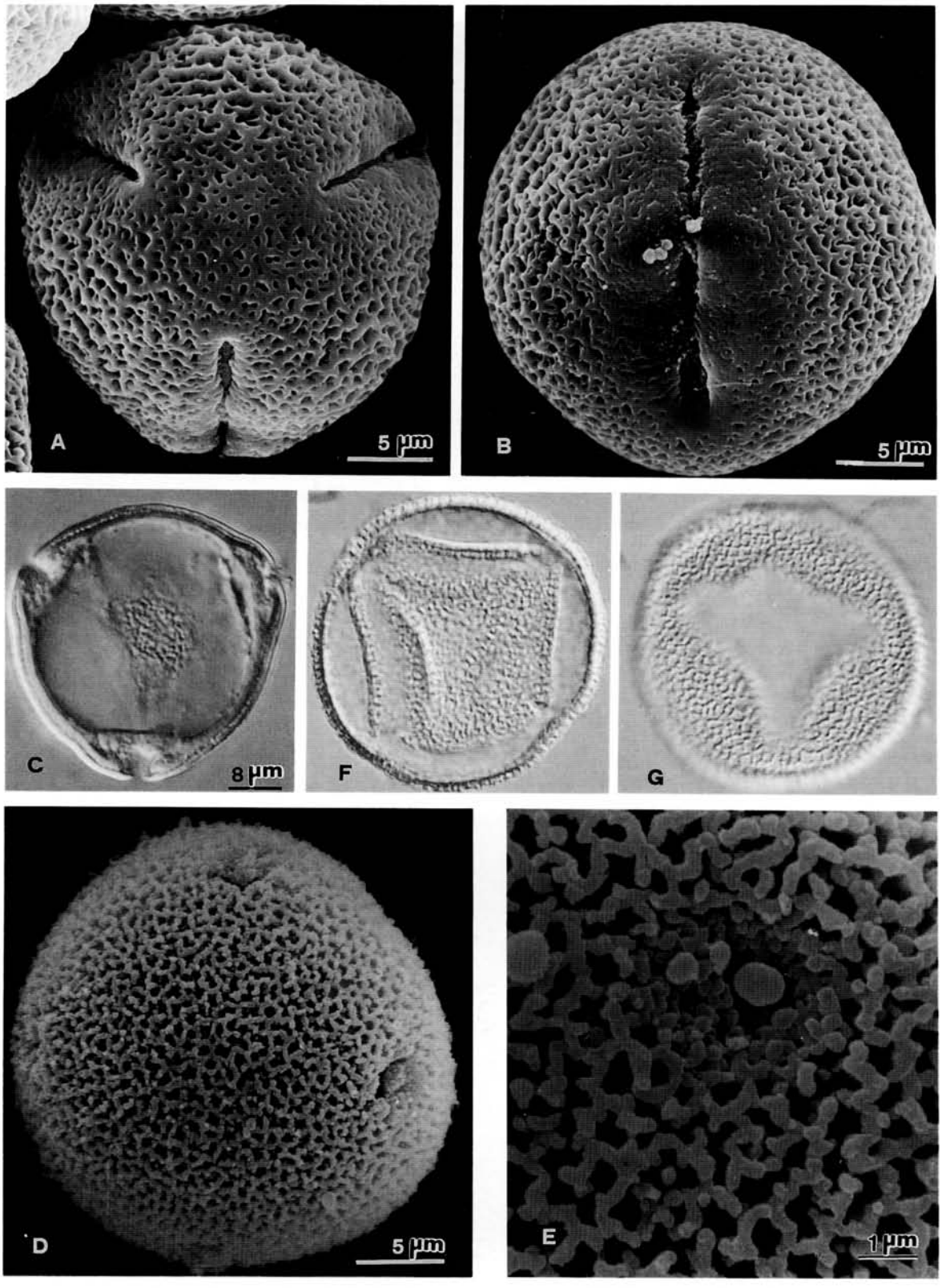

Plate 10. A-C: *Schefflera taiwaniana* (Nakai) Kanehira. A & B, SEM; C, LM. A & C. 3-colporate grains in polar view showing reticulate sexine. B, grain in equatorial view showing protruding os and lumina decreasing in size or disappearing toward colpus margins. D-G: *Asarum crassusepalum* S. F. Huang, T. H. Hsieh & T. C. Huang. D & E, SEM; F & G, LM. D, F & G, 4-porate grains in polar view. E, detail of a pore and rugulo-reticulate sexine.

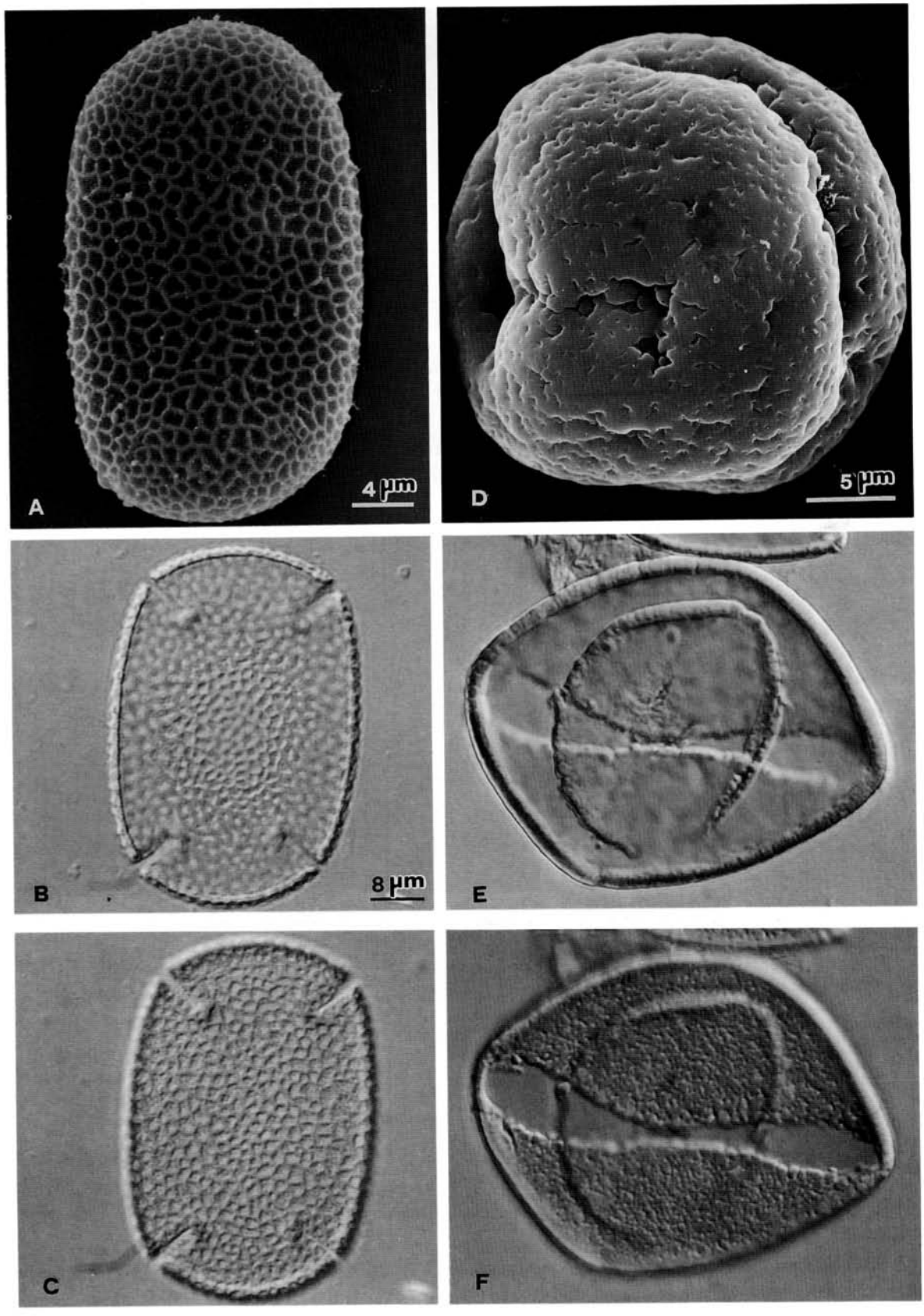

Plate 11. A-C: *Impatiens uniflora* Hayata. A, SEM; B & C, LM. A-C, 4-colpate grains in polar view showing reticulate sexine. D-F: *Berberis kawakamii* Hayata. D, SEM; E & F, LM. D-F. spiraperturate grains in equatorial view showing perforated and fossulate sexine and sexine cracking in mesocolpium.

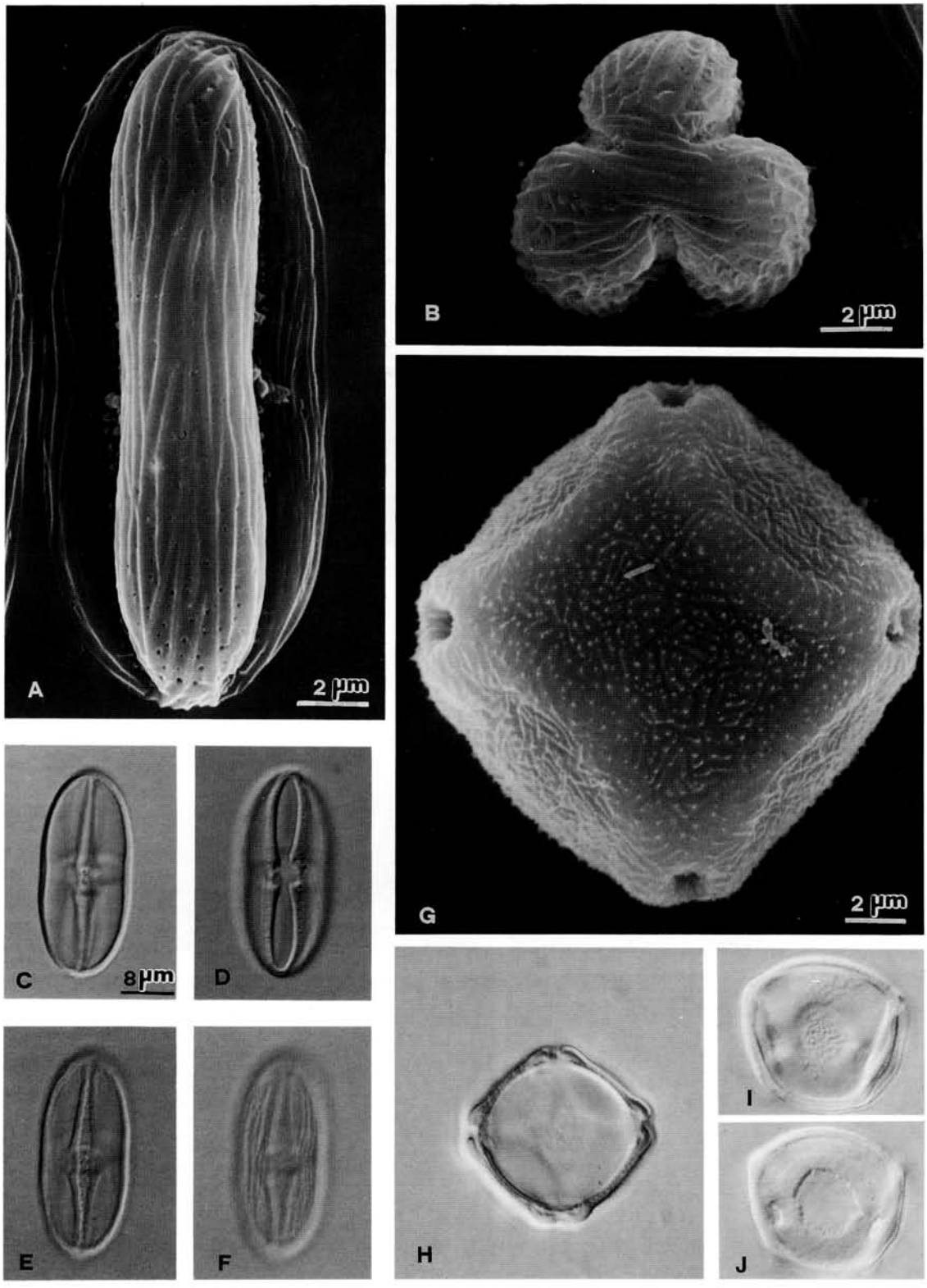

Plate 12. A-F: *Begonia formosana* (Hayata) Masamune. A & B, SEM; C-F, LM. A & C-F, 3-colporate grains in equatorial view showing striate sexine and a lalongate os. B, grain in polar view. G-J: *Alnus formosana* (Burk.) Makino, G, SEM; H-J, LM. G & H, 4-porate grains in polar view showing supratectal ridges bearing spinules on exine surface. I & J, grains in equatorial view showing neighboring pores connected by exinous thickening arci.

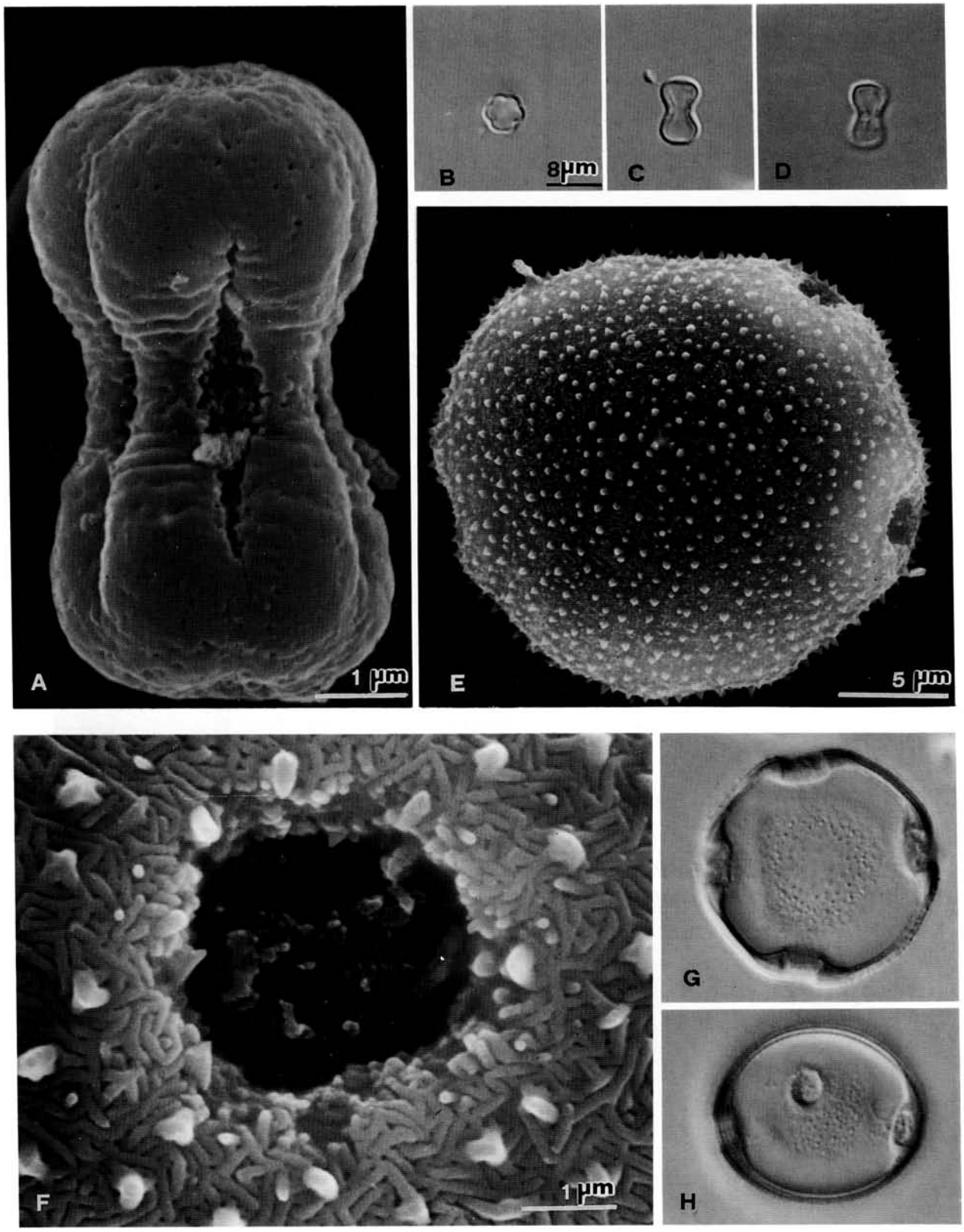

Plate 13. A-D: *Trigonotis elevato-venosa* Hayata. A, SEM; B-D, LM. A, a 6-heterocolporate grain in equatorial view showing rhomboidal colpi, tooth-like colpus margins and a rectangular os. B, grain in polar view. C & D, grains in equatorial view showing a lalongate os. E-H: *Peracarpa carnosa* (Wall.) Hook. f. & Thoms. E & F, SEM; G & H, LM. E, 5-porate grain in polar view. F, detail of circular sunken pore and spinulate sexine showing pore membrane partially destroyed and reticulato-striate sexine surface between spinules. G, 4-porate grain in polar view. H, grain in equatorial view.

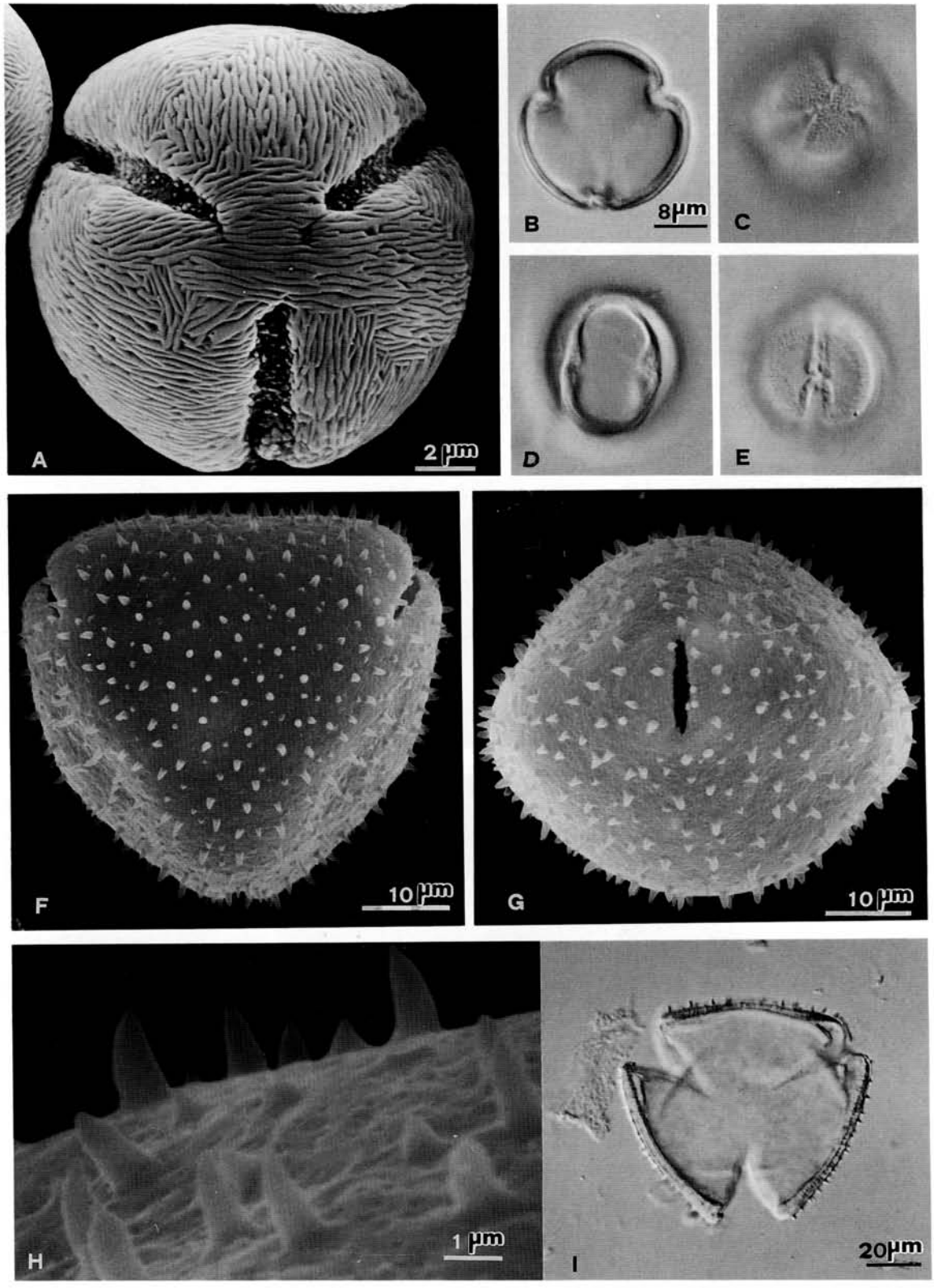

Plate 14. A-E: *Pratia nummularia* (Lam.) A. Br. & Asch. A, SEM; B-E, LM. A, 3-colporate grain in polar view showing striate sexine. B & C, grains in polar view showing reticulato-striate sexine. D & E. grains in equatorial view showing circular os. F-I: *Lonicera acuminata* Wall. F-H, SEM; I, LM. F & I, 3-colporate grains in polar view showing spinulate sexine. G, grain in equatorial view showing brevicolpi. H, detail of spinulate sexine showing conical spinules and rugulo-perforated sexine surface among spinules.

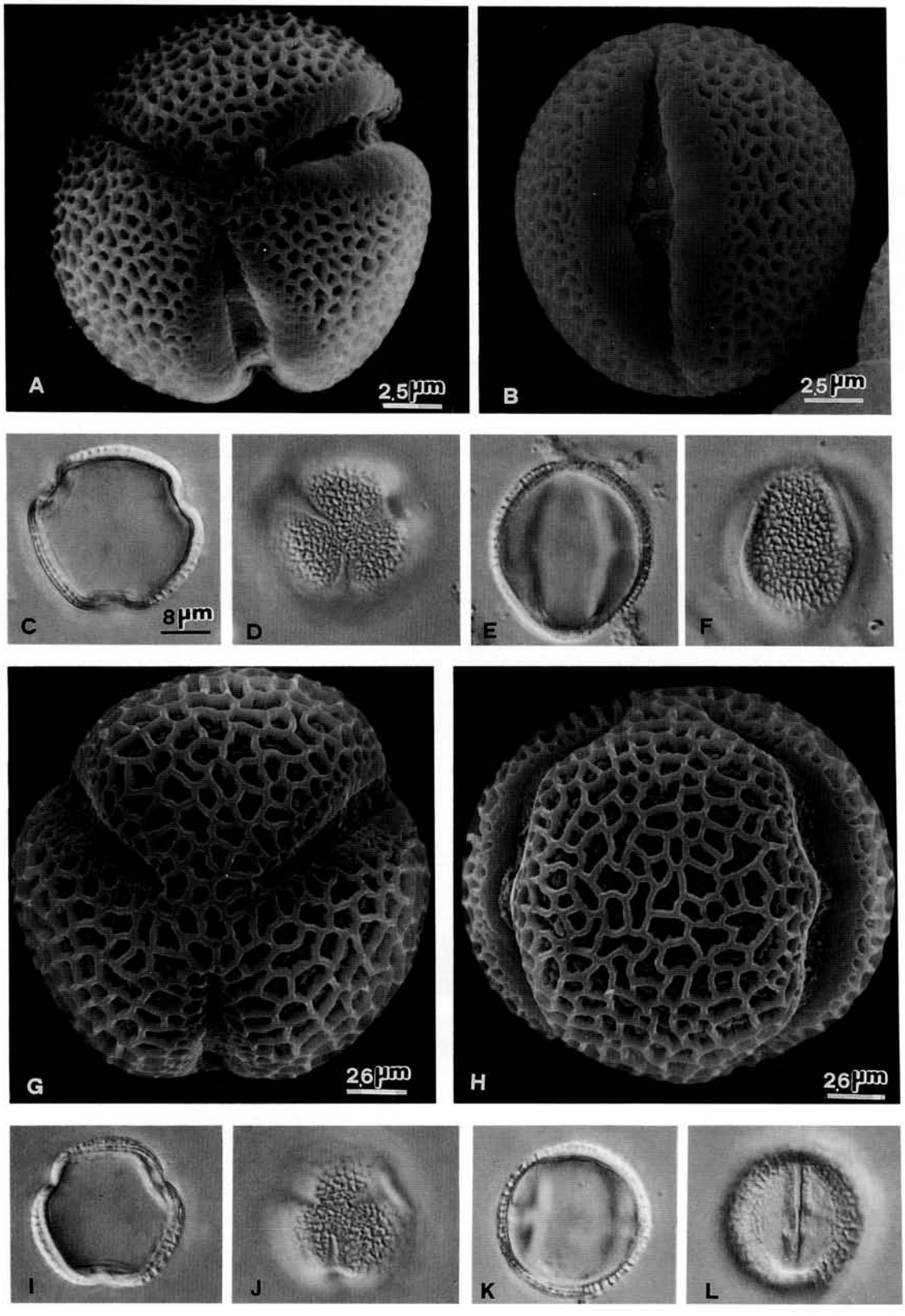

Plate 15. A-F: *Viburnum furcatum* Blume ex Maxim. A & B, SEM; C-F, LM. A, C & D, 3-colporate grains in polar view showing reticulate sexine. B, E & F, grains in equatorial view, showing psilate sexine surface on colpus margins and scabrate colpus membrane in B. G-L: *Viburnum integrifolium* Hayata. G & H, SEM; I-L, LM. G, I & J, 3-colporate grains in polar view showing reticulate sexine. H, K & L, grains in equatorial view showing lalongate os.

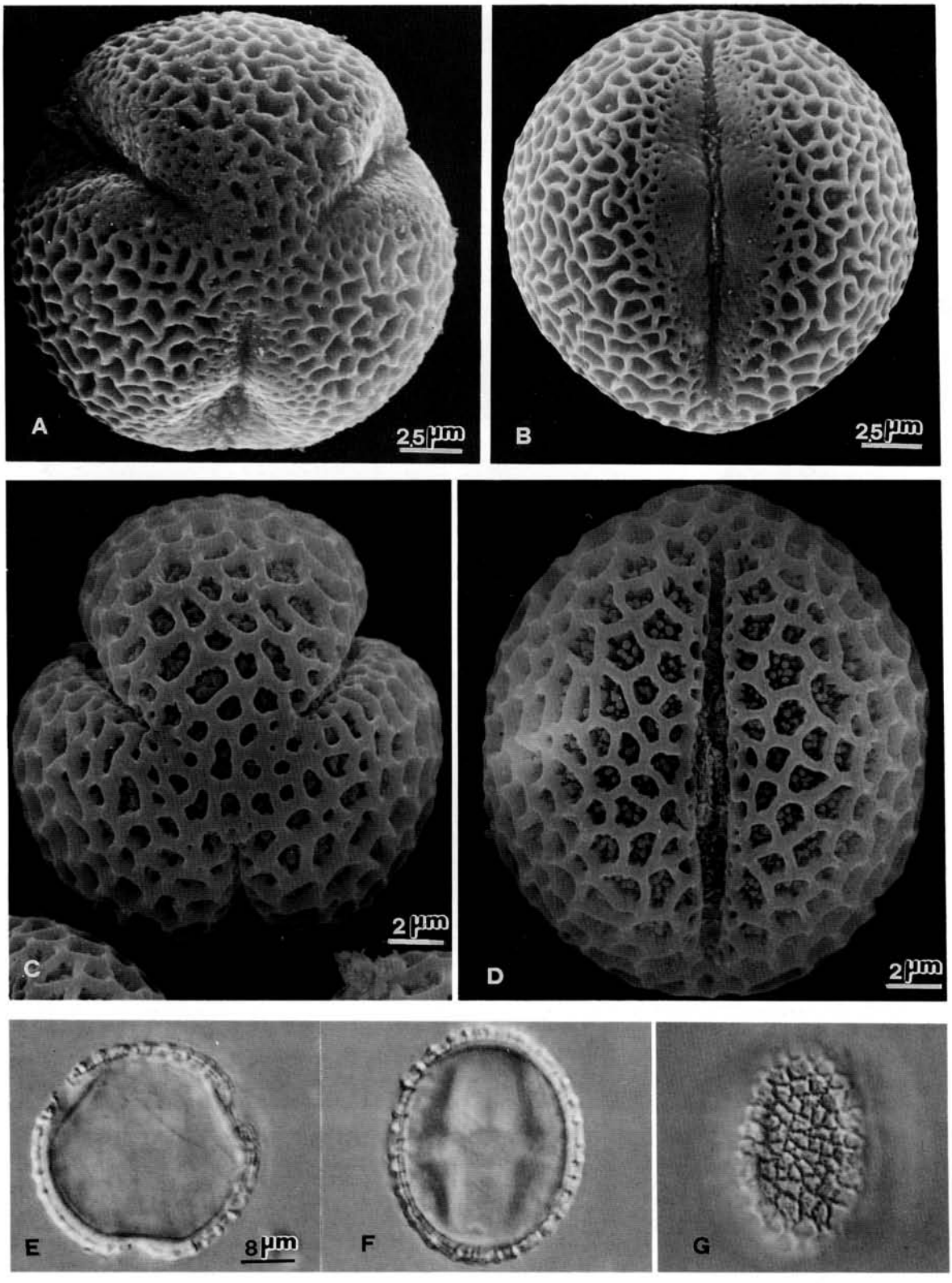

Plate 16. A-B: *Viburnum luzoncium* Rolfe. var. *formosanum* (Hance) Rehder. A & B, SEM. A, 3-colporate grain in polar view showing reticulate sexine. B, grain in equatorial view showing psilate sexine surface on colpus margins. C-G: *Viburnum taiwanianum* Hayata. C & D, SEM; E-G, LM. C & E, 3-colporate grains in polar view showing reticulate sexine. D, F & G, grains in equatorial view showing densely distributed verrucae in lumina, muri simpli-collumelate.

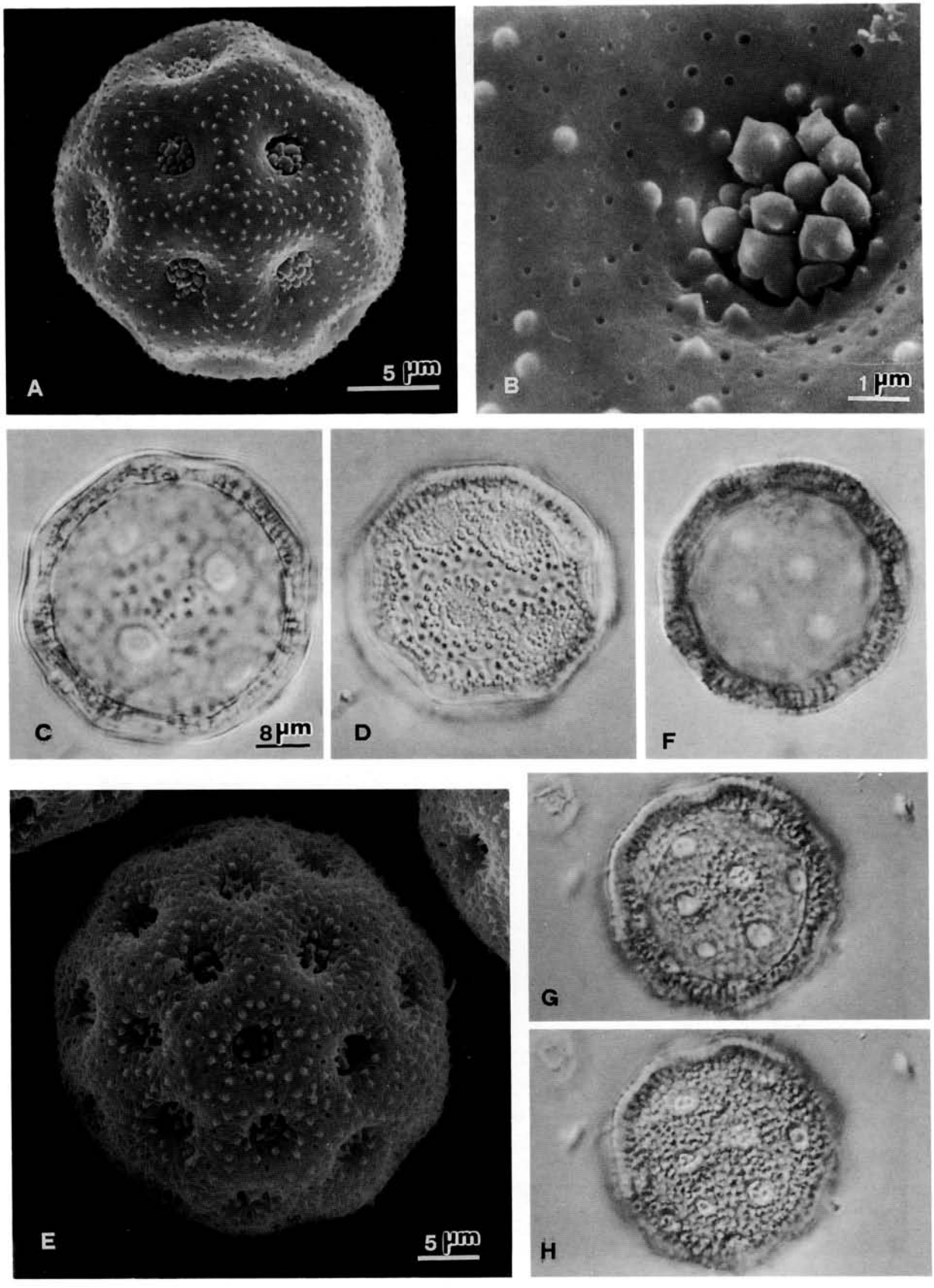

Plate 17. A-D: *Stellaria arisanensis* (Hayata) Hayata. A & B, SEM; C & D, LM. A, C & D, pantoporate grains. B, detail of spinulate/perforated sexine surface and pore with densely cone shaped spinulate operculum. E-H: *Cucubalus baccifer* L., E, SEM; F-H, LM. E-H, pantoporate grains.

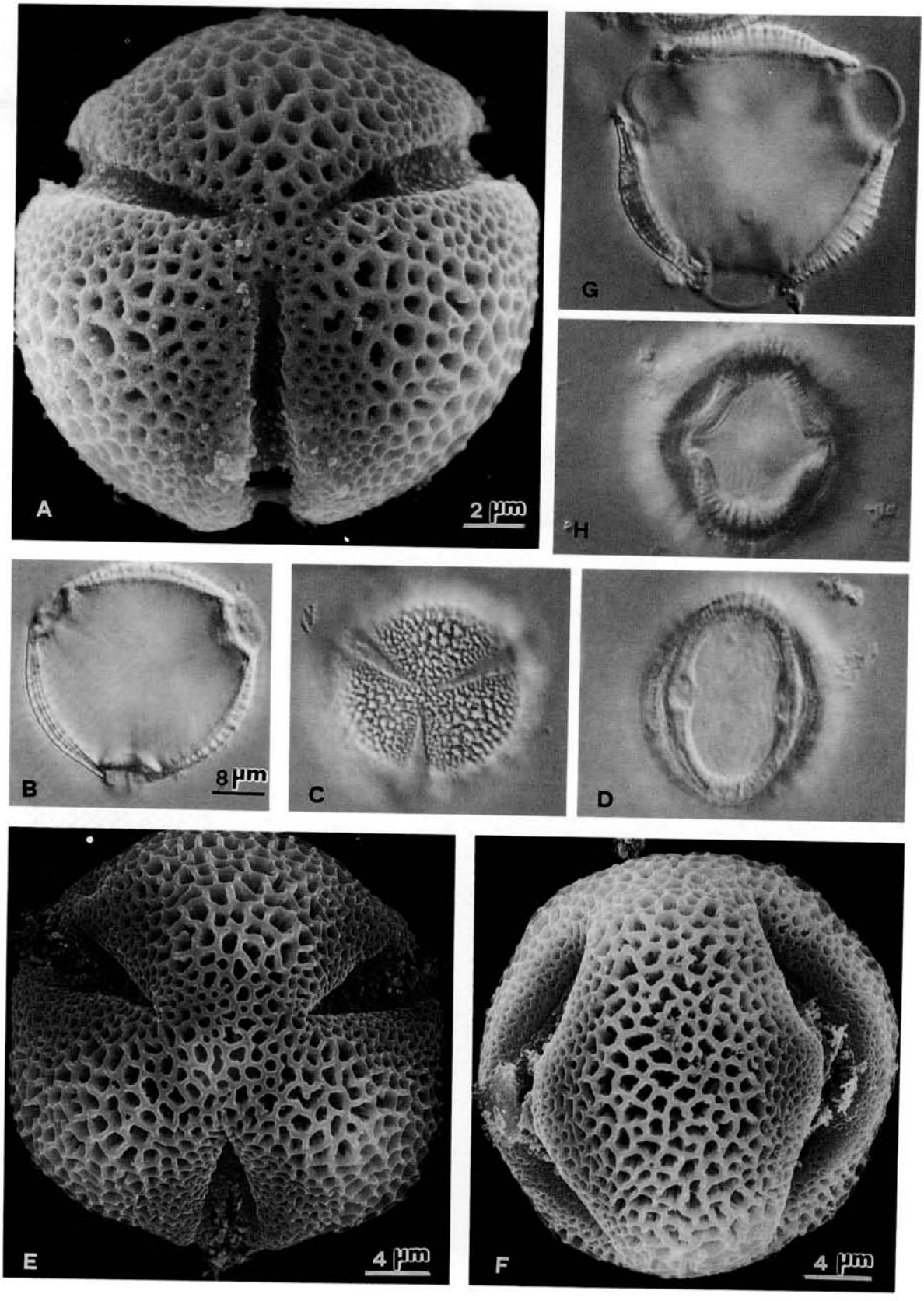

Plate 18. A-D: *Celastrus hindsii* Benth., A, SEM; B-D, LM. A-C, 3-colporate grains in polar view showing reticulate sexine. D, grain in equatorial view. E-H: *Euonymus spraguei* Hayata. E & F, SEM; G & H, LM. E & G, 3-colporate grains in polar view showing reticulate sexine. F & H, grains in equatorial view.

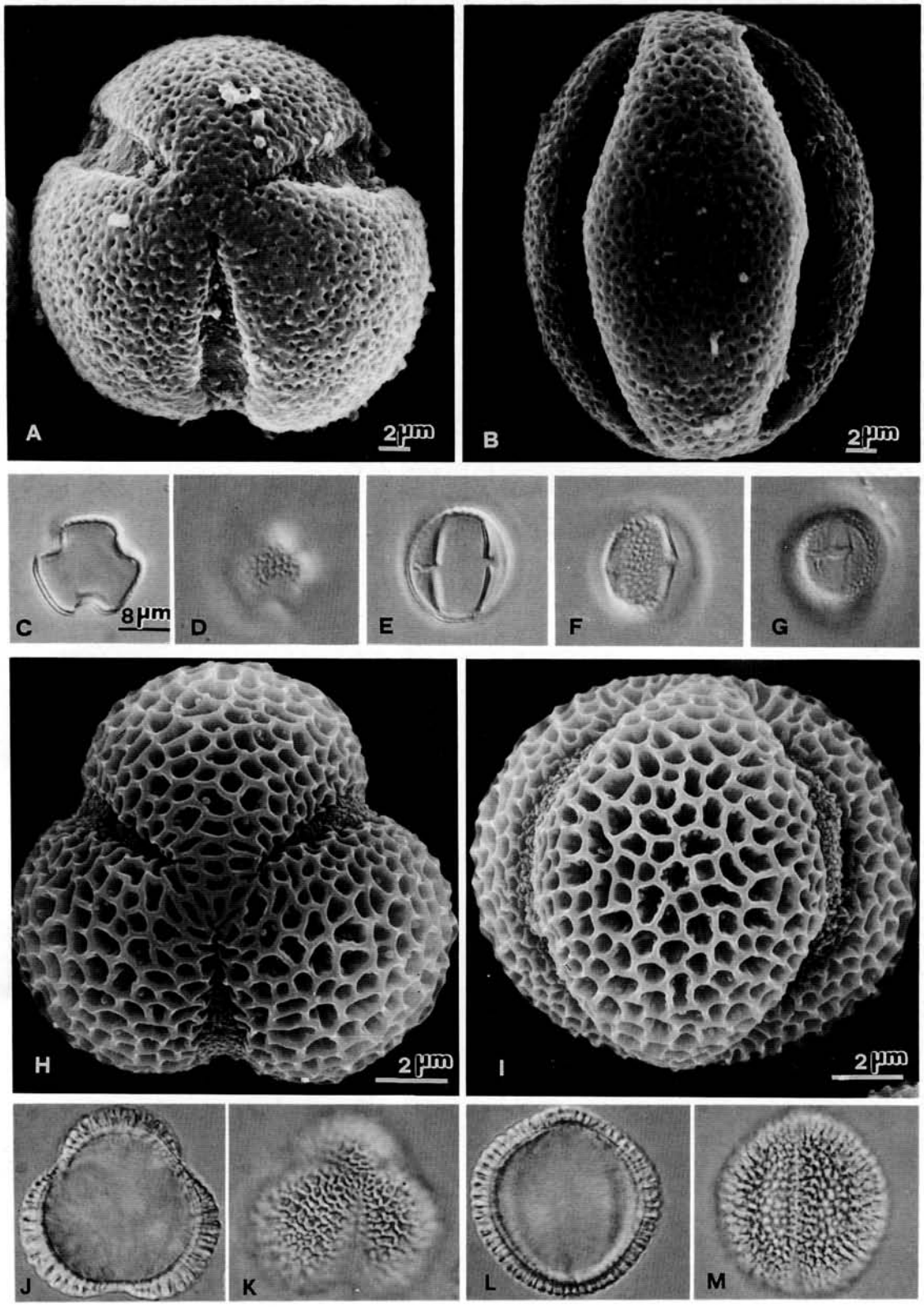

Plate 19. A-G: *Perrottetia arisanensis* Hayata. A & B, SEM; C-G, LM. A, C & D, 3-colporate grains in polar view showing reticulate sexine. B, E, F & G, grains in equatorial view showing transversally parallel os. H-M: *Cardamine flexuosa* With. H & I, SEM; J-M, LM. H, J & K, 3-colpate grains in polar view showing reticulate sexine. I, L & M, grains in equatorial view.

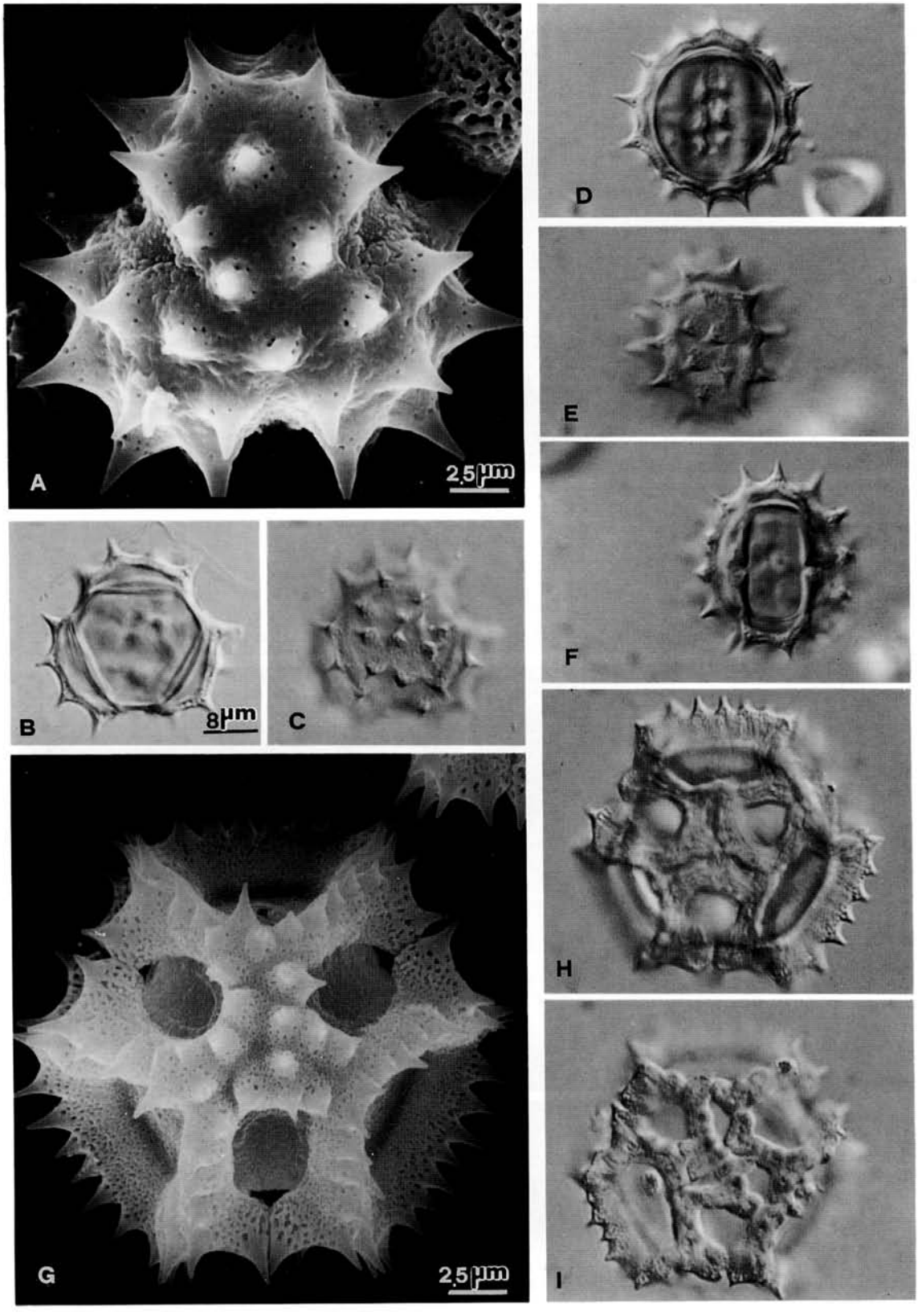

Plate 20. A-F: *Eupatorium formosanum* Hayata. A, SEM; B-F, LM. A-C, 3-colporate grains in polar view showing echinate sexine. D-F, grains in equatorial view showing circular os in F. G-I: *Sonchus arvensis* L., G, SEM; H & I, LM. G-I, fenestrate grains in polar view.

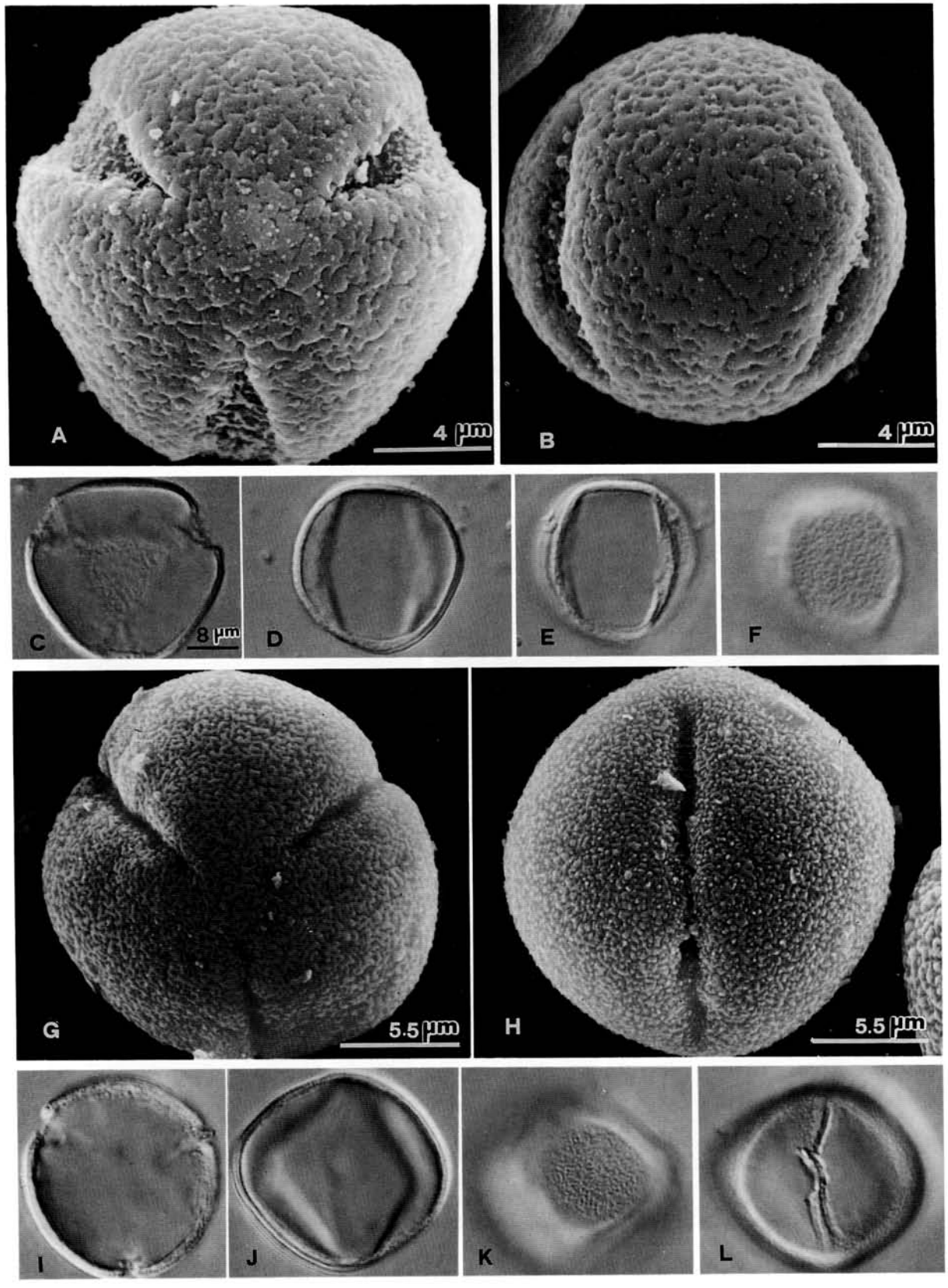

Plate 21. A-F: *Daphniphyllum himalaense* (Benth.) Muell.-Arg. subsp. *macropodum* (Miq.) Huang. A & B, SEM; C-F, LM. A & C, 3-colporate grains in polar view. B, D, E & F, grains in equatorial view showing rugulate sexine. G-L: *Shortia exappendiculata* Hayata. G & H, SEM; I-L, LM. G & I, 3-colporate grains in polar view showing rugulo-reticulate sexine. H & J-L, grains in equatorial view showing long colpi and indistinct os.

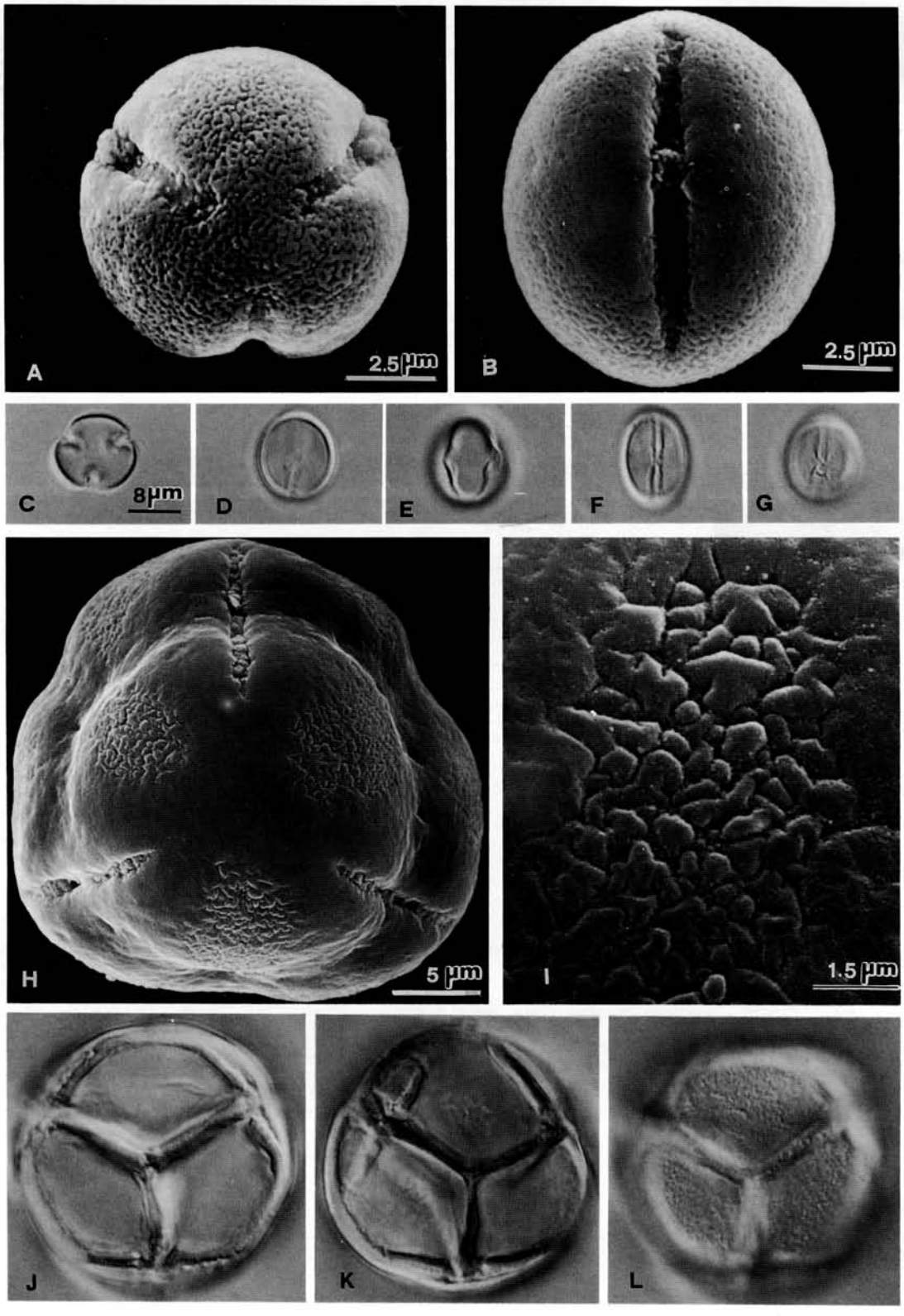

Plate 22. A-G: *Elaeocarpus japonicus* Sieb. & Zucc., A & B, SEM; C-G, LM. A & C, 3-colporate grains in polar view showing rugulo-reticulate sexine in apocolpium. B & D-G, grains in equatorial view showing uneven colpus membrane and transversally parallel os. H-L: *Pieris taiwanensis* Hayata. H & I, SEM; J-L, LM. H & J-L, tetrahedral tetrad grains showing psilate sexine in apocolpium and colpi interconnected at juncture of adjacent grains. I, detail of rugulate sexine in mesocolpia.

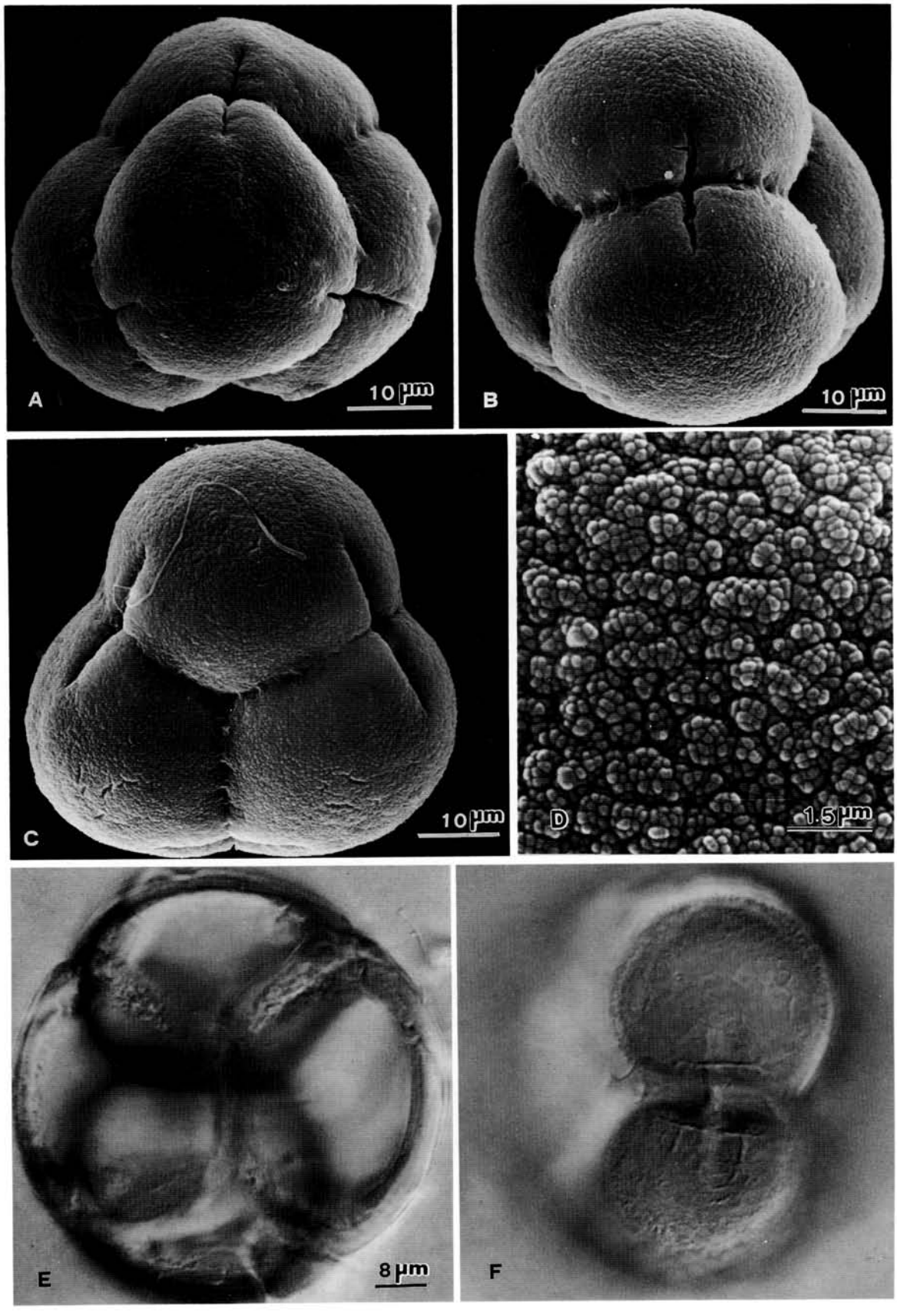

Plate 23. A-F: *Rhododendron formosanum* Hemsl. A-D, SEM; E & F, LM. A, tetrahedral tetrad grains in polar view. B, C, E & F, tetrads in equatorial view showing cracking in middle of mesocolpia and viscin strands. D, detail of compactly verrucate sexine showing verrucae distributed in cluster.

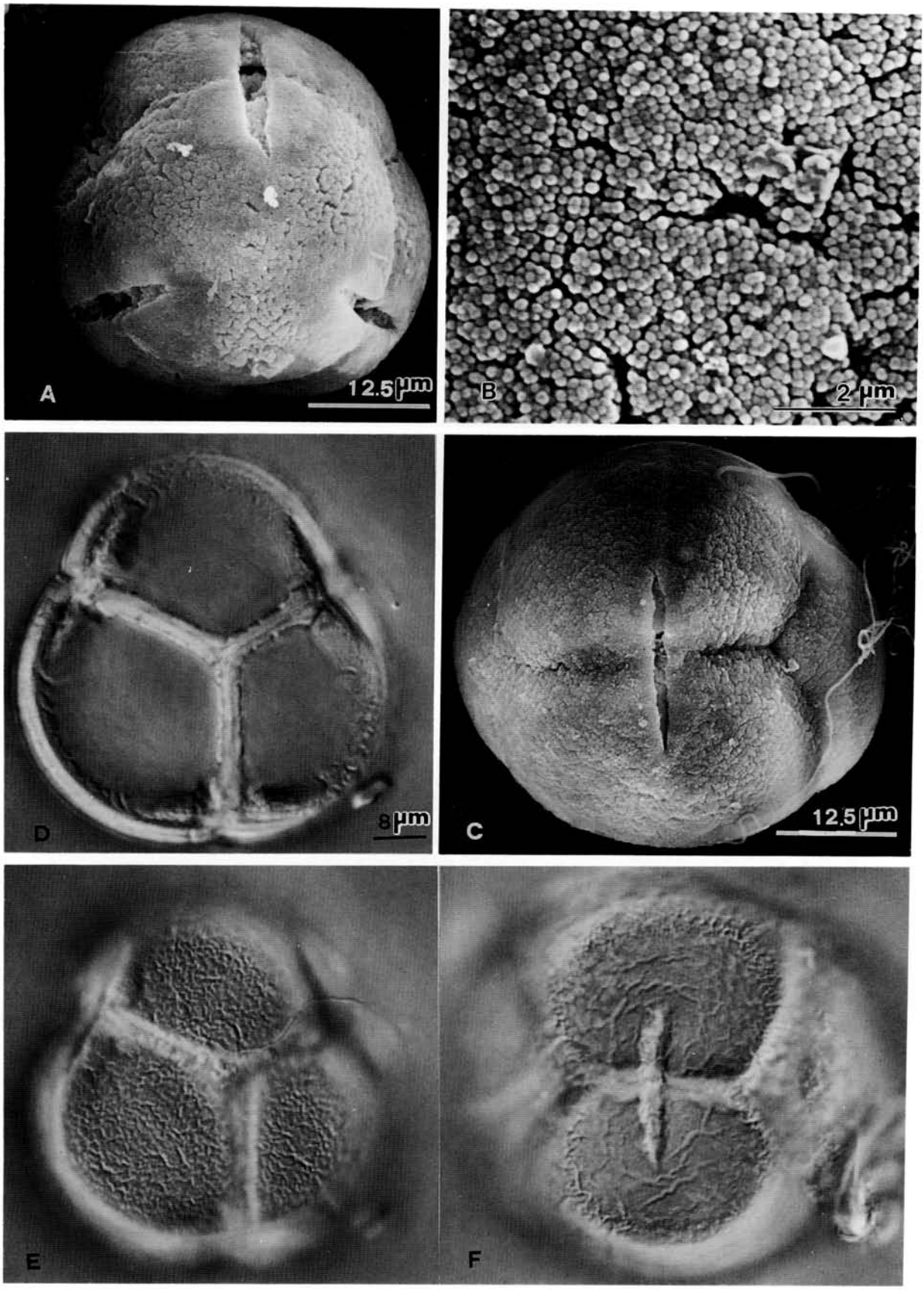

Plate 24. A-F: *Rhododendron mariesii* Hemsl. & Wilson. A-C, SEM; D-F, LM. A, D & E, tetrahedral tetrad grains in polar view. B, detail of compactly verrucate sexine showing verrucae distributed in cluster. C & F, tetrads in equatorial view showing conspicuous cracking in middle of mesocolpia.

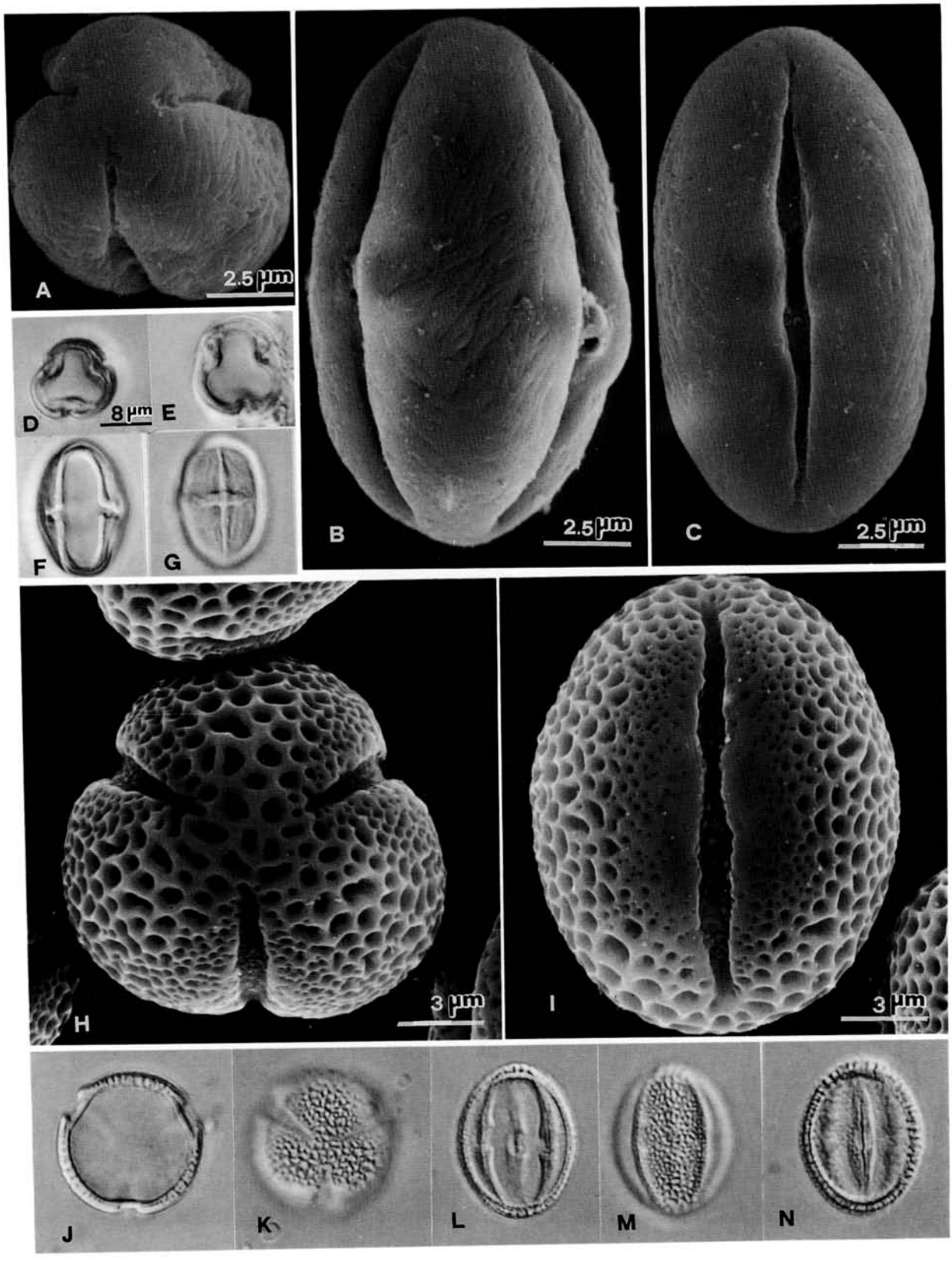

Plate 25. A-G: *Pasania kawakamii* (Hayata) Schott. A-C, SEM; D-G, LM. A, D & E, 3-colporate grains in polar view. B, C, F & G, grains in equatorial view showing striato-rugulate sexine and transversally parallel os in G. H-N: *Idesia polycarpa* Maxim. H & I, SEM; J-N, LM. H, J & K, 3-colporate grains in polar view showing reticulate sexine. I & L-N, grains in equatorial view showing granulate colpus membrane and lumina decreasing in size near colpi in I and circular os in L.

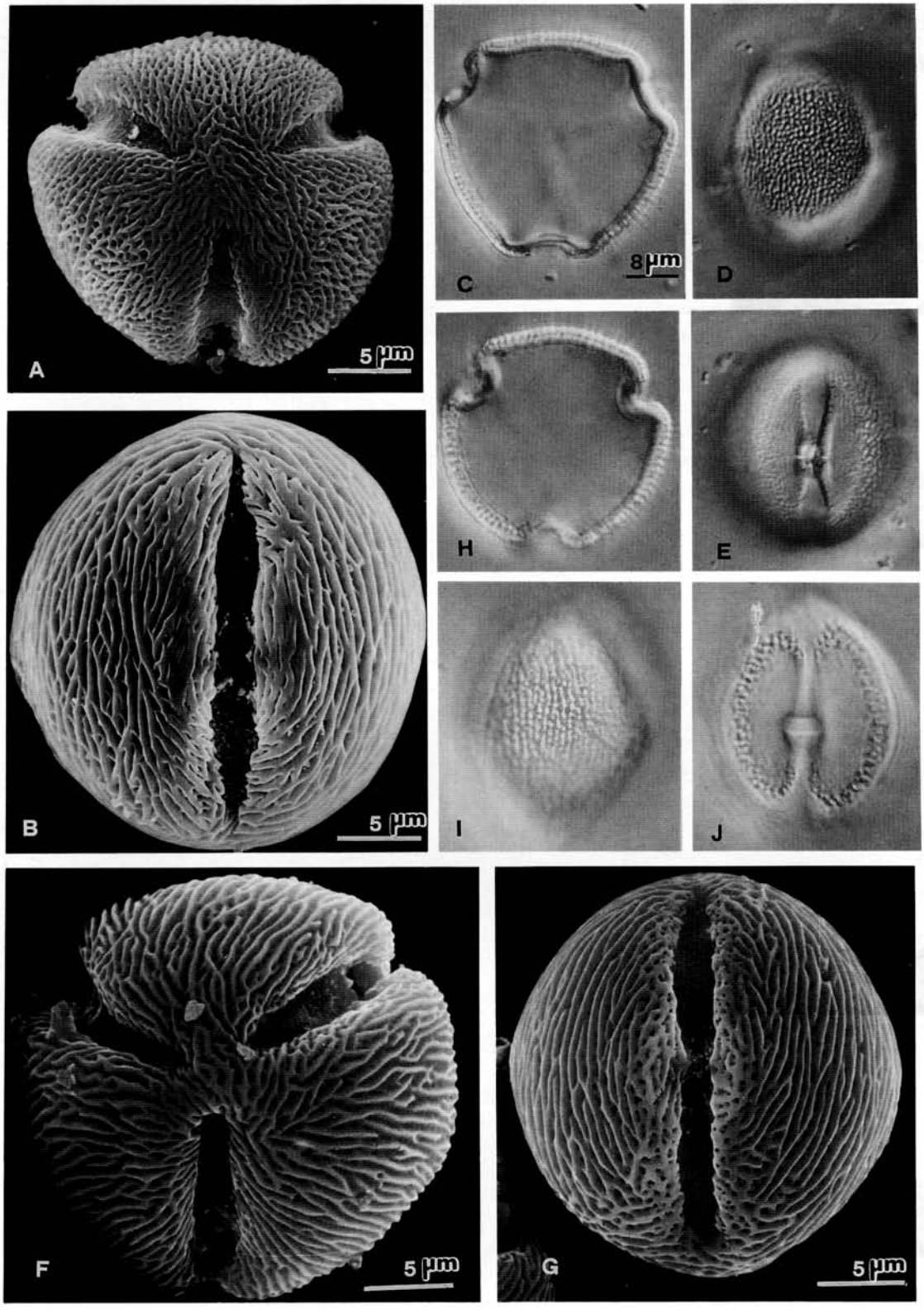

Plate 26. A-E: *Gentiana atkinsonii* Burk. var. *formosana* (Hayata) Yamamoto. A & B, SEM; C-E, LM. A & C, 3-colporate grains in polar view showing reticulato-striate sexine in A. B, D & E, grains in equatorial view showing circular os and granulate colpus membrane. F-J: *Gentiana flavo-maculata* Hayata. F-G, SEM; H-J, LM. F & H, 3-colporate grains in polar view showing reticulato-striate sexine. G, I & J, grains in equatorial view showing circular os and scabrate colpus membrane.

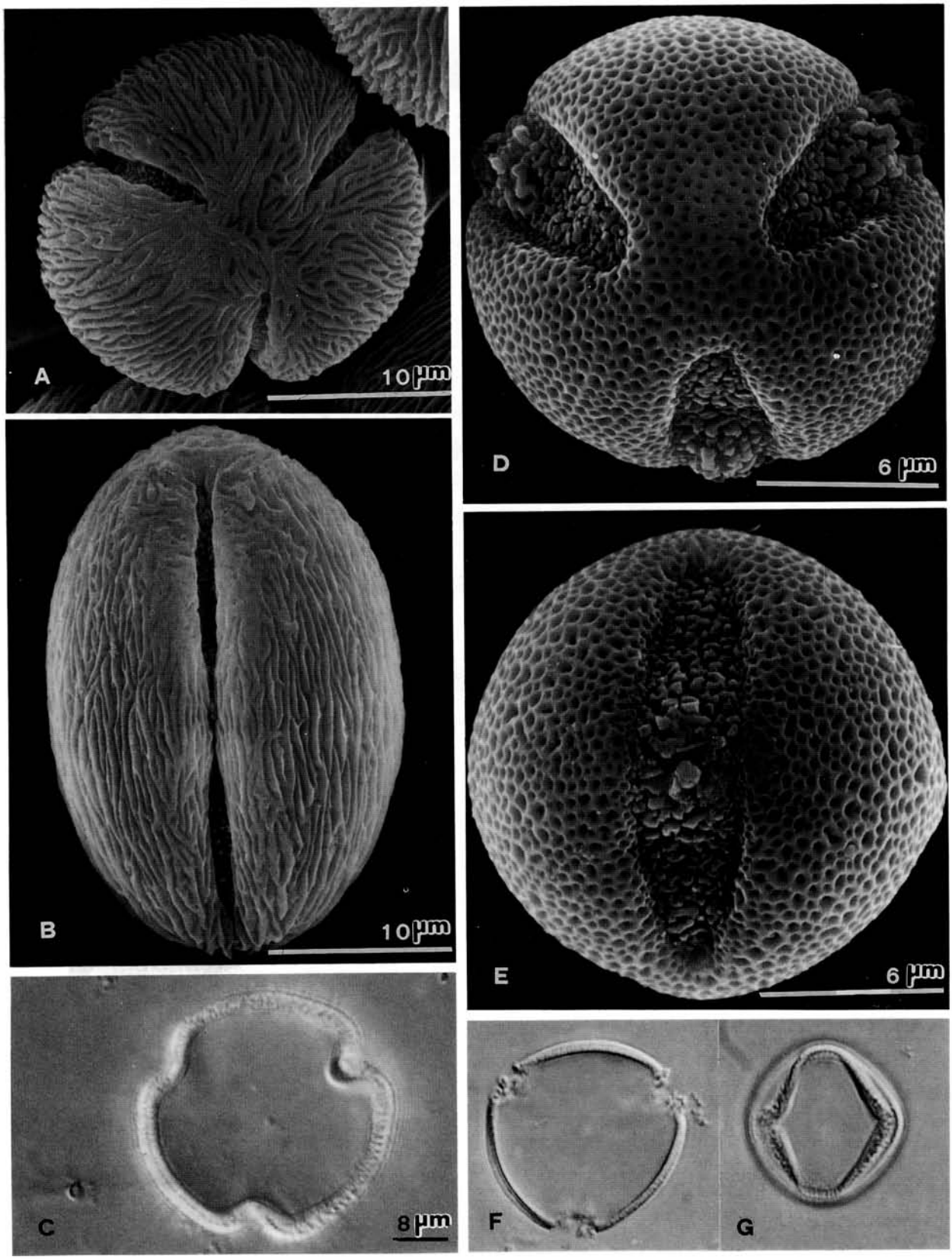

Plate 27. A-C: *Tripterospermum lanceolatum* (Hayata) Hara ex Satake. A & B, SEM; C, LM. A & C, 3-colporate grains in polar view showing striate sexine. B, grain in equatorial view showing colpus constricted at equator and granulate colpus membrane. D-G: *Hemiboea bicornuta* (Hayata) Ohwi. D & E, SEM; F & G, LM. D & F. 3-colporate grains in polar view showing reticulate sexine. E & G, grains in equatorial view showing rugulate colpus membrane in E.

台灣鴛鴦湖自然保留區花粉誌（I）

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（收稿日期：1999 年 2 月 8 日；接受日期：1999 年 2 月 26 日）

摘　　要

鴛鴦湖為酸性湖泊，位於台灣北部之自然保留區內。此湖泊周圍山地生長了台灣重要的植物—紅檜和台灣扁柏，湖積物因此成為研究紅檜和台灣扁柏植株之消長的良好材料。本研究採集該區隸屬於三十科五十種植物的新鮮花粉，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，分為十一群：具氣囊、薄孔、三至六孔、多孔、螺旋孔、窗型、三溝、四至七溝、三溝孔、異溝孔、和四分粒具三溝孔的花粉。這些結果可做為研究鴛鴦湖湖積物內之花粉，並進而探討湖泊周圍植被變遷之先驅資料。

關鍵詞：花粉誌、花粉形態、鴛鴦湖自然保留區、台灣。

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