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Pollen morphology of some rainforest taxa occurring in the Illawarra region of New South Wales, Australia

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Abstract

Pollen morphological descriptions and photographic illustrations based on light microscope analyses are provided for over 60 angiosperm taxa that occur in rainforest and wet sclerophyll forest communities in the Illawarra region of New South Wales. The resulting pollen taxonomy contributes to the study of Holocene mesotherm rainforest floras in coastal and tableland New South Wales and, because many species are or will have been shared with other vegetation types in the past, also to the floras of other botanical regions. Taxonomic relationships assessed on pollen morphology are discussed for several taxa.

Introduction

Pollen representing over 60 taxa occurring in rainforests and wet sclerophyll forests in the Illawarra region, including the Robertson–Moss Vale plateau and the Illawarra escarpment and coastal plain, were investigated and described. The aim was to assist the identification of pollen types found in moss/lichen cushions used in modern pollen rain studies (Kodela 1990a, b) and in swamp deposits investigating vegetation history of the region (Kodela 1992, 1996). Due to the under-representation of many rainforest taxa by their pollen it was important to be able to identify as many rainforest pollen types as possible in order to investigate the history and dynamics of the rainforest vegetation in the region. The morphological descriptions and illustrations will also be available for use in pollen flora keys, atlases and taxonomic studies. This study contributes to both neobotanical taxonomy and rainforest palaeoecology.

Methods

Modern reference pollen was obtained from flowers of plant specimens collected in the field or from herbarium material. Plant specimen vouchers are housed in the John T. Waterhouse Herbarium at the University of New South Wales (UNSW). The taxa investigated occur in the Illawarra region of New South Wales, however, the reference

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pollen representing these taxa have often been extracted from plant specimens collected from elsewhere in the State. An exception is *Cyclophyllum protractum*, which is a species occurring in northeastern Queensland.

Flowers or mainly just the anthers underwent standard hydroxide, acetolysis and alcohol dehydration treatments prior to mounting in silicone oil (Faegri & Iversen 1975, Moore & Webb 1978). Pollen morphological descriptions are based on features recognised at 500× and sometimes 1250× magnifications using a Wild Heerbrugg light microscope. Photographs of pollen grains were taken mainly at 500× magnification. Terminology used in the pollen descriptions follows Erdtman (1966, 1969), Faegri and Iversen (1975), Moore and Webb (1978) and Boyd (1992). Features characteristic of Myrtaceae pollen are also provided by Chalson and Martin (1995). A useful glossary of palynological terms is available on the web (Hoen et al. 1999). Nomenclature follows the *New South Wales FloraOnline* (http://plantnet.rbgsyd.nsw.gov.au/floraonline.htm).

A limitation of light microscope (LM) observations is the level of detail discernable for pollen grain surface sculpture and other features; detail that is available from SEM or TEM and often required for taxonomic studies. With LM it is often difficult to distinguish micro-projections versus micro-pits, and therefore define a sculpturing type. Ornamentation may not only be less distinct under LM but can appear different to the type of sculpture revealed by SEM analyses.

Features used in the pollen descriptions

Symmetry

Symmetric pollen grains may be radially symmetric (= radiosymmetric, with more than two vertical planes of symmetry and the equatorial axes equilong) or bilateral (with only two vertical planes of symmetry and the equatorial axes not equilong) (Erdtman 1966). Asymmetric grains are either fixiform or nonfixiform (without fixed shape).

Size

The size of pollen grains for a taxon may vary naturally, i.e. within flowers or between individual plants. Size may also be affected by the means of preservation, chemical treatments or the degree of pollen maturity. Impact of the mounting medium on size can be considerable, for example, grains mounted in silicon oil may be up to one third smaller than equivalent grains mounted in glycerol jelly (Drs A.H.R. Martin, formerly of University of Sydney, & M.K. Macphail, Australian National University, pers. comm.). Pollen grains tend to swell over time in the latter medium.

For radiosymmetric pollen types a minimum of 30 grains were measured for each taxon to calculate mean lengths and standard deviations of both the polar and equatorial axes. The longest axis was measured for most other pollen types. Qualitative descriptions for size follow Erdtman (1966) and are based on the length of the longest axis, not including appendages such as spines, i.e. very small: < 10 μm, small: 10–25 μm, medium: 25–50 μm, large: 50–100 μm, very large: 100–200 μm.

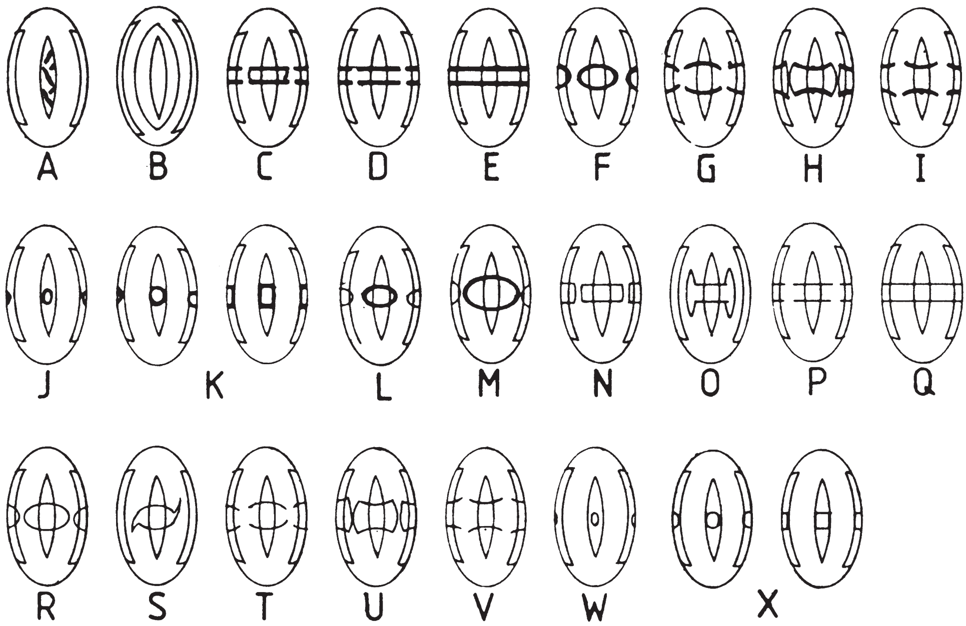

Fig. 1. Line illustrations of pollen grain apertures in equatorial view (from El Ghazali 1990)

A, endoapertures with endocracks; **B**, endoapertures meridionally elongated; **C**, endoapertures with parallel transverse costae, meridional edges encircling; **D**, endoapertures with parallel transverse costae, meridional edges lacking or indistinct; **E**, pollen grains with costae equatorialis; **F**, endoapertures with converging transverse costae, meridional edges encircling; **G**, endoapertures with converging transverse costae, meridional edges lacking or indistinct; **H**, endoapertures with diverging transverse costae, meridional edges encircling; **I**, endoapertures with diverging transverse costae, meridional edges lacking or indistinct; **J**, endoapertures with closed costae, diameter of endoapertures less than the width of the ectoapertures; **K**, endoapertures with closed costae, diameter of endoapertures ± equal to the width of the ectoapertures; **L**, endoapertures with closed costae, diameter of endoapertures broader than the width of the ectoapertures, length of endoapertures ≤ ½ the length of the ectoapertures; **M**, endoapertures with closed costae, diameter of endoapertures broader than the width of the ectoapertures, length of the endoapertures ≥ ⅔ the length of the ectoapertures; **N**, endoapertures with transverse parallel edges, meridional edges encircling, endoapertures rectangular; **O**, endoapertures with transverse parallel edges, meridional edges encircling, endoapertures H-shaped; **P**, endoapertures with transverse parallel edges, meridional edges lacking or indistinct; **Q**, pollen grains with colpus transversalis equatorialis; **R**, endoapertures with transverse converging edges, meridional edges encircling, without horns; **S**, endoapertures with transverse converging edges, meridional edges encircling, with horns; **T**, endoapertures with transverse converging edges, meridional edges lacking or indistinct; **U**, endoapertures with transverse diverging edges, meridional edges encircling; **V**, endoapertures with transverse diverging edges, meridional edges lacking or indistinct; **W**, endoapertures with closed edges, diameter of endoapertures less than the width of the ectoapertures; **X**, endoapertures with closed edges, diameter of endoapertures ± equal to the width of the ectoapertures.

Shape

The shapes of the polar and equatorial views of radiosymmetric tricolp(or)ate grains are described mainly following the scheme of Kuyl et al. (1955; see Fig. 1 in Faegri & Iversen 1975, p. 20). In prolate grains the polar axis (i.e. the axis of rotation) is greater than the equatorial axis while in oblate grains the equatorial axis is the longer axis. In spherical pollen grains both axes are ± equal. Radiosymmetric pollen grains described as oblate to prolate oval include spherical shapes. The above terms can be further divided according to the degree of eccentricity (ratio of polar axis length to equatorial axis length) (see Erdtman 1966), however this was not attempted given the variability of many taxa and the information already provided by the quantitative size data.

The term 'apiculate' is used to define pollen grains with somewhat abruptly and slightly protruding polar caps as illustrated by Kuyl et al. (loc. cit.), rather than other common uses of the term to refer to ending abruptly with a distinct, short, sharply pointed tip or having small pointed projections (= minutely echinate). 'Amb' refers to the outline shape of a grain in polar view.

Apertures

Pollen grains without apertures are referred to as inaperturate (= non-aperturate), while the terms pore, colpus and sulcus are used mostly in this study when describing apertures in aperturate grains. Colpi are elongated apertures (or furrows) where the length/breadth ratio is greater than two. A sulcus is another type of furrow and has the same general shape as a colpus, but differs in orientation, being an essentially latitudinal aperture situated at the distal or proximal pole whereas colpi are essentially longitudinal apertures (Hoen et al. 1999). Apertures are described by their position (polar, equatorial, global), shape, structure, size and number. The system described by Erdtman (1966) in which pores and furrows are differentiated according to their distribution and position was not applied here.

In radiosymmetric pollen grains apertures are normally arranged equally distanced around the equator, i.e. equidistantly and meridionally if colpi are present (Moore & Webb 1978). Pores are described as lalongate when they are equatorially (= transversely) elongated or lolongate when longitudinally (= meridionally) elongated. When two or more colpi meet at the poles the pollen grains are described as syncolpate. In some of the pollen descriptions endoapertures (often = pores) are defined using the coded letters from the scheme of El Ghazali (1990, p. 229; see Fig. 1). The term 'annulus' (adj. annulate) is used to refer to an area of the exine surrounding a pore that is sharply differentiated from the remainder of the exine, either in ornamentation or thickness (Hoen et al. 1999). When it is a thickening of the nexine bordering the pore it is called a costa.

Exine stratification

The exine refers to the chemically resistant outer layer of the wall of pollen and spores, and is primarily composed of sporopollenin. Various terms have been used to define the layers that make up the exine. Following Erdtman (1966), the inner, non-sculptured layer is the nexine lying below the outer, usually sculptured sexine. The sexine is usually stratified, consisting of sculpture elements on the outer surface of a layer called the tectum which overlies a layer of columellae (rod-like elements supporting the tectum) or a combination of these three layers. Layers in the sexine, such as the tectum, may be complete (continuous), partially present (discontinuous) or completely absent, resulting in characteristic surface patterns (sculpturing types). When a columellae layer is present the exine can be described as columellate. Further terms relating to the exine are defined within the text where they are relevant.

Sculpturing types (Ornamentation)

Differences in the exine structure, in the way various layers are structured and the elements arranged, are responsible for the different types of sculpture or ornamentation seen in pollen grains. The main terms used in this study to describe exine surface sculpturing follow Faegri and Iversen (1975) and Moore and Webb (1978) and include smooth or psilate, perforate (surface pitted with holes < 1 µm diam.), granulate or scabrate, striate, rugulate and reticulate ornamentation. Reticula are further defined as fine, medium or coarse when the lumina (i.e. the spaces between the muri or walls) are < 1 µm, 1–2 µm or > 2 µm wide, respectively. The ornamentation is microreticulate when the muri and lumina are smaller than 1 µm.

When pollen grains have projections or spines these may be: rod-shaped where the elements are of even thickness and longer than broad (baculate); wart-like where the elements are equal or broader than high and not constricted at the base (verrucate); club-shaped where the elements are longer than broad and narrowed towards their base (clavate); drumstick-shaped with a short shaft and swollen top (pilate); short, globular and basally constricted (gemmate); or sharply pointed (echinate). Echinae are referred to as spinules when they are ≤ 3 µm long or spines when > 3 µm long.

Results

Pollen descriptions are provided in alphabetical order by family, genus and species. Features that are less common and may represent extremes of range are given in brackets. Exine sculpturing types are based mainly on appearance under LM. Key to abbreviations: S = qualitative size based on longest axis; EV = shape in equatorial view; PV = shape in polar view; σ = one standard deviation; *n* = sample number of pollen grains measured.

Adoxaceae

Sambucus australasica (Lindl.) Fritsch Fig. 2a

(2)3-colporate, isopolar, radiosymmetric. S: small (to medium); EV (oblate to) prolate oval; PV circular to inter-hexagonal, colpi intruding to open; colpi constricted equatorially, the pores inconspicuous, slightly protruding; exine 0.5–0.8(–1) µm thick, finely reticulate. Polar axis, mean value: 20.1 µm, σ = 1.5 µm, range 18.0–21.6(–25.2) µm; equatorial axis, mean value: 18.9 µm, σ = 1.5 µm, range 17.4–20.4(–25.2) µm; *n* = 31.

Voucher: Mt Keira near Scout Camp, 15 May 1975, *Howard & Quinn* (UNSW5325).

Note: *Sambucus* is sometimes placed in the family Caprifoliaceae or Sambucaceae.

Anacardiaceae

Euroschinus falcatus Hook.f. Fig. 2b

3-colporate, isopolar, radiosymmetric. S: medium; EV prolate oval; PV semi-angular to circular, colpi open; apertures with ragged margins, endoapertures D (or G), the pores lalongate, ± oblong, usually exceeding the colpi rims, 3–5(–8.4) µm long, 7.2–12 µm wide; colpi maintain ± even width until reaching polar areas where they have obtuse, often poorly defined apices, the colpus membrane ± smooth; exine < 1.5 µm thick at equator, slightly thicker (i.e. 2–2.5 µm) at poles, 2.4–3.6 µm thick at pores, distinctly columellate, with a medium reticulum becoming slightly coarser at poles. Polar axis, mean value: 30.1 µm, σ = 1.5 µm, range (26.4–)28.8–32.4 µm; equatorial axis, mean value: 25.7 µm, σ = 1.8 µm, range 22.8–28.8 µm; *n* = 30.

Voucher: Treachery Headland, 6 Dec 1983, *Adam* (UNSW16403).

Aphanopetalaceae

Aphanopetalum resinosum Endl. Fig. 2c

(2)3-colpor(oid)ate (often appears tricolpate due to poorly defined pores), isopolar, radiosymmetric; S: small; EV (oblate to) prolate oval; PV semi-angular with convex sides to ± circular, colpi open; endoapertures X_l (or W), pores ± indistinct, the colpi slightly constricted at equator; exine 0.8–1 µm thick, smooth to faintly or vaguely granulate-rugulate. Polar axis, mean value: 19.6 µm, σ =1.1 µm, range 17.4–21.6 µm; equatorial axis, mean value: 17.0 µm, σ = 1.1 µm, range (13.8–)15.6–19.2 µm; *n* = 32.

Voucher: behind Oaky Beach, 24 Nov 1983, *Więcek & Stricker* (UNSW15520).

Polar axis, mean value: 17.4 µm, σ = 1.4 µm, range (13.8–)15.6–19.2 µm; equatorial axis, mean value: 15.1 µm, σ = 1.1 µm, range 12.0–17.4 µm; *n* = 30.

Voucher: Tantawangalo State Forest, near Bega, Oct 1987, *Kodela* (UNSW).

Notes: *Aphanopetalum* was previously placed in Cunoniaceae. The larger, usually 3-colporate pollen of *A. resinosum* differs from the small to very small, 2-colporate pollen of Cunoniaceae species examined in this study. This finding supports anatomical and molecular studies which excluded *Aphanopetalum* from Cunoniaceae (Dickison et al. 1994, Bradford & Barnes 2001, Fishbein et al. 2001, Hilu et al. 2003).

Apocynaceae

Parsonsia brownii (Britten) Pichon Fig. 2d

(2)3(4)-porate, apolar. S: small to medium; shape spheroidal to ellipsoidal; pores ± circular to elliptical, annulate with a raised rim-like border, the annuli c. 1 µm wide and often fragmented, the orifice (2.4–)3.6–6.6(–7.2) µm in diam.; exine 0.6–0.9 µm thick, 1.8–2.4(–3) µm thick around pores, smooth or often finely wrinkled. Longest axis, mean value: 28.9 µm, σ = 3.1 µm, range (16.8–)21.6–34.2(–36.0) µm; *n* = 60.

Voucher: near Wingecarribee Swamp, Robertson, 10 Feb 1986, *Kodela* (UNSW).

Notes: an obscure shallow surface pattern appears at higher magnifications. See also Sampson and Anusarnsunthorn (1990).

Parsonsia straminea (R.Br.) F.Muell. Fig. 2e

3- or 4-porate, occasionally with 5 or 6 pores, apolar. S: medium; shape spheroidal to ellipsoidal; pores ± circular to elliptical, annulate, the annuli usually fragmented and with irregular outline, the orifice 2.4–6.6 µm in diam.; exine 0.5–0.8 µm thick, 1.8–2.4(–3) µm thick at pores, almost smooth, appearing finely wrinkled especially at higher magnification when the surface may appear vaguely granulate to shallowly rugulate. Longest axis, mean value: 32.7 µm, σ = 3.5 µm, range 26.4–40.2 µm; n = 30.

Notes: pollen sample from Minnamurra Estuary (no voucher). Smaller, 17.4–25.2 µm diam., 2- or 3-porate, darker, possibly immature grains were observed. See also Sampson and Anusarnsunthorn (1990).

Araceae

Gymnostachys anceps R.Br. Fig. 3a

1-sulcate (= monosulcate). S: small to medium; shape variable, ± boat-shaped to ellipsoidal; sulcus with ragged margins; exine 0.8–1 µm thick, minutely and distinctly reticulate, becoming finer near sulcus margins. Polar axis, mean value: 18.3 µm, σ = 2.4 µm, range (13.2–)15.6–21.6(–24.0) µm; longitudinal equatorial axis (following furrow), mean value: 25.6 µm, σ = 2.1 µm, range (20.4–)24.0–27.6(–31.2) µm; n = 30.

Voucher: Bola Creek, Royal National Park, 27 Mar 1958, *Evans & Blaxell* (UNSW).

Bignoniaceae

Pandorea pandorana (Andrews) Steenis Fig. 3b

(2)3-colpate, isopolar, radiosymmetric. S: medium; EV oblate to prolate oval; PV circular to rounded inter-hexagonal, colpi open; colpi high on the poles with acute apices almost meeting, mostly 2.5–7(–12) µm wide at equator, colpus membrane often with ladder-like arrangement of rupture patterns (i.e. endoapertures with endocracks = A in Fig. 1); exine 0.8–1.3(–1.5) µm thick, with distinct medium reticulum, becoming finer towards colpi. Polar axis, mean value: 28.4 µm, σ = 1.6 µm, range 25.2–30.6(–33.6) µm; equatorial axis, mean value: 27.4 µm, σ = 2.1 µm, range 22.8–30.0(–32.4) µm; n = 39.

Voucher: North Wilson Camp, Mount Boss State Forest, 26 Aug 1975, *Waterhouse* (UNSW4444).

Notes: abnormal, syncolpate (mostly 2-colpate) grains were observed. See also Suryakanta (1973, *n.v.*), Buurman (1977) and James and Knox (1993).

Boraginaceae

Ehretia acuminata R.Br. Fig. 3c

3(4)-colporate, isopolar, radiosymmetric. S: small; EV spherical to slightly oblate or prolate oval; PV inter-hexagonal with ± straight to slightly convex or sometimes concave sides; aperture margins ragged, the pores lalongate, conspicuous when elliptical or may be indeterminable where constriction of colpus occurs at the equator; exine c. 1 µm thick, with fine to medium reticulum. Polar axis, mean value: 20.8 µm,

σ = 1.5 µm, range 18.0–24.0 µm; equatorial axis, mean value: 19.9 µm, σ = 2.1 µm, range (10.8–)18.0–23.4 µm; *n* = 31.

Voucher: Dyke Forest on the Dyke River, Kempsey–Armidale road, 14 Nov 1978, *Hindmarsh & Waterhouse* (UNSW8036).

Note: *Ehretia* is sometimes placed in the family Ehretiaceae.

Celastraceae

Celastrus australis Harv. & F.Muell. Fig. 3d

(2)3(4)-colporate, isopolar, radiosymmetric. S: small to medium; EV oblate to prolate oval; PV circular, colpi open; endoapertures K_1, the pores conspicuous, mostly confined within the margins of colpi, lalongate, ± elliptical, 1.5–3(–3.6) µm long, 3.1–4.2(–5) µm wide, the colpi tapering with conspicuous margins to acute or obtuse apices, the colpus membrane ± smooth; exine 1.3–1.8 µm thick, sometimes thicker (to 2.6 µm) at the poles, distinctly columellate, with a distinct fine to medium reticulum, becoming finer near colpi. Polar axis, mean value: 22.4 µm, σ = 2.4 µm, range (18.0–)20.4–24.0(–31.8) µm; equatorial axis, mean value: 21.7 µm, σ = 2.5 µm, range 18.0–24.0(–30.0) µm; *n* = 30.

Voucher: 3.5 km S of Albion Park on the road to Jamberoo, 23 Nov 1982, *Hindmarsh & Waterhouse* (UNSW11583).

Polar axis, mean value: 18.8 µm, σ = 1.5 µm, range 16.2–21.6 µm; equatorial axis, mean value: 19.1 µm, σ = 1.8 µm, range (14.4–)16.2–21.6(–23.4) µm; *n* = 30.

Voucher: downhill of 'Sunny View', S of East Kangaloon, 17 Nov 1987, *Kodela* (UNSW).

Cunoniaceae

Ceratopetalum apetalum D.Don Fig. 4a

2-colporate, isopolar, bilateral. S: very small to small; shape ± ellipsoidal with an encircling groove where longitudinal colpi intrude; pores minute, inconspicuous, mostly defined by small protrusions at the equator; colpi almost meet at poles; exine 0.5–0.6 µm thick, finely reticulate (to rugulate), smooth near colpi. Longest axis, mean value: 9.9 µm, σ = 1.1 µm, range 8.4–12.0 µm; *n* = 30.

Voucher: Rocky Ck Crossing, Gordon, 17 Nov 1977, *Waterhouse* (UNSW5076).

Notes: *Ceratopetalum* has very similar pollen to *Bauera* species (formerly in Baueraceae), *Callicoma serratifolia*, *Eucryphia moorei* (formerly in Eucryphiaceae) and *Schizomeria ovata*. Pollen morphology supports a phylogenetic study of molecular and morphological data by Bradford and Barnes (2001) which places these genera together in Cunoniaceae.

Eucryphia moorei F.Muell. Fig. 4b

2-colp(or)ate, isopolar, bilateral. S: very small; shape ± ellipsoidal with narrow grooves where longitudinal colpi intrude, the colpi almost meeting at the poles, with some grains appearing ± syncolpate, the pores minute, inconspicuous, absent or appear as very slight protrusions; exine c. 0.5 μm thick, very finely reticulate, the pattern disappearing towards the colpi. Longest axis, mean value: 6.7 μm, σ = 0.4 μm, range 6–7.8 μm; n = 52.

Voucher: Milo Rd, via Milo via Princes Hwy, Ulladulla/Batemans Bay, 18 May 1983, *Bruhl & Wood* (UNSW14737).

Notes: the pollen of *Eucryphia moorei* is relatively smaller with more obscure pores and surface ornamentation than *Ceratopetalum apetalum* pollen. Pollen morphology is consistent with molecular studies (Bradford & Barnes 2001) which place *Eucryphia* in Cunoniaceae rather than Eucryphiaceae.

Schizomeria ovata D.Don Fig. 4c

2-colporate, isopolar, bilateral. S: very small to small; shape ± ellipsoidal with longitudinal grooves where colpi intrude; pores distinctly protrude at the equator, oblong or irregularly shaped when open, to 2 μm long; colpi taper and almost meet at poles, the colpus membrane smooth; exine c. 0.5 μm thick, finely reticulate (to rugulate), becoming obscure and then smooth before reaching the colpi margins. Longest axis, mean value: 9.8 μm, σ = 0.6 μm, range 8.4–11.4 μm; n = 30.

Voucher: Dog Trap Rd, 8.9 km E from Central Mangrove road, 8 Nov 1978, *Waterhouse & Quinn* (UNSW7874).

Note: the pores and surface ornamentation in pollen of *Schizomeria ovata* are more pronounced than in *Ceratopetalum apetalum.*

Dilleniaceae

Hibbertia scandens (Willd.) Gilg Fig. 4d

3-colporate, isopolar, radiosymmetric. S: small; EV (oblate to) prolate oval; PV circular, colpi open; endoapertures ± X_2, the pores lolongate, oblong to narrowly oblong, not exceeding margins of the colpi, (4–)6–11 μm long, 2–6 μm wide, open or with a rough membrane; colpi with ragged margins, ± smooth membrane except where pores occur, tapering to acute apices; exine 1.3–1.5 μm thick, distinctly columellate, with a fine (to medium) reticulum. Polar axis, mean value: 17.9 μm, σ = 1.2 μm, range 15.6–20.4 μm; equatorial axis, mean value: 16.3 μm, σ = 0.9 μm, range 14.4–18.6 μm; n = 32.

Voucher: Liguria Street, Lurline Bay, Coogee, 3 Nov 1981, *Francis & Więcek* (UNSW12730).

Polar axis, mean value: 19.6 μm, σ = 1.1 μm, range 16.8–22.2 μm; equatorial axis, mean value: 18.6 μm, σ = 2.2 μm, range 15.0–24.0 μm; n = 35.

Voucher: Robertson Cemetery, 9 Feb 1988, *Kodela* (UNSW).

Note: the pore length:width ratio varies, often being 2:1, 3:1 or 4:1 and ratios intermediate between these.

Ebenaceae

Diospyros australis (R.Br.) Hiern. Fig. 4e

3-colporate, isopolar, radiosymmetric. S: medium; EV prolate oval; PV circular to rounded inter-hexagonal, colpi open; endoapertures D, the pores lalongate, exceeding margins of the colpi; colpi narrow, with granulate membrane, the margins and apices distinct; exine c. 1 μm thick (1.2–2.4 μm thick at pores), smooth to minutely scabrate. Polar axis, mean value: 36.9 μm, σ = 2.0 μm, range 33.0–40.8 μm; equatorial axis, mean value: 29.7 μm, σ = 1.3 μm, range 27.0–32.4 μm; *n* = 31.

Voucher: Mungo Brush, 20 Jan 1977, *Hindmarsh & Waterhouse* (UNSW6404).

Elaeocarpaceae

Elaeocarpus reticulatus Sm. Fig. 4f

3-colporate, isopolar, radiosymmetric. S: very small to small; EV prolate oval to almost circular; PV circular, colpi intruding; pores minute, slightly protruding; exine c. 0.5 μm thick, smooth. Polar axis, mean value: 8.7 μm, σ = 0.8 μm, range 7.2–10.2 μm; equatorial axis, mean value: 7.9 μm, σ = 0.5 μm, range 7.2–9.6 μm; *n* = 35.

Voucher: Hotel Ck Rd, Wallingat State Forest, 5 Dec 1981, *Francis & Więcek* (UNSW12750).

Euphorbiaceae

Baloghia inophylla (G.Forst.) P.S.Green Fig. 4g
(syn. *Baloghia lucida* Endl.)

Inaperturate, apolar. S: medium; shape ± spheroidal to ellipsoidal; exine 2–2.6 μm thick; very coarsely reticulate with the 'croton pattern', which is described by Erdtman (1966, p. 173) and Lieux (1983, p. 345). Longest axis, mean value: 33.0 μm, σ = 2.6 μm; range 27.6–37.2 μm; *n* = 37.

Voucher: Fountaindale Rd, on Saddleback Mountain, 25 Jan 1978, *Hindmarsh & Waterhouse* (UNSW7697b).

Breynia oblongifolia Muell.Arg. Fig. 5a

8-colpate with 1 or 2 pores in each colpus (occasionally 3 or no pores in some colpi). S: small; EV slightly oblate oval; PV circular, colpi slightly intruding; endoapertures L, the pores annulate, ± circular with an orifice c. 1.5 μm in diam., often arranged irregularly and not located on equator, annuli smooth, the colpi ± closed, with distinct margins; exine 1.3–1.5 μm thick, with a distinct medium reticulum. Polar axis, mean value: 20.2 μm, σ = 0.7 μm, range 19.2–21.6 μm; equatorial axis, mean value: 21.7 μm, σ = 0.8 μm, range 20.4–23.4 μm; *n* = 30.

Voucher: Diamond Hill, at the junction of Blue Gum and Little Wheeney Creeks, Kurrajong, 13 Nov 1978, *Quinn* (UNSW7767).

Note: pollen of *Breynia* and related genera in Euphorbiaceae are described by Sagun and van der Ham (2003).

Homalanthus populifolius Graham Fig. 5b
(syn. *Omalanthus populifolius* Graham)

3-colporate, isopolar, radiosymmetric. S: medium; EV oblate to prolate oval, often ± spherical; PV inter-subangular, colpi intruding to open; endoapertures D, the pores lalongate, oblong or elliptical, 1.8–3.6 μm long, 8.4–12.6 μm wide, the colpi narrow, tapering to pointed apices; exine 2–2.6 μm thick, usually thicker (to 3.1 μm) at the poles, finely reticulate (to rugulate). Polar axis, mean value: 33.0 μm, σ = 1.5 μm, range 29.4–36.0 μm; equatorial axis, mean value: 32.8 μm, σ = 1.5 μm, range 30.0–36.0 μm; n = 34.

Voucher: Scarborough Beach, 9 Nov 1982, *Więcek & Stricker* (UNSW14160).

Flacourtiaceae

Scolopia braunii (Klotzsch) Sleumer Fig. 5c

3-colporate, isopolar, radiosymmetric. S: small; EV prolate oval; PV circular, colpi intruding to open; endoapertures W, the pores very small, 1–2.5 μm long, indistinct, the colpi equatorially constricted; exine c. 1 μm thick, with a very fine reticulum. Polar axis, mean value: 17.1 μm, σ = 1.2 μm, range 14.4–19.8 μm; equatorial axis, mean value: 12.0 μm, σ = 1.0 μm, range 10.2–13.8 μm; n = 42.

Voucher: Cape Hawke, 7 Dec 1981, *Waterhouse & Quinn* (UNSW12839).

Lauraceae

Cryptocarya glaucescens R.Br. Fig. 5d

Inaperturate, apolar. S: small to medium; shape ± spheroidal, often irregularly shaped due to wrinkling and folding, very thin-walled, the exine ≤ 0.5 μm thick, smooth (may appear striated due to wrinkling). Longest axis, mean value 24.1 μm, σ = 2.2 μm, range 19.2–28.8 μm; n = 44.

Voucher: Ourimbah Ck Rd, 9 km from turn-off from Pacific Hwy, 17 Oct 1975, *Waterhouse & Hindmarsh* (UNSW5055a, b).

Note: Sampson (2000) provides a synopsis of Lauraceae pollen.

Cryptocarya microneura Meisn. Fig. 5e

Shape and exine features similar to those of *Cryptocarya glaucescens.* Longest axis, mean value: 28.6 μm, σ = 2.8 μm, range 21.6–34.8 μm; n = 39.

Voucher: Ourimbah Ck Rd, 1.6 km from turn-off, 17 Oct 1975, *Waterhouse & Hindmarsh* (UNSW4475b).

Endiandra sieberi Nees Fig. 5f

Inaperturate, apolar. S: small to medium; shape ± spheroidal to ellipsoidal, often irregularly shaped due to folding; exine < 1 μm thick, the surface echinate with spinules to 1.3 μm but mainly < 1 μm high, smooth between spinules. Longest axis, mean value: 25.4 μm, σ = 3.2 μm, range (16.8–)22.8–31.2 μm; n = 46.

Voucher: Bass Point, 21 Jul 1983, *Adam, Więcek & Stricker* (UNSW15128).

Neolitsea dealbata (R.Br.) Merr. Fig. 5g

Inaperturate, apolar. S: small (to medium); shape spheroidal to ellipsoidal, often folded and/or wrinkled; very thin-walled, the exine c. 0.5–0.8 µm thick, minutely echinate with spinules to c. 1 µm high (sometimes with short baculae). Longest axis, mean value: 20.8 µm, σ = 2.3 µm, range 16.8–25.2 µm; n = 55.

Voucher: Narara Ck, Ourimbah, 22 May 1958, *Evans & Blaxell* (UNSW).

Luzuriagaceae

Eustrephus latifolius R.Br. ex Ker Gawl. Fig. 6a

Trichotomosulcate (the trifid furrow occurring as a 3-armed slit opening on the proximal face), heteropolar. S: small to medium; shape of amb triangular with straight or very slightly concave or convex sides and rounded, obtuse angles that are slightly notched where the furrow intrudes, the distal face rounded convex, the proximal face concave to convex, the trifid furrow often open; exine 0.5–0.6 µm thick, finely reticulate to rugulate-reticulate. Polar axis, mean value: 14.0 µm, σ = 1.4 µm, range 10.8–16.8 µm; equatorial axis, mean value: 24.5 µm, σ = 1.5 µm, range 21.6–27.0 µm; n = 30; base of amb to angle, mean value: 22.5 µm, σ = 1.5 µm, range 19.8–25.8 µm; n = 42.

Voucher: Hotel Ck Rd, 1 km outside Wallingat State Forest, 5 Dec 1981, *Więcek & Francis* (UNSW12752).

Note: *Eustrephus* is sometimes placed in the family Philesiaceae.

Geitonoplesium cymosum (R.Br.) A.Cunn. ex Hook. Fig. 6b

Trichotomosulcate, heteropolar. S: small to medium; shape of amb triangular with straight or slightly convex or concave sides and broadly rounded, obtuse angles that are often slightly notched where the furrow intrudes; trifid furrow often open; exine c. 0.8 µm thick, finely reticulate to rugulate-reticulate. Base of amb to angle, mean value: 21.9 µm, σ = 1.5 µm, range 19.2–24.0 µm; n = 30.

Voucher: Dog Trap Rd, 8.9 km E from Central Mangrove Rd, 13 Oct 1978, *Waterhouse & Hindmarsh* (UNSW7743).

Notes: the pollen surface ornamentation of *Geitonoplesium cymosum* is finer than that of *Eustrephus latifolius.* Erdtman (1966, p. 240) describes pollen from a specimen of *G. cymosum* from New Caledonia as being monosulcate and distinctly reticulate while pollen from an Australian specimen was trichotomosulcate with a ± obscure pattern. The pollen sample investigated in this survey was clearly trichotomosulcate and was distinctly ornamented. *Dianella* pollen grains and the pollen of some other liliaceous taxa (Liliaceae s. lat.) are very similar to Luzuriagaceae pollen. *Geitonoplesium* is sometimes placed in the family Philesiaceae.

Meliaceae

Synoum glandulosum (Sm.) A.Juss. Fig. 6c

4-colporate, isopolar, radiosymmetric. S: medium; EV spherical to slightly prolate oval (sometimes ± depressed oval when the sides are slightly flattened); PV obtuse straight-convex quadrangular (Moore & Webb 1978); endoapertures L or F, the pores lalongate, ± elliptical, exceeding margins of the colpi, 1.8–3 μm long, 4.2–6.6 μm wide, the nexine markedly thickened around pores (i.e. costate), the colpi narrow, with rough margins, not reaching the poles, sometimes diagonal; exine 1–1.5 μm thick (3.6–4.1 μm thick at pores), (smooth to) granulate. Polar axis, mean value: 27.6 μm, σ = 1.5 μm, range 25.2–31.2 μm; equatorial axis, mean value: 26.4 μm, σ = 1.9 μm, range 24.0–31.8 μm; *n* = 31.

Voucher: Scotchman Range, S of Bellingen, 17 Jun 1985, *Kodela & Dodson* (UNSW).

Toona ciliata M.Roem. Fig. 6d
(syn. *T. australis* (F.Muell.) Harms)

(3)4-colporate, isopolar, radiosymmetric. S: small; EV circular to slightly prolate oval (often ± depressed or compressed oval, i.e. poles or sides slightly flattened), rarely oblate; PV circular or broadly rounded quadrangular inter-hexagonal, with colpi intruding to open; endoapertures K or L, the pores often lalongate, circular to elliptical or oblong, within or slightly exceeding width of colpi, 1.2–2.4 μm long, 2.4–3.6(–6) μm wide, distinctly costate, the colpi narrow, tapering to acute or obtuse ends not reaching the poles, the colpus membrane slightly granulate; exine to c. 1 μm thick (1.8–2.0 μm thick at pores), smooth, though slightly granulate near colpi margins. Polar axis, mean value: 21.0 μm, σ = 2.4 μm, range (14.4–)18.0–24.0 μm; equatorial axis, mean value: 20.0 μm, σ = 2.5 μm, range (13.8–)16.8–23.4 μm; *n* = 34.

Voucher: Dykes Forest on the Dyke River, Kempsey to Armidale road, 14 Nov 1978, *Hindmarsh & Waterhouse* (UNSW8037).

Notes: pores may be torn-like (and ragged) when exceeding the colpi margins. *Toona ciliata* pollen differs from *Synoum glandulosum* grains in the polar view being less angled with the apertures intruding more deeply into the angles, as well as generally being smaller and thinner-walled.

Menispermaceae

Legnephora moorei (F.Muell.) Miers Fig. 7a

3(4)-colporate, isopolar, radiosymmetric. S: small; EV prolate oval; PV circular with intruding colpi; pores often slightly lolongate, circular to elliptical, exceeding the ± closed faint colpi, 2–3 μm long, 1–2 μm wide; exine 0.8–1.0 μm thick, distinctly columellate, very finely reticulate. Polar axis, mean value: 17.6 μm, σ = 1.2 μm, range 15.6–19.8(–21.6) μm; equatorial axis, mean value: 15.8 μm, σ = 1.1 μm, range 14.4–18.6 μm; *n* = 30

Voucher: Seal Rocks opposite the Post Office, 23 Feb 1981, *Quinn & Waterhouse* (UNSW10400).

Note: see also Erdtman (1966, p. 270).

Sarcopetalum harveyanum F.Muell. Fig. 7b

3-colporate, isopolar, radiosymmetric. S: small; EV prolate oval; PV circular with intruding colpi; pores conspicuous, often slightly lolongate, circular to elliptical, the orifice 1.8–2.6 μm long, 1–2 μm wide, the colpi with ± conspicuous margins and pointed apices almost meeting at the poles; exine 0.8–1.0 μm thick, very finely reticulate. Polar axis, mean value: 13.5 μm, σ = 0.6 μm, range 12.6–14.4 μm; equatorial axis, mean value: 11.2 μm, σ = 0.6 μm, range 10.2–12.0 μm; *n* = 31.

Voucher: Cattai Creek, Cattai, 13 Nov 1963, *Blaxell* (UNSW).

Stephania japonica var. ***discolor*** (Blume) Forman Fig. 7c

3-porate, isopolar, radiosymmetric. S: small; EV oblate oval; PV circular to semi-angular (slightly rounded triangular); pores lalongate to lolongate, circular to elliptical (often appearing slit-like at lower magnification), with ragged margins, 1.5–2.5 μm long, c. 1 μm wide; exine 1.3–1.5 μm thick, with fine (to medium) reticulum. Polar axis, mean value: 11.7 μm, σ = 0.5 μm, range 10.2–12.0 μm; equatorial view, mean value: 13.7 μm, σ = 0.6 μm, range 12.0–14.4 μm; *n* = 30.

Voucher: Mungo Brush, 20 Jan 1977, *Hindmarsh & Waterhouse* (UNSW5983).

Monimiaceae s. lat.

Doryphora sassafras Endl. Fig. 7d

2-sulcate, isopolar, bilateral. S: medium to large; shape variable, (± spheroidal to) ellipsoidal; furrows open or with granulate membrane, the margins often torn-like and ragged when furrows open, the ends almost meeting (sometimes the grains syncolpate); exine 1.5–2 μm thick (sexine thicker than nexine), thinning towards margins of furrows, columellate, with a fine to medium reticulum becoming finer and disappearing towards furrow margins. Axis following the furrows (usually the longest axis), mean value: 43.2 μm, σ = 3.9 μm, range 34.8–52.8 μm; width, mean value: 37.1 μm, σ = 3.9 μm, range (25.2–)30–42 μm; *n* = 40.

Notes: pollen sample from Jamberoo Mountain road below Barren Grounds (no voucher). Sampson and Foreman (1988) describe the two elongated apertures being centred and widest at the poles and tapering at their ends, to terminate, without meeting, near the equator of the grain. As well as having disulcate pollen with the above type of aperture, *Doryphora sassafras* can have meridionosulcate pollen where there is a median encircling aperture that narrows markedly or slightly in two regions opposite one another near the equator of the grain (Sampson 2000). See also Erdtman (1966, p. 271), and a synopsis of pollen of Monimiaceae s. lat. by Sampson (2000). *Doryphora* is sometimes placed in the family Atherospermataceae.

Hedycarya angustifolia A.Cunn. Fig. 7e

Inaperturate, acalymmate tetrads (the sexine of each monad is well differentiated, but does not form a single continuous envelope around the tetrad unit). S: medium. Pollen in permanent tetrads, usually with isobilateral (tetragonal) or decussate arrangement, sometimes T-shaped or intermediate between these types. Exine thin (c. 0.5 μm thick), finely granulate; under SEM the exposed surfaces of the grains have a verrucose warty configuration (Sampson 1997). Polar axis, mean value: 26.3 μm, σ = 2.5 μm, range 20.4–30.0 μm; longitudinal equatorial axis, mean value: 34.7 μm, σ = 2.5 μm, range (27.6–)31.8–36.0(–40.8) μm; transverse equatorial axis, mean value: 31.3 μm, σ = 2.0 μm, range 27.6–36.0 μm; *n* = 30.

Voucher: Mt Tomah, Blue Mtns, near Bells Line of Road, 4 Oct 1982, *Winterhalder* (UNSW13985).

Notes: Sampson (1997) reports 37–44 µm diameter tetragonal tetrads (measured along the polar axis). See also Sampson (1977, 1982) and Foreman and Sampson (1987).

Palmeria scandens F.Muell. Fig. 7f

Inaperturate, apolar. S: small to medium; shape ± spheroidal, grains often folded; echinate with spinules to c. 1 µm long; exine c. 0.5 µm thick. Longest axis (± equal to diam.), mean value: 24.1 µm, σ = 3.0 µm, range 18.0–32.4 µm; n = 30.

Notes: Pollen sample from Dorrigo National Park (no voucher). See also Foreman and Sampson (1987), Sampson and Foreman (1990) and Sampson (2000).

Myoporaceae

Myoporum boninense subsp. ***australe*** Chinnock Fig. 8a

3-colpate and diorate (= diploporate, with 2 pores in each colpus arranged north and south of the equator), fossaperturate, isopolar, radiosymmetric. S: small (to medium); EV usually prolate oval, sometimes circular or oblate oval; PV circular, colpi open; pores lalongate, frequently exceeding the rims of the colpi, elliptical to slit-like with jagged edges, 0.5–1.8(–7.4) µm long, 5.1–9.2 µm wide, without thickened margins, the colpi taper to acute apices high on the poles, with a smooth to granular membrane persistent except at the pores where it is broken; exine 1.0–1.3 µm thick, distinctly columellate, finely reticulate, becoming slightly finer at the poles. Polar axis, mean value: 23.1 µm, σ = 1.2 µm, range 20.4–25.2 µm; equatorial axis, mean value: 21.4 µm, σ = 1.0 µm, range 19.2–22.8 µm; n = 41.

Voucher: Dee Why Head, 25 Jun 1982, *Więcek & Stricker* (UNSW13056).

Note: see also Niezgoda and Tomb (1975).

Myrsinaceae

Myrsine howittiana (F.Muell. ex Mez) Jackes Fig. 8b
(syn. *Rapanea howittiana* (F.Muell.) Mez)

3-colporate, isopolar, radiosymmetric. S: very small to small; EV prolate oval, rarely circular; PV circular or inter-subangular, colpi intruding to open; pores small (≤ 1 µm diam.), indistinct, protruding at equator where colpi are slightly constricted, the colpi narrow; exine 0.5–0.8 µm thick, smooth. Polar axis, mean value: 14.8 µm, σ = 1.5 µm, range 10.8–16.8 µm; equatorial axis, mean value: 10.9 µm, σ = 1.0 µm, range 8.4–12.6 µm; n = 38.

Voucher: Smiths Lake Field Station, 20 Aug 1982, *Adam* (UNSW14101).

Notes: recently transferred to the genus *Myrsine* (Jackes 2005). See also Vasanthy and Pocock (1981) who describe abnormalities in '*Rapanea*' pollen.

Myrtaceae

Acmena smithii (Poir.) Merr. & L.M.Perry Fig. 8c

3-colporate, syncolpate, without apocolpia or polar islands, angulaperturate (i.e. apertures are situated at the angles of the amb), radiosymmetric, isopolar. S: small; EV oblate (often depressed) oval, the polar areas often slightly concave or more rarely raised; PV rounded triangular with the sides of the amb ± straight to slightly concave or convex (semi-angular to semi-lobate); pores lalongate, slit-like, exceeding the width of the colpi, the vestibulum absent or very narrow with a concave floor; exine 1–1.5 μm thick, surface ± smooth. Polar axis, mean value: 11.8 μm, $\sigma = 0.9$ μm, range 9.6–13.2 μm; equatorial axis, mean value: 16.0 μm, $\sigma = 1.0$ μm, range (13.8–)15.6–18.0 μm; $n = 42$; base of amb to angle, mean value: 14.9 μm, $\sigma = 0.8$ μm, range (12.0–)14.4–16.8 μm; $n = 32$.

Voucher: 6 km along Ourimbah Ck Rd from tum-off on Pacific Hwy, 6 Nov 1975, *Waterhouse* (UNSW5250).

Notes: employing SEM, Patel et al. (1984) found intercolpar concavities that are equatorially elongated and elliptic in shape clearly defined in *Acmena smithii* pollen grains. Chalson (1991) found the vestibulum of *A. smithii* pollen indistinct with a straight floor. *A. smithii* grains have a less angular amb and thicker walls than pollen grains of *Backhousia myrtifolia* and *Syncarpia glomulifera.* See also Pike (1956). Craven et al. (2006) have recently adopted a broader circumscription of *Syzygium*, including *Acmena.* If accepted this will resurrect the name *Syzygium smithii* (Poir.) Nied. for the taxon investigated here.

Backhousia myrtifolia Hook. & Harv. Fig. 8d

3(4)-colporate, syncolpate without apocolpia, angulaperturate, isopolar, radiosymmetric. S: small; EV ± depressed oblate oval, the polar regions concave; PV rounded triangular amb with slightly concave sides (angular to semi-lobate); pores lalongate, slit-like, exceeding the width of the colpi, the vestibulum absent or very narrow with a concave floor; exine c. 1 μm thick, smooth. Polar axis, mean value: 7.9 μm, $\sigma = 0.8$ μm, range 6.6–9.6 μm; equatorial axis, mean value: 16.1 μm, $\sigma = 0.9$ μm, range 14.4–18.0 μm; $n = 33$; base of amb to angle, mean value: 14.3 μm, $\sigma = 0.7$ μm, range 12.6–16.2 μm; $n = 38$.

Voucher: 8 km S of Albion Park on the road to Jamberoo, 23 Nov 1982, *Hindmarsh & Waterhouse* (UNSW11591).

Note: see also Pike (1956), Gadek and Martin (1981) and Chalson (1991).

Syncarpia glomulifera (Sm.) Nied. subsp. ***glomulifera*** Fig. 9a

(2)3(4)-colporate, syncolpate, angulaperturate, isopolar, radiosymmetric. S: small; EV oblate (often depressed) oval, polar areas slightly concave or sometimes raised; PV rounded triangular amb with straight or slightly concave sides (angular to semi-lobate); pores lalongate, exceeding colpi width, the margins distinct due to slight thickening of nexine around pores, the costa vaguely elliptical in outline, the orifice elliptical to slit-like, 0.5–1.5 μm long, 2–3.6 μm wide, the vestibulum often able to be delimited, to 1.1 μm high, with a concave floor; exine 0.6–1.0 μm thick (c. 2–3 μm thick at pores), smooth to finely granulate. Polar axis, mean value: 11.0 μm, $\sigma = 0.8$ μm, range

9.6–13.2 μm; equatorial axis, mean value: 18.2 μm, σ = 1.2 μm, range 15.6–21.0 μm; base of amb to angle, mean value: 16.0 μm, σ = 1.0 μm, range 14.4–17.4(–19.2) μm; *n* = 35.

Voucher: Coops Creek Crossing on Comenarra Parkway, Wahroonga, 21 Oct 1975, *Waterhouse* (UNSW3758).

Notes: sometimes one polar face is concave while the other is slightly raised. Chalson (1991) describes *Syncarpia glomulifera* pollen grains that are parasyncolpate with the apocolpium < 2 μm wide, and the exine with a faint granular/scabrate pattern. See also Pike (1956) and Gadek and Martin (1981).

Tristaniopsis collina Peter G.Wilson & J.T.Waterh. Fig. 9b

3(4)-colporate, syncolpate, isopolar, radiosymmetric. S: (very small to) small; EV oblate (often depressed) oval, the polar regions ± flat or raised; PV rounded triangular amb with slightly concave sides; pores very small and poorly defined, ± circular, the colpi indistinct; exine 0.5(–0.8) μm thick, smooth. Polar axis, mean value: 6.9 μm, σ = 0.4 μm, range 6.0–7.2 μm; equatorial axis, mean value: 12.1 μm, σ = 0.9 μm, range 9.6–13.8 μm; *n* = 30; base of amb to angle, mean value: 10.9 μm, σ = 0.5 μm, range 10.2–12.0 μm; *n* = 34.

Voucher: not recorded.

Notes: Chalson (1991) reports *Tristaniopsis collina* pollen with convex sides and rounded to blunt angles in the amb. See also Gadek and Martin (1981), where this species is treated as *Tristania* sp. aff. *laurina.*

Oleaceae

Notelaea venosa F.Muell. Fig. 9c

3(4)-colporate, isopolar, radiosymmetric. S: small; EV circular, otherwise slightly prolate or oblate oval; PV circular, colpi open; pores small, often indistinct, defined by protrusions at the equator, colpi of ± even width in equatorial view, tapering to obtuse ends; exine 0.5–0.8 μm thick, microreticulate. Polar axis, mean value: 12.7 μm, σ = 0.8 μm, range 10.8–14.4 μm; equatorial axis, mean value: 12.4 μm, σ = 0.6 μm, range 10.8–14.4 μm; *n* = 48.

Voucher: Minnamurra Falls Reserve, 25 Jan 1978, *Hindmarsh & Waterhouse* (UNSW7673).

Pennantiaceae

Pennantia cunninghamii Miers Fig. 9d

3(4)-colporate, isopolar, radiosymmetric. S: small; EV prolate oval; PV circular, colpi intruding; pores very small (< 1 μm diam.), often appearing costate; exine 0.5–0.8 μm thick, smooth. Polar axis, mean value: 13.0 μm, σ = 0.9 μm, range 10.2–14.4 μm; equatorial axis, mean value: 11.2 μm, σ = 0.9 μm, range 9.6–13.2 μm; *n* = 33.

Voucher: Long Gully Rd, 15 miles [24 km] W of Tabulam, no date, *Blaxell* (UNSW).

Notes: *Pennantia* was previously placed in Icacinaceae. See also Lobreau-Callen (1972).

Peperomiaceae

Peperomia tetraphylla (G.Forst.) Hook. & Arn. Fig. 9e

Inaperturate, apolar. S: very small to small; shape variable, ± ellipsoidal, circular in some views; exine 1–1.5 µm thick, the surface rough (appearing verrucate to reticulate or pitted depending on depth of field focus). Longest axis, mean value: 10.8 µm, $\sigma = 1.3$ µm, range 8.4–13.2 µm; $n = 30$.

Voucher: Minnamurra Falls, 22 May 1961, *Blaxell* (UNSW).

Note: *Peperomia* pollen is reported to have granules below a thick tectum (Walker 1976, per Sampson 2000).

Piperaceae

Piper novae-hollandiae Miq. Fig. 9f

l-sulcate. S: very small to small. Shape very variable, ± ellipsoidal with a sunken furrow/pore (i.e. concave on side with aperture and rounded-convex on the distal face); exine 0.8–1.0 µm thick, at some magnifications the surface appears finely reticulate in the depressed aperture region (which may rupture out) but this is possibly a granulate sulcus membrane (appearing reticulum-like under LM); rest of the surface appears smooth to shallowly ornamented. Longest axis, mean value: 10.4 µm, $\sigma = 0.8$ µm, range 8.4–12 µm; $n = 30$.

Voucher: Mt Kiera Scout Camp, 20 May 1974, *Waterhouse & Howard* (UNSW2415).

Note: Sampson (2000) illustrates the large ornamented aperture occurring in pollen of *Macropiper excelsum* using SEM.

Pittosporaceae

Bursaria spinosa Cav. subsp. ***spinosa*** Fig. 9g

(2)3-colporate, isopolar, radiosymmetric. S: small; EV circular to prolate oval, sometimes slightly oblate; PV circular with colpi intruding to open; pores circular to elliptical, within or exceeding width of colpi, 1.8–3.1 µm long, (2.3–)3.1–3.6 µm wide, the colpi tapering to acute apices, the colpus membrane smooth, persistent except at pores; exine 0.8–1.0(–1.5) µm thick, with a distinct, (fine to) medium reticulum, finer near colpi margins. Polar axis, mean value: 14.2 µm, $\sigma = 1.1$ µm, range 12.0–16.8 µm; equatorial axis, mean value: 13.8 µm, $\sigma = 0.8$ µm, range 12.0–15.6 µm; $n = 30$.

Voucher: Kalang River, near Bellingen, 17 Jun 1985, *Kodela & Dodson* (NSW804257, UNSW).

Note: see also Erdtman (1966, p. 323).

Pittosporum multiflorum (A.Cunn. ex Loudon) L.W.Cayzer, Crisp & I.Telford (syn. *Citriobatus pauciflorus* A.Cunn. ex Ettingsh.) Fig. 10a

3- or 4-colporate, isopolar, radiosymmetric. S: small to medium; EV circular to slightly prolate oval, rarely slightly oblate; PV circular to ± inter-hexagonal, colpi open; pores irregularly shaped, confined within margins of colpi or appearing broken and exceeding margins of the colpi, 1.5–4.1 µm long, 1.5–2.3(–5.1) µm wide, the colpi slightly constricted at equator, with somewhat ragged margins and acute to obtuse ends; exine 0.6–1.0 μm thick (to c. 1.3 μm at pores, c. 1.5 μm at poles), very finely reticulate, becoming finer and indistinguishable at colpi margins. Polar axis, mean value: 24.3 μm, σ = 1.6 μm, range 21.6–27.6 μm; equatorial axis, mean value: 23.6 μm, σ = 1.7 μm, range (18–)21–25.8 μm; *n* = 30.

Voucher: Robertson Nature Reserve, 28 Oct 1986, *Kodela* (UNSW).

Polyosmaceae

Polyosma cunninghamii Benn. Fig. 10b

3-porate, rarely with 4 pores, isopolar, radiosymmetric. S: medium; EV oblate oval; PV semi-angular, a triangular amb with convex sides; pores mostly elliptical when lalongate (sometimes ± circular or irregularly shaped), 2.4–3.6(–5.4) μm long, (2.4–)3.6–6.0(–7.2) μm wide, costate, with a coarse granulate pattern to 8.4 μm wide surrounding each pore; exine 1–1.5(–2) μm thick, granulate to faintly rugulate-reticulate. Polar axis, mean value: 31.7 μm, σ = 2.2 μm, range 28.2–36.0 μm; equatorial axis, mean value: 44.1 μm, σ = 2.7 μm, range 38.4–49.2 μm; *n* = 30; base of amb to angle, mean value: 41.7 μm, σ = 2.5 μm, range (36.0–)38.4–46.8 μm; *n* = 34.

Voucher: Mt Keira Scout Camp, 14 May 1975, *Howard & Quinn* (UNSW5316).

Polar axis, mean value: 33.3 μm, σ = 2.4 μm, range 28.8–36.0(–38.4) μm; equatorial axis, mean value: 42.4 μm, σ = 2.6 μm, range (37.2–)39.6–45.6(–48.0) μm; base of amb to angle, mean value: 41.2 μm, σ = 2.6 μm, range 37.2–45.6 μm; *n* = 30.

Voucher: Robertson, Jun 1987, *Kodela* (UNSW).

Notes: *Polyosma* was previously placed in Escalloniaceae.

Proteaceae

Stenocarpus salignus R.Br. Fig. 10c

3-porate, (sub)isopolar, radiosymmetric. S: medium; EV oblate, rhomboidal to apiculate; PV triangular amb with slightly convex sides, the arms pronounced and protruding, angulaperturate; pores conspicuous, ± circular, the orifice 2.8–3.6 μm in diam., often maintaining a thin membrane cap protruding to 3 μm; exine 1.8–2.0 μm thick, thicker (2.3–2.6 μm) near pores due to thickening of nexine, tectate-perforate (Feuer 1989; referring to the tectum having perforations smaller than 1 μm in diam.), appearing like a shallow reticulum under certain magnifications, granulate around the pores. Polar axis, mean value: 18.7 μm, σ = 0.9 μm, range 16.8–20.4 μm; equatorial axis, mean value: 29.7 μm, σ = 1.2 μm, range 26.4–32.4 μm; base of amb to angle, mean value: 25.4 μm, σ = 1.1 μm, range 24.0–27.6 μm; *n* = 30.

Voucher: Ourimbah Ck Rd, 26 Dec 1975, *Waterhouse* (UNSW5422).

Notes: some *Stenocarpus* pollen grains are subisopolar when one polar face is slightly more rounded convex than the opposite face. In equatorial view the arms sometimes appear to be very slightly orientated towards one pole. See also Erdtman (1966, p. 368).

Quintiniaceae

Quintinia sieberi A.DC. Fig. 10d

(3)4(5)-colporate, isopolar, radiosymmetric. S: small; EV (circular to) prolate oval; PV circular, colpi intruding; pores small, to c. 2 μm long, appearing as protrusions interrupting the colpi at the equator, the colpi equatorially constricted; exine c. 1 μm thick, smooth (obscurely granulate at higher magnification). Polar axis, mean value: 15.5 μm, σ = 1.1 μm, range (10.8–)14.4–17.4 μm; equatorial axis, mean value: 14.3 μm, σ = 0.9 μm, range 12.0–15.6 μm; n = 41.

Voucher: 6.2 km from Ulong on road to Coramba, 22 Oct 1978, *Waterhouse* (UNSW7850).

Notes: *Quintinia* was previously placed in Escalloniaceae. Most modern and fossil *Quintinia* pollen grains recorded by Kodela (1996) were 5-colporate.

Ranunculaceae

Clematis glycinoides DC. Fig. 10e

3-colpate, isopolar, radiosymmetric. S: small to medium; EV oblate oval, sometimes circular or very slightly prolate; PV circular, colpi intruding to open; colpi with finely granulate membrane; exine 0.8–1.0 μm thick, echinate to baculate, the projections to 1 μm high. Polar axis, mean value: 21.4 μm, σ = 1.7 μm, range 18.0–24.0 μm; equatorial axis, mean value: 23.1 μm, σ = 1.6 μm, range 20.4–26.4(–28.2) μm; n = 37.

Voucher: Mirrabooka, c. 6 km E of Morisset, Lake Macquarie, 1986, *Kodela* (UNSW).

Note: very similar to pollen of *Clematis aristata* and some species of *Ranunculus*.

Rhamnaceae

Alphitonia excelsa (Fenzl) Benth. Fig. 11a

3-colporate, angulaperturate, isopolar, radiosymmetric. S: small; EV oblate to prolate oval to slightly rhomboidal-apiculate; PV triangular with amb sides slightly concave, straight or slightly convex, colpi open in the angles; endoapertures J–K_1, the pores small, ± circular to slightly elliptical, costate; exine 1.5–2.0 μm thick, smooth to faintly scabrate. Polar axis, mean value: 16.7 μm, σ = 1.1 μm, range 14.4–19.2 μm; equatorial axis, mean value: 17.2 μm, σ = 0.9 μm, range 15.0–19.2 μm; n = 39; base of amb to angle, mean value: 16.0 μm, σ = 1.0 μm, range 14.4–18.0 μm; n = 36.

Voucher: Minnamurra Falls Reserve, 25 Jan 1978, *Waterhouse* (UNSW7665).

Rosaceae

Rubus moluccanus var. ***trilobus*** A.R.Bean Fig. 11b
(formerly *Rubus hillii* F.Muell.)

3(4)-colporate, isopolar, radiosymmetric. S: medium; EV usually prolate oval, sometimes circular or more rarely oblate oval; PV circular to semi-angular, colpi open; pores circular to elliptical, often bulging, very variable in size (may be small and poorly defined to large, torn-like ruptures), the colpus membrane granulate (colpi may be constricted at a small pore); exine 1.3–1.5 μm thick, the surface striated to striate-rugulate. Polar axis, mean value: 29.3 μm, σ = 1.4 μm, range (25.8–)27.6–31.2 μm; equatorial axis, mean value: 28.1 μm, σ = 1.5 μm, range (24.0–)26.4–30.0 μm; *n* = 30.

Voucher: Bulahdelah State Forest, 19 Jan 1961, *Blaxell* (UNSW).

Rubus rosifolius Sm. Fig. 11c

3-colporate, isopolar, radiosymmetric. S: small; EV prolate oval; PV circular, colpi intruding to open; pores protruding, the orifice poorly defined, the colpi equatorially constricted; exine 1.0–1.4 μm thick, the surface finely striate. Polar axis, mean value: 21.9 μm, σ = 1.4 μm, range 18.6–24.6 μm; equatorial axis, mean value: 16.8 μm, σ = 0.8 μm, range 15.6–19.2 μm; *n* = 30.

Voucher: Mt Keira near Scout Camp, 15 May 1975, *Howard & Quinn* (UNSW5322).

Rubiaceae

Coprosma quadrifida (Labill.) B.L.Rob. Fig. 11d

3-colporate, brevicolpate, isopolar, radiosymmetric. S: small to medium; EV oblate oval; PV circular, colpi open; endoapertures D or G, the pores lalongate, exceeding the colpi rims, ± elliptical when the transverse sides merge to pointed ends or may have poorly defined meridional edges, 2.0–3.8 μm long, 7.7–13.8 μm wide, the orifice irregularly shaped, slit-like or often oblong, usually confined within margins of the colpus, a patterned membrane maintained over rest of the pore; colpi very narrowly elliptical to slit-like, 0.5–2.0 μm wide at equator, 7.7–12.8 μm long, with pointed apices not reaching the poles; exine c. 1 μm thick, granulate to minutely reticulate. Polar axis, mean value: 23.3 μm, σ = 1.4 μm, range (19.2–)21.6–24.6(–26.4) μm; equatorial axis, mean value: 27.5 μm, σ = 1.3 μm; range 24.0–30.0 μm; *n* = 32.

Voucher: Tantawangalo State Forest, near Bega, Sep 1987, *Kodela* (UNSW).

Note: the pore length:width ratio is often 3:1 or greater, in which case the pores may be referred to as transverse colpi.

Cyclophyllum protractum S.T.Reynolds & R.J.F.Hend. Fig. 12a
(previously included as part of *Canthium coprosmoides* F.Muell.)

3-porate, isopolar, radiosymmetric. S: medium; EV oblate oval; PV rounded triangular, amb sides convex; pores ± circular, 4.8–10.8 μm in diam., sometimes lolongate, with ragged margins; exine c. 1.5 μm thick, coarsely suprareticulate with lumina of variable shape and (< 1–) 2–10.7 μm wide, muri wide and verrucate between lumina, the verrucae merging and becoming ± granulate around pores (i.e. at annulus). Polar axis, mean value: 32.0 μm, σ = 2.4 μm, range 26.4–36.0 μm; equatorial axis, mean value: 38.3 μm, σ = 1.6 μm, range 34.8–41.4 μm; *n* = 33.

Voucher: State Forest 143, Little Mossman Logging Area, Qld, 1 Oct 1978, *Moriarty 2470* (UNSW).

Note: distinguished by its bimodal sculpturing consisting of a suprareticulum and a finer ornamentation, as well as having large ± circular pores.

Morinda jasminoides A.Cunn. Fig. 12b

3-colporate, isopolar, radiosymmetric. S: medium; EV oblate oval; PV circular or very rounded inter-semi-angular to inter-hexagonal; pores ± circular to elliptical (orifice 1.8–7.2 µm in diam. and surrounded by a granular margin), occurring within transverse, elliptical colpi with more prominent margins on the polar sides (8.4–16.8 µm long, 13.2–20.4 µm wide); longitudinal colpi often faintly delimited, tapering to irregular, acute or bluntly obtuse ends, the colpus membrane granulate, persistent except at pore orifice; exine 1.5–2.0 µm thick, distinctly thickened near pores, rugulate to irregularly very finely reticulate. Polar axis, mean value: 27.9 µm, σ = 2.6 µm, range 22.8–32.4 µm; equatorial axis, mean value: 32.5 µm, σ = 2.6 µm, range (26.4–)28.8–36.6(–39.0) µm; n = 35.

Voucher: Buds Crossing, on Eungai Ck, Collombatti State Forest, Kempsey, 17 Nov 1978, *Hindmarsh & Waterhouse* (UNSW8059).

Note: see also Johansson (1987).

Sapindaceae

Alectryon subcinereus (A.Gray) Radlk. Fig. 12c

3(4)-colporate, parasyncolpate with polar islands, angulaperturate, isopolar, radiosymmetric. S: small; EV oblate oval; PV obtuse triangular (semi-angular) amb with convex sides and broadly rounded angles, sometimes almost circular; pores conspicuous, mostly lalongate, elliptical or oblong, the orifice 1.5–3.8 µm long, 2.6–5.1 µm wide; vestibulum poorly defined or to c. 1 µm high with a concave floor; exine 1.0–1.5 µm thick, very finely reticulate. Polar axis, mean value: 16.8 µm, σ = 2.1 µm, range 13.2–19.2(–22.8) µm; equatorial axis, mean value: 20.9 µm, σ = 1.8 µm, range 17.4–24.0 µm; n = 34; base of amb to angle, mean value: 20.7 µm, σ = 1.8 µm, range 16.8–24.6 µm; n = 32.

Voucher: 1.1 km below Watsons picnic area on the road to Gloucester Tops, 21 Jan 1977, *Hindmarsh & Waterhouse* (UNSW6432).

Note: size of the triangular-shaped polar islands often slightly different on opposing poles.

Sapotaceae

Pouteria australis (R.Br.) Baehni Fig. 12d
(syn. *Planchonella australis* (R.Br.) Pierre)

4-colporate, isopolar, radiosymmetric. S: medium; EV prolate oval to compressed prolate oval; PV obtuse, convex ± quadrangular, colpi mostly positioned between the angles, intruding to slightly open; endoapertures L, the pores circular or elliptical when lalongate or more rarely lolongate, slightly protruding, the orifice 2.3–3.6 µm × (2.3–) 3.3–4.8 µm, the colpi narrow, with ragged margins, often with vague ends not reaching the poles; exine 1.5–2.0 µm thick, with nexine markedly thickened at pores where exine to 3.5 µm thick, the surface scabrate to shallowly rugulate. Polar axis, mean value: 33.3 µm, σ = 1.5 µm, range 30.6–37.8 µm; equatorial axis, mean value: 25.9 µm, σ = 1.4 µm, range 22.8–28.8 µm; n = 34.

Voucher: specimen was not retained.

Smilacaceae

Smilax australis R.Br. Fig. 13a

Inaperturate, apolar. S: small; shape ± spheroidal; exine very thin (c. 0.5 μm thick), the surface finely echinate with minute spinules (< 1 μm long) irregularly arranged, otherwise smooth. Diameter, mean value: 17.4 μm, σ = 0.9 μm, range 15.6–19.2 μm; n = 30.

Voucher: Pacific Hwy 1.2 km S of Wootton, 23 Sep 1978, *Waterhouse* (UNSW7818).

Solanaceae

Duboisia myoporoides R.Br. Fig. 13b

3-colporoidate, isopolar, radiosymmetric. S: small (to medium), EV mostly prolate oval, sometimes circular to oblate oval; PV circular, colpi intruding to open; pores often indistinct or appear as irregular ruptures in the colpi (occasionally the grains are diploporate with two slit-like pores/transverse furrows in the colpi), the colpi with distinct (sometimes fragmented) margins, tapering to pointed apices almost meeting at the poles, the colpus membrane smooth to slightly granulate; exine c. 1 μm thick, rugulate to striate. Polar axis, mean value: 22.0 μm, σ = 1.8 μm, range (16.8–)20.4–25.2 μm; equatorial axis, mean value: 19.5 μm, σ = 1.4 μm, range 16.8–22.8 μm; n = 36.

Voucher: specimen was not retained.

Sterculiaceae

Brachychiton acerifolius (A.Cunn. ex G.Don) Macarthur & C.Moore Fig. 13c

3-colporate, isopolar, radiosymmetric. S: medium; EV prolate oval; PV circular to ± inter-hexagonal, colpi intruding to open; pores conspicuous, exceeding the colpi rims without definite or distinct meridional edges and equatorial limits (c. 7.7–12.2 μm wide), the open orifice oblong, usually confined within rims of the colpus, 2.0–5.1 μm long, (0.5–)1.5–5.9 μm wide, the colpi widest at the equator, tapering to blunt or acute apices, the smooth to slightly granular colpus membrane persistent except at pores; exine c. 1.8 μm thick, slightly thicker at the poles where to 2.5 μm thick, distinctly columellate, with fine to medium reticulum. Sample 1: Polar axis, mean value: 35.2 μm, σ = 1.5 μm, range 32.4–37.2 μm; equatorial axis, mean value: 30.0 μm, σ = 1.5 μm, range 28.2–33.6 μm; n = 31. Sample 2: polar axis range 30.0–34.2 μm; equatorial axis range 22.8–28.8 μm; n = 30.

Vouchers: specimens were not retained.

Symplocaceae

Symplocos stawellii F.Muell. Fig. 13d

3(4)-colporate (2-aperturate grains occupied 30 % of a sample studied by van der Meijden 1970), brevicolpate, angulaperturate, (sub-)isopolar, radiosymmetric. S: medium; EV oblate oval; PV obtuse/rounded triangular (semi-angular) amb with convex sides, sometimes almost circular; pores ± elliptical, ± lalongate, with granulate membrane (around orifice) often difficult to distinguish from the surrounding sexine, with costa formed from thickening of bordering nexine; colpi slit-like to narrowly open, within boundary of irregular, fragmented annulus, 4.8–7.2 μm long, 1–2.4 μm wide; exine 1–1.5 μm thick, following van der Meijden (1970) the sexine would be described as finely verrucate above a ± distinct columellae layer; surface sculpturing may appear irregularly finely reticulate (–rugulate) at certain magnifications. Polar axis, mean value: 19.8 μm, σ = 1.1 μm, range 17.4–21.6 μm; equatorial axis, mean value: 27.9 μm, σ = 1.7 μm, range 24.6–31.2 μm; n = 29; base of amb to angle, mean value: 26.6 μm, range (22.2–) 24–28.8 μm; n = 39.

Voucher: between Port Macquarie and Crescent Head, 5.6 km N of Hastings River, 21 Aug 1973, *Waterhouse* (UNSW3059).

Notes: in New South Wales, *Symplocos stawellii* occurs north from Royal National Park, while *S. thwaitesii* F.Muell. occurs north from Victoria and is present in the Illawarra region. The pollen of both species are described and illustrated by van der Meijden (1970). *Symplocos* is a ± eurypalynous genus (Erdtman 1966), meaning there is much diversity in the pollen of this genus. See Barth (1979) for aperture features in *Symplocos* pollen.

Ulmaceae

Trema tomentosa var. ***viridis*** (Planch.) Hewson Fig. 14a
(formerly *Trema aspera* (Brongn.) Blume)

2-porate, isopolar, ± bilateral. S: small; shape ± ellipsoidal with slightly protruding pores; pores usually arranged ± equidistant on the equator (and therefore ± opposite), circular to slightly elliptical, distinctly annulate, 4.1–5.6 μm in diam. (including margin), orifice 2–3.1 μm in diam., annulus width c. 1 μm; exine c. 1 μm thick (2.3–3.1 μm around pores), the surface appears granulate. Longest axis, mean value: 21.4 μm, σ = 1.4 μm, range 19.2–24.6 μm; n = 30.

Voucher: [Royal] National Park, 14 Feb 1958, *Blaxell* (UNSW).

Notes: in the following Urticaceae species the pores of the pollen are minute and barely protruding while in *Trema tomentosa* var. *viridis* pollen the pores are more pronounced. See also Erdtman (1966, p. 442). Zavada's (1983) study found: (1) wall structure and exine sculpturing were the best diagnostic pollen characteristics for determining subfamilial affinities in Ulmaceae; (2) the pollen morphological characteristics of the subfamily Celtidoideae (which includes *Trema*) are more like those of Moraceae than of subfamily Ulmoideae; and (3) the pollen morphology supports family status for Celtidoideae, which would occupy a phylogenetically intermediate position between the Ulmaceae (Ulmoideae) and the Moraceae.

Urticaceae

Australina pusilla Gaudich. Fig. 14b

3-porate, ± isopolar, radiosymmetric. S: very small to small; EV oblate oval; PV ± circular (overall the grains appear ellipsoidal); pores ± equally distanced on the equator, ± circular, minute and often indistinct, 1.5–2.4 μm in diam. (including margin), the orifice 0.5–1.1 μm in diam., the margin to 0.5 μm wide; exine 0.5–0.6 μm thick, slightly thicker around pores; surface appears ± smooth at 500× magnification, however 1250× magnification reveals an obscure pattern that appears shallowly rugulate. Polar axis, mean value: 9.4 μm, σ = 0.7 μm, range 7.7–10.8 μm; equatorial axis, mean value: 11.2 μm, σ = 1.0 μm, range 9.0–13.8 μm; *n* = 45.

Voucher: 'Doradell', c. 1.5 km S of Robertson, 9 Feb 1988, *Kodela* (UNSW).

Notes: Moar (1993) reported *Australina pusilla* pollen c. 18 μm in size with a scabrate pattern (from a New Zealand specimen).

Elatostema reticulatum Wedd. Fig. 14c

2-porate. S: very small to small; shape ± ellipsoidal, probably oblate oval in equatorial view and ± circular in polar view; pores mostly not equally distanced on the equator, ± circular or occasionally elliptical, 2.0–2.8 μm in diam. (including margin), the orifice 0.8–1.5 μm in diam, the margin c. 0.5 μm wide; exine 0.5–0.8 μm thick, slightly thicker around pores; surface appears obscurely rugulate to reticulate, especially at higher magnification. Longest axis, mean value: 11.0 μm, σ = 0.8 μm, range 9.0–12.9 μm; *n* = 30.

Vouchers: (mixed pollen preparation): Minnamurra Falls, 22 May 1961, *Blaxell* (UNSW); Barrengarry Mt at head of Kangaroo Valley, 20 Jan 1969, *Barber* (UNSW).

Note: *Elatostema reticulatum* pollen is distinguished from *Australina pusilla* and *Urtica incisa* by being 2-porate and having a more pronounced surface ornamentation.

Urtica incisa Poir. Fig. 14d

3-porate, isopolar, radiosymmetric. S: small; EV oblate oval; PV ± circular; pores positioned ± equally distanced on the equator, ± circular, 2.3–3.3 μm in diam. (including prominent margin), the orifice 1.0–1.5 μm in diam., the margin to 0.8 μm wide; exine 0.5–0.6 μm thick; surface smooth at 500× magnification, appearing faintly and minutely reticulate at 1250× magnification. Polar axis, mean value: 12.7 μm, σ = 0.8 μm, range 10.8–14.3 μm; equatorial axis, mean value: 14.7 μm, σ = 1.0 μm, range 12.0–15.9 μm; *n* = 45.

Note: pollen sample from Robertson area (no voucher).

Verbenaceae

Lantana camara L. Fig. 15a

3(4)-colporate, isopolar, radiosymmetric. S: medium; EV oblate to prolate oval, PV rounded semi-angular, a triangular amb with obtuse angles and convex sides when 3-colporate, ± square when 4-colporate; pores lalongate, 7–11 μm long, to 20 μm wide, with granulate membrane where exceeding colpus margins, often with a distinct ± oblong–square orifice (to c. 8.5 μm) within colpus margins; colpi with granulate membrane except at pore opening, with tapering ends; exine c. 2 μm thick, thicker (to c. 4 μm) at pores, appearing ± rugulate–reticulate or variably patterned under some magnifications but under SEM shown to be tectate-perforate (Raj 1983). Polar axis, mean value: 33.4 μm, σ = 6.6 μm, range 24.6–49.2 μm; equatorial axis, mean value: 33.6 μm, σ = 4.8 μm, range 26.4–44.4 μm; *n* = 37.

Notes: *Lantana camara* is a naturalised species in Australia. The pollen sample is from Lane Cove, Sydney (no voucher specimen was retained). The pollen of *Lantana camara* is also described and illustrated by Raj (1983) and Willard et al. (2004).

Violaceae

Hymenanthera dentata R.Br. ex DC. Fig. 15b

(2)3-colporate, isopolar, radiosymmetric. S: small; EV oblate to prolate oval, PV circular, colpi intruding; pores small, defined by protrusions where the colpi are constricted equatorially, occasionally seen with large oblong orifices; exine c. 0.8 μm thick, the surface smooth. Polar axis, mean value: 15.5 μm, σ = 0.9 μm, range 13.8–17.4 μm; equatorial axis, mean value: 14.6, μm, σ = 1.1 μm, range 12.6–16.8 μm; n = 30.

Voucher: Tantawangalo State Forest, near Bega–Eden, Oct 1987, *Kodela* (UNSW).

Vitaceae

Cissus hypoglauca A.Gray Fig. 15c

3-colporate, isopolar, radiosymmetric. S: medium; EV prolate oval; PV semi-lobate (triangular with concave sides and cavities at angles); endoapertures L, the pores lalongate, slightly elliptical, 3.6–5.1 μm long, 4.1–6.1 μm wide, the colpi narrowly open; exine 1.3–1.5 μm thick, often thicker (to 3.6 μm) at poles, distinctly columellate, with a medium reticulate ornamentation, in colpi region finely reticulate. Polar axis, mean value: 41.7 μm, σ = 1.3 μm, range 38.4–43.8 μm; equatorial axis, mean value: 30.6 μm, σ = 1.2 μm, range (27.0–)28.8–32.4 μm; n = 30.

Voucher: Bola Creek, Royal National Park, 14 Jan 1963, *Blaxell* (UNSW).

Discussion

Investigation of pollen morphology revealed, as would be expected, similarities between species in the same genus, e.g. species of *Cryptocarya* and *Parsonsia.* Using the light microscope it would be difficult, or impossible, to differentiate pollen at the species level for most genera in fossil or modern pollen rain studies with a satisfactory degree of certainty. However, it is possible to differentiate the pollen of some plant groups to species level after detailed analyses of the regional pollen flora, e.g. an investigation of Myrtaceae pollen morphology (particularly *Eucalyptus* species) for a study of the vegetation history of the Blue Mountains (Chalson 1991, Chalson & Martin 1995). Determining the species likely to be represented in a modern or fossil pollen study will also be assisted by a regional vegetation survey, e.g. an investigation of rainforest history and dynamics in the Robertson area (Kodela 1990a, b, 1996). These types of study benefit from establishing reference pollen sets to compare morphologies. It is important however to recognise the potential problems and limitations when relating pollen morphology of existing taxa from actual plant specimens ('actuo' pollen morphological pollen classification and nomenclature) to palaeopalynological pollen, as discussed by Joosten and de Klerk (2002). These authors concluded that fossil pollen cannot, beyond reasonable doubt, be ascribed to recent and native taxa that produce the same kind of pollen. Hence their argument to refer to pollen types defined by a limitative collection of morphological properties rather than identifying fossil pollen as that of a taxon which involves interpretation.

This study shows that it would be difficult to differentiate *Ceratopetalum, Callicoma* and *Eucryphia* pollen in sediments, especially if the fossil pollen is damaged (eroded, folded, broken). This would also be the case for many Myrtaceae genera and some tricolporate taxa. Monimiaceae s. lat. is a very eurypalynous family with the genera investigated here having distinctly different pollen types, which adds support to recent evidence from molecular and morphological data (Renner 1999) indicating the polyphyletic nature of the family.

The pollen of *Parsonsia brownii*, *P. straminea*, *Pandorea pandorana*, *Legnephora moorei*, *Doryphora sassafras*, *Hedycarya angustifolia*, *Palmeria scandens*, *Acmena smithii*, *Backhousia myrtifolia*, *Syncarpia glomulifera*, *Tristaniopsis collina*, *Bursaria spinosa*, *Stenocarpus salignus*, *Morinda jasminoides*, *Symplocus stawellii, Trema tomentosa*, *Australina pusilla* and *Lantana camara* in this study generally agree with previously published descriptions, with size being one of the most variable features, and shape and sculpturing type sometimes described differently by different researchers. Some of the differences might be accounted for by methodologies, including: (a) pollen preparation, e.g. chemical pre-treatment or mounting medium (glycerine jelly versus silicone oil) may affect size and shape of pollen; (b) light microscope versus scanning electron microscope (SEM) or transmission electron microscope (TEM) observations, e.g. SEM is particularly useful when studying external features such as surface sculpturing and ornamentation for taxonomic research; and (c) degree of magnification which influences the type of surface sculpturing or other features revealed. Differences in pollen descriptions of the same taxon will also result from natural differences in samples (particularly size) and possibly due to the different interpretations and terminologies of investigators.

In some taxa the shape of the pollen appears to vary widely, for example, radiosymmetric tricoporate pollen taxa that are oblate to prolate in equitorial view, or the shape of the amb in species of Myrtaceae (whether the sides are concave, straight or convex). Apertures can also vary, including the degree of ‘openness’ of colpi, or whether pores exceed the colpi margins due to ‘tearing of the wall’ in some tricolporate grains.

This study provides some insight into the features useful for pollen identification, as well as problems that may be encountered when differentiating pollen of related taxa. The pollen morphological descriptions and illustrations are available for use in palynological investigations and plant taxonomic studies. Pollen taxonomy is essential for the identification of fossil pollen and spores to reconstruct past floras and palaeoenvironments. While acknowledging the limitations of relating ‘actuo’ pollen morphology to palaeopalynological studies (see Joosten & de Klerk 2002), palaeoenvironmental and plant history investigations still benefit from the knowledge of modern pollen for comparison. This assists the interpretation of pollen types and the taxa they are likely to represent. In the case of vegetation and environmental history studies it is particularly important to have an understanding of the variability, as well as the similarities, in the pollen flora to assist the interpretation of fossil pollen records. Superficially similar pollen types from the same family may represent genera or species with very different habits and/or habitat/environmental conditions. Pollen morphological studies integrated with modern pollen rain studies greatly assist the interpretation of pollen representation in palaeo-investigations.

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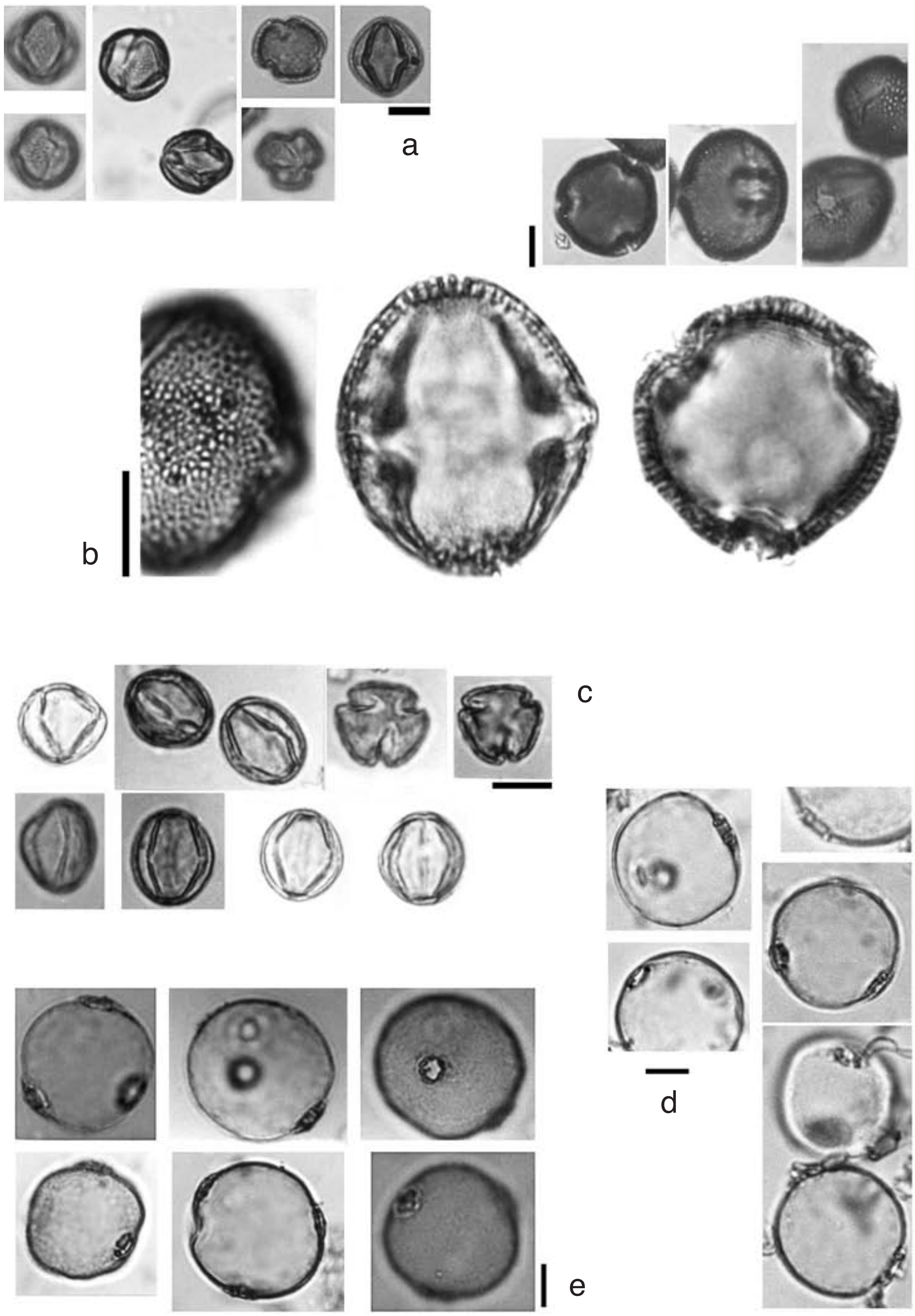

Fig. 2. Light micrographs of pollen: **a**, *Sambucus australasica*; **b**, *Euroschinus falcata*; **c**, *Aphanopetalum resinosum*; **d**, *Parsonsia brownii*; **e**, *Parsonsia straminea*. Scale bars = 10 µm.

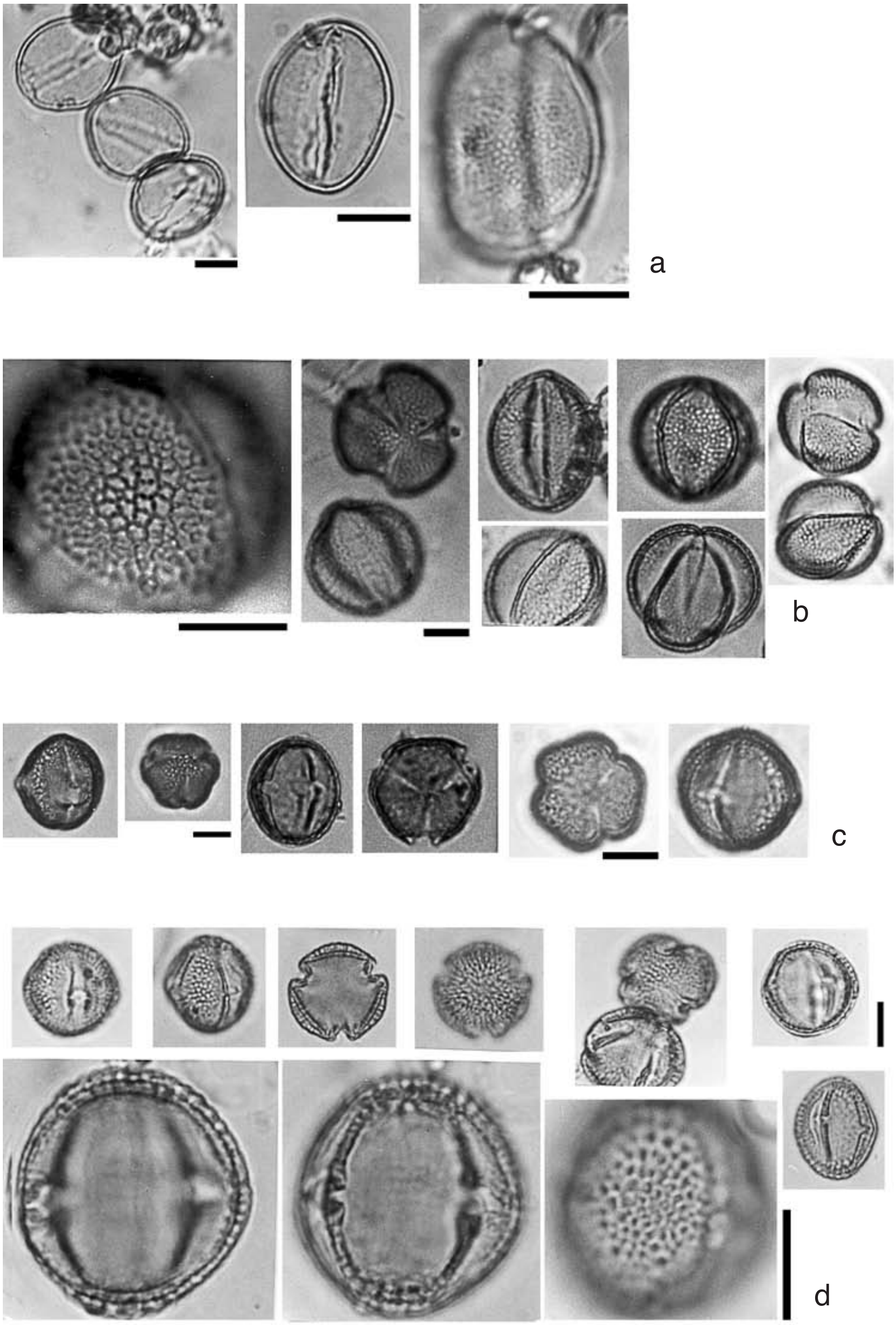

Fig. 3. Light micrographs of pollen: **a**, *Gymnostachys anceps*; **b**, *Pandorea pandorana*; **c**, *Ehretia acuminata*; **d**, *Celastrus australis.* Scale bars = 10 µm.

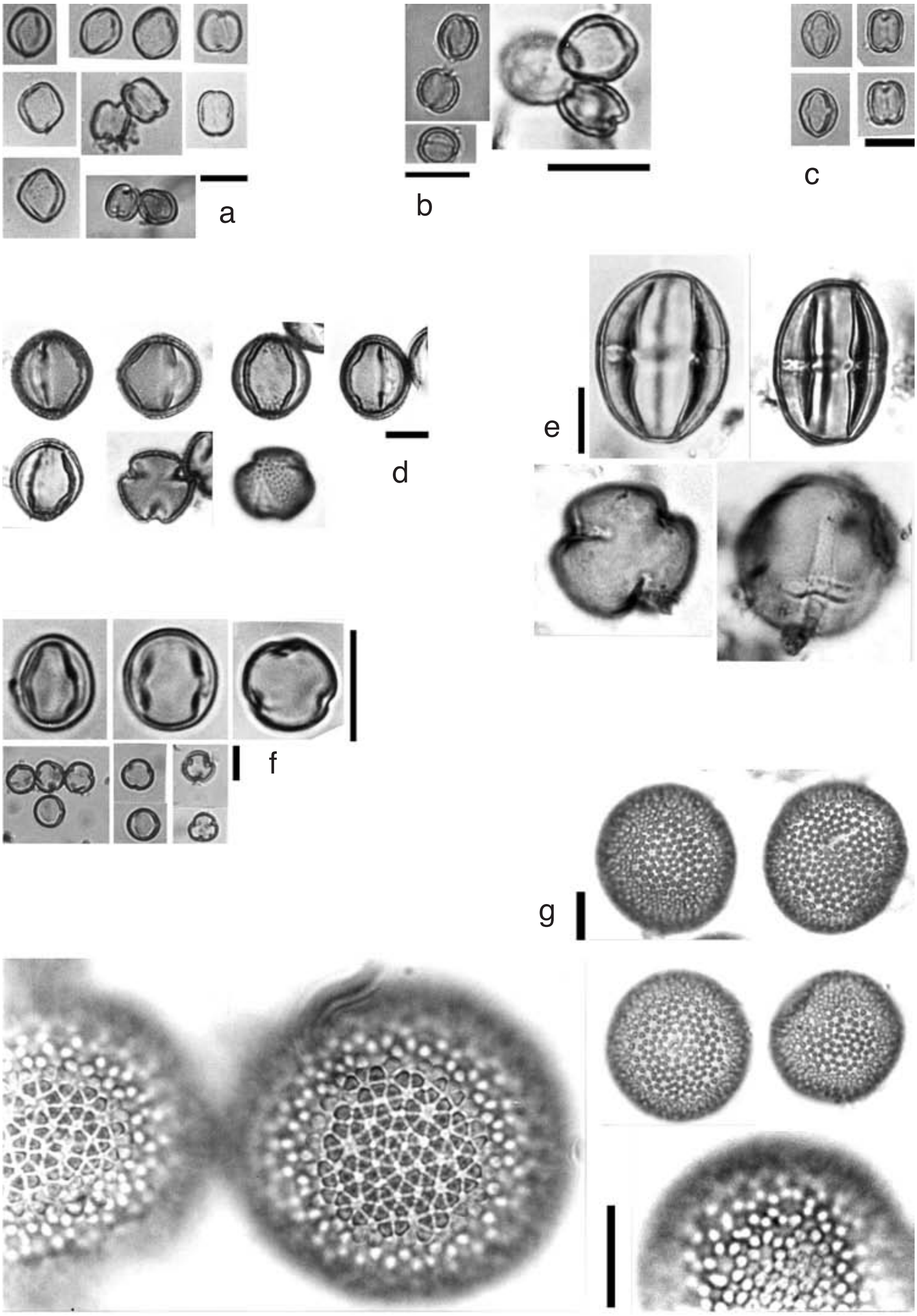

Fig. 4. Light micrographs of pollen: **a**, *Ceratopetalum apetalum*; **b**, *Eucryphia moorei*; **c**, *Schizomeria ovata*; **d**, *Hibbertia scandens*; **e**, *Diospyros australis*; **f**, *Elaeocarpus reticulatus*; **g**, *Baloghia inophylla*. Scale bars = 10 µm.

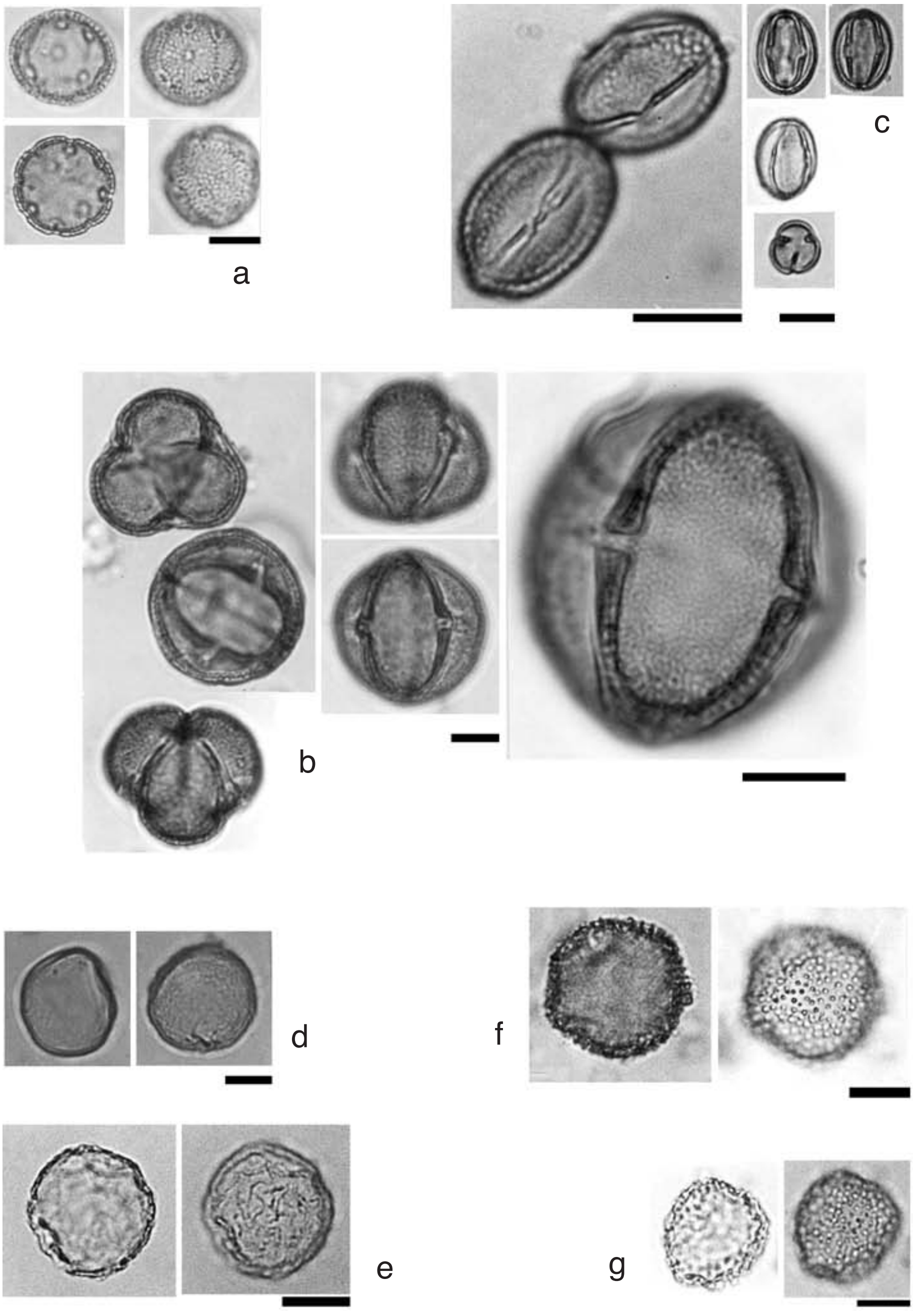

Fig. 5. Light micrographs of pollen: **a**, *Breynia oblongifolia*; **b**, *Homalanthus populifolius*; **c**, *Scolopia braunii*; **d**, *Cryptocarya glaucescens*; **e**, *Cryptocarya microneura*; **f**, *Endiandra sieberi*; **g**, *Neolitsea dealbata*. Scale bars = 10 µm.

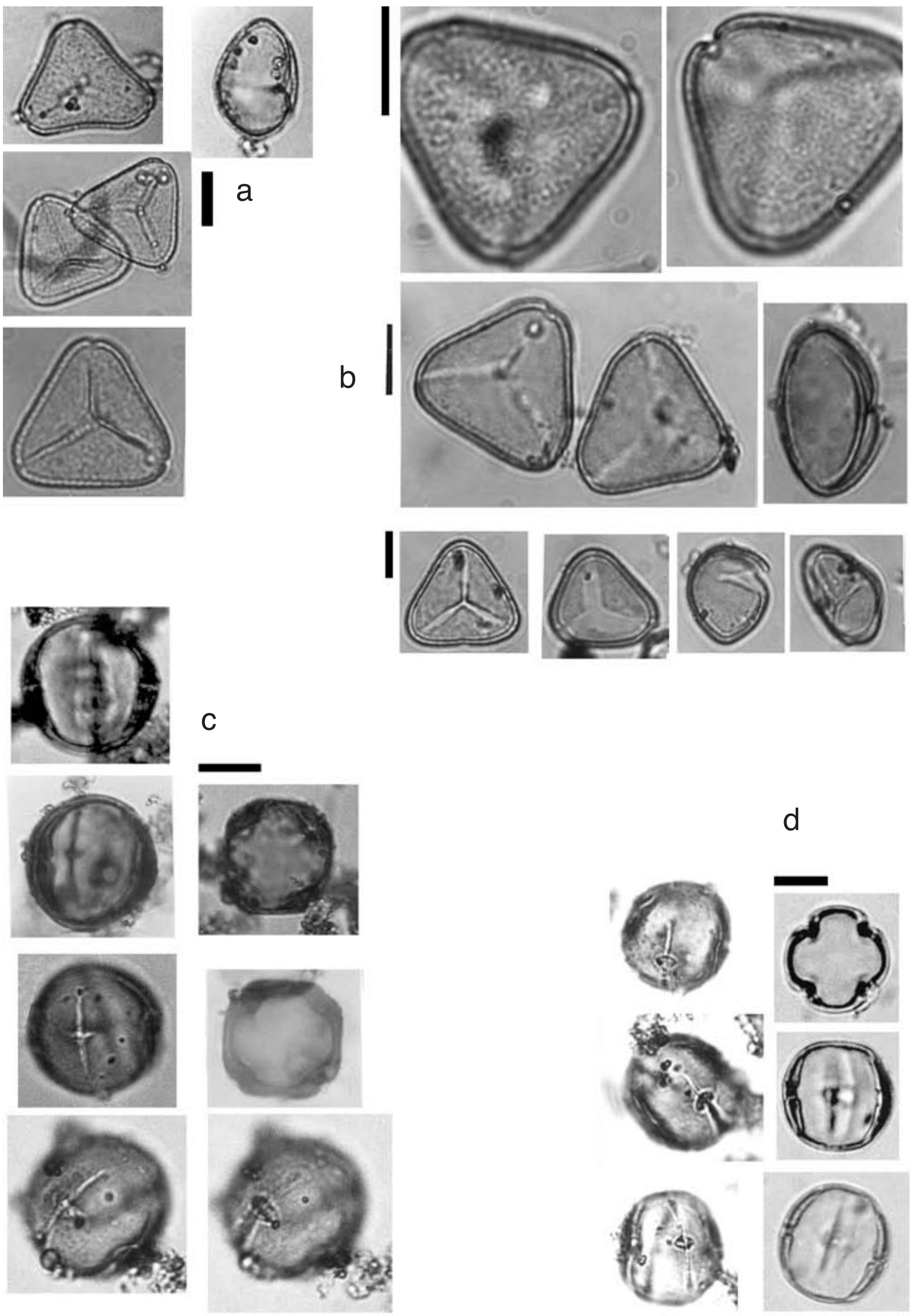

Fig. 6. Light micrographs of pollen: **a**, *Eustrephus latifolius*; **b**, *Geitonoplesium cymosum*; **c**, *Synoum glandulosum*; **d**, *Toona ciliata*. Scale bars = 10 µm.

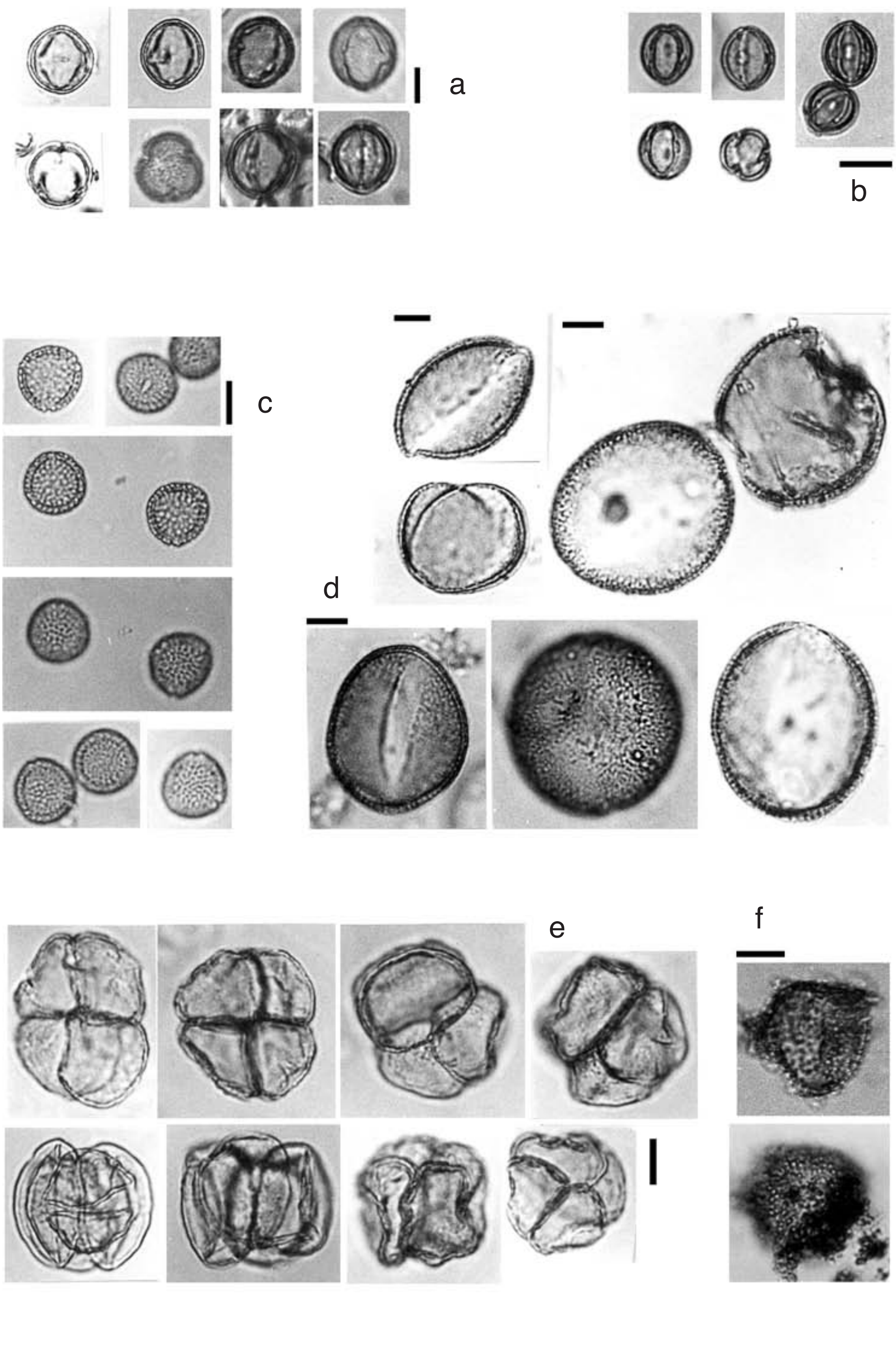

Fig. 7. Light micrographs of pollen: **a**, *Legnephora moorei*; **b**, *Sarcopetalum harveyanum*; **c**, *Stephania japonica* var. *discolor*; **d**, *Doryphora sassafras*; **e**, *Hedycarya angustifolia*; **f**, *Palmeria scandens*. Scale bars = 10 µm.

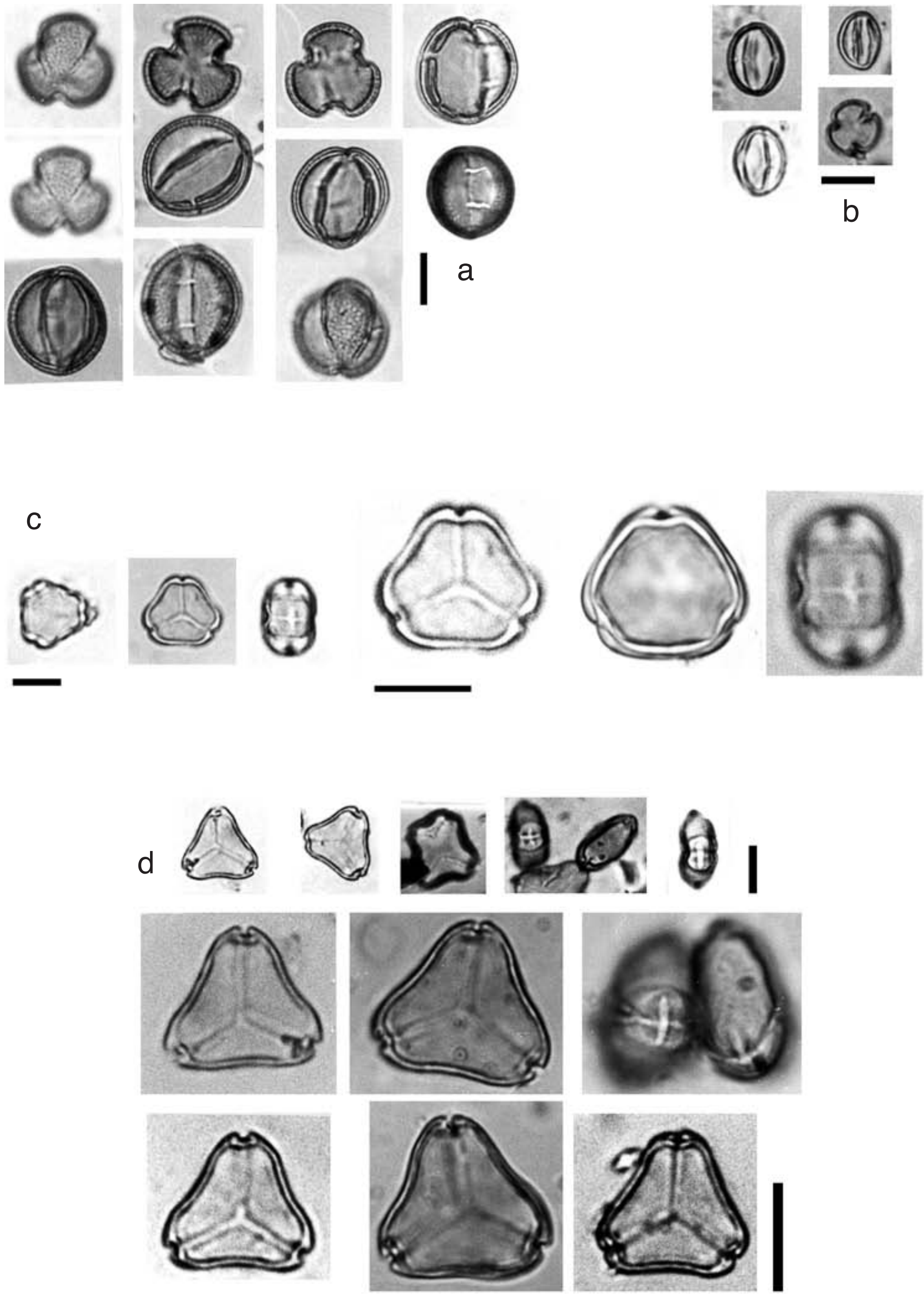

Fig. 8. Light micrographs of pollen: **a**, *Myoporum boninense* subsp. *australe*; **b**, *Myrsine howittiana*; **c**, *Acmena smithii*; **d**, *Backhousia myrtifolia*. Scale bars = 10 µm.

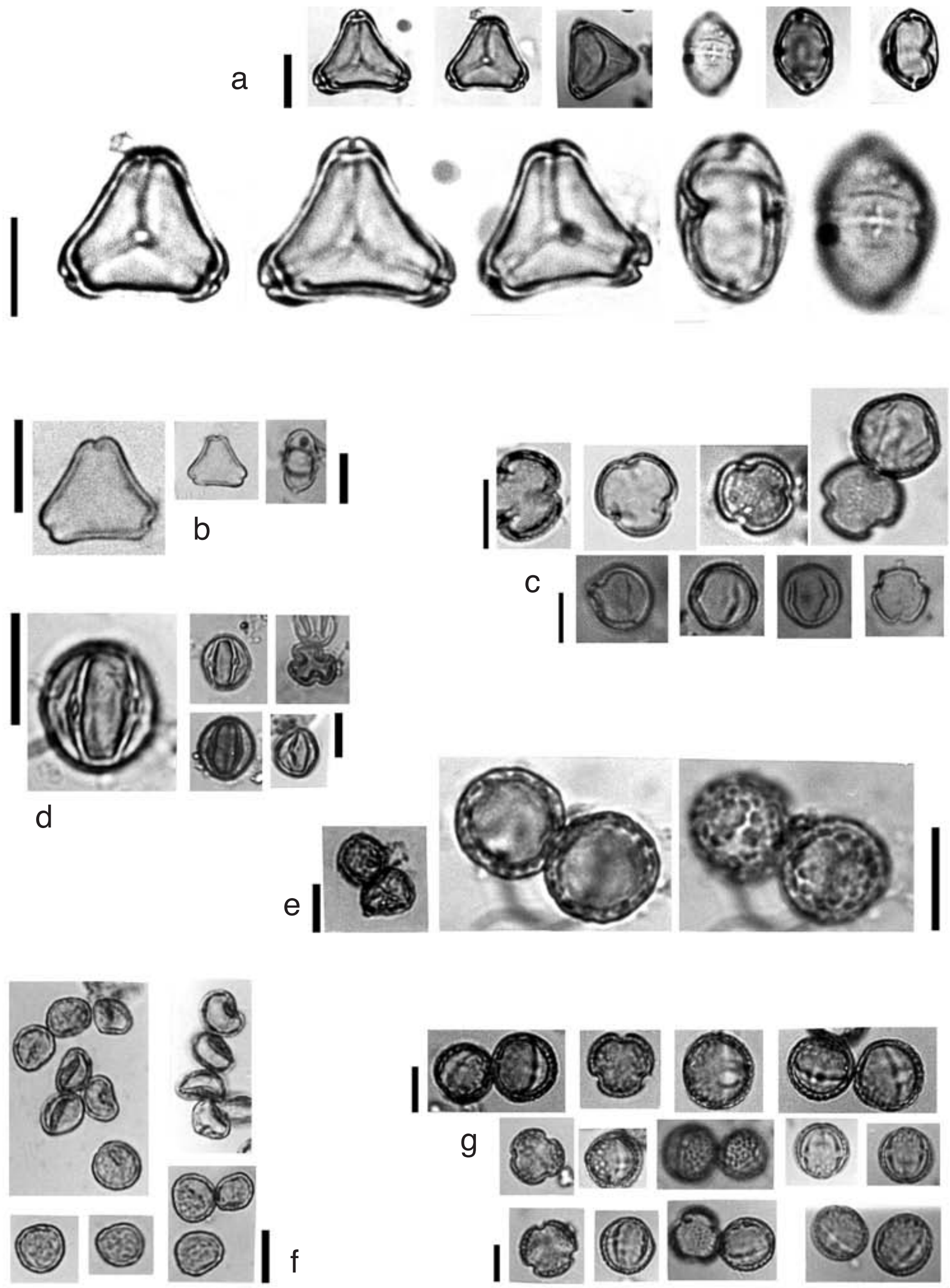

Fig. 9. Light micrographs of pollen: **a**, *Syncarpia glomulifera* subsp. *glomulifera*; **b**, *Tristaniopsis collina*; **c**, *Notelaea venosa*; **d**, *Pennantia cunninghamii*; **e**, *Peperomia tetraphylla*; **f**, *Piper novae-hollandiae*; **g**, *Bursaria spinosa* subsp. *spinosa*. Scale bars = 10 µm.

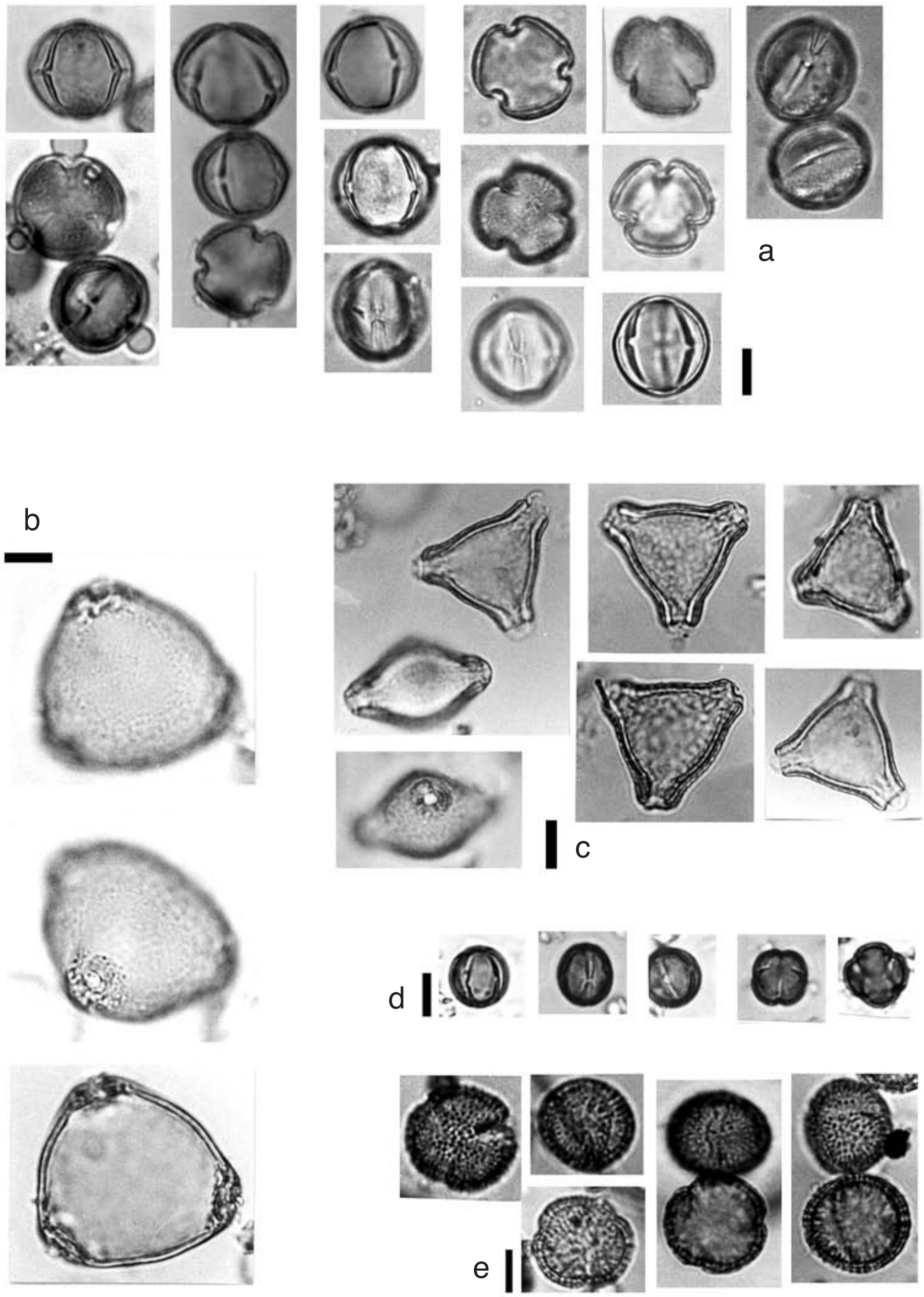

Fig. 10. Light micrographs of pollen: **a**, *Pittosporum multiflorum*; **b**, *Polyosma cunninghamii*; **c**, *Stenocarpus salignus*; **d**, *Quintinia sieberi*; **e**, *Clematis glycinoides*. Scale bars = 10 µm.

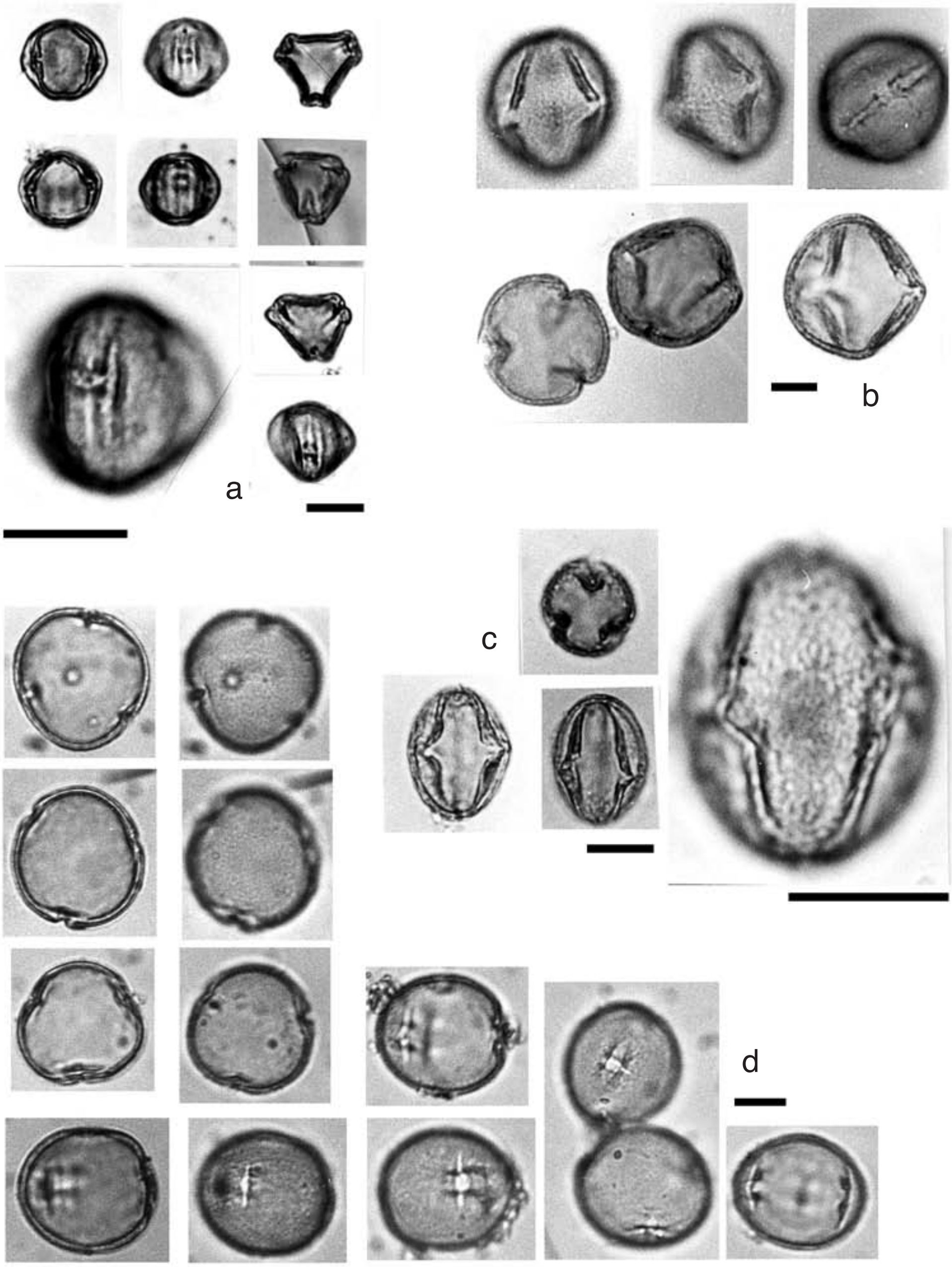

Fig. 11. Light micrographs of pollen: **a**, *Alphitonia excelsa*; **b**, *Rubus moluccanus* var. *trilobus*; **c**, *Rubus rosifolius*; **d**, *Coprosma quadrifida*. Scale bars = 10 µm.

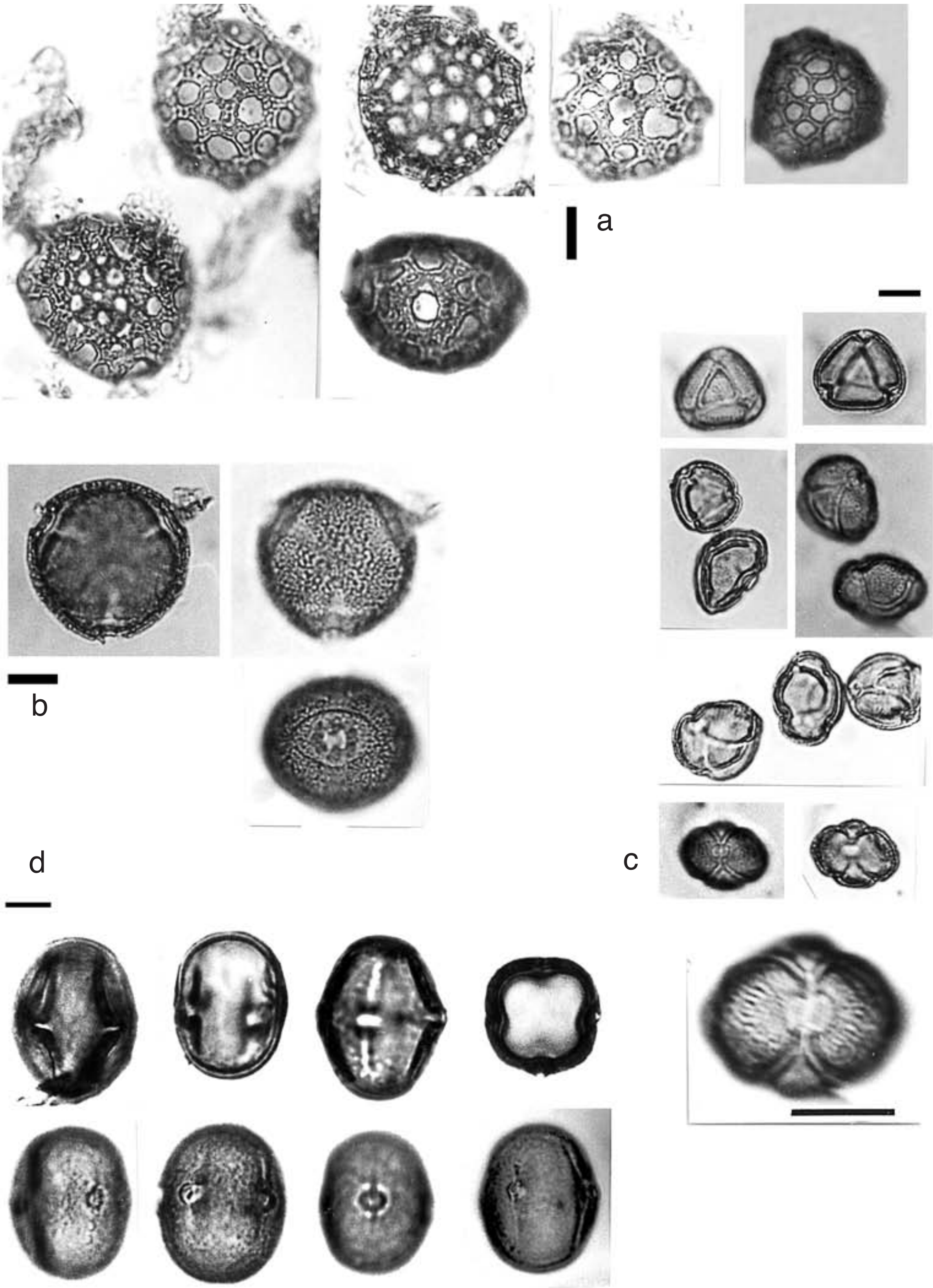

Fig. 12. Light micrographs of pollen: **a**, *Cyclophyllum protractum*; **b,** *Morinda jasminoides*; **c**, *Alectryon subcinereus*; **d**, *Pouteria australis*. Scale bars = 10 µm.

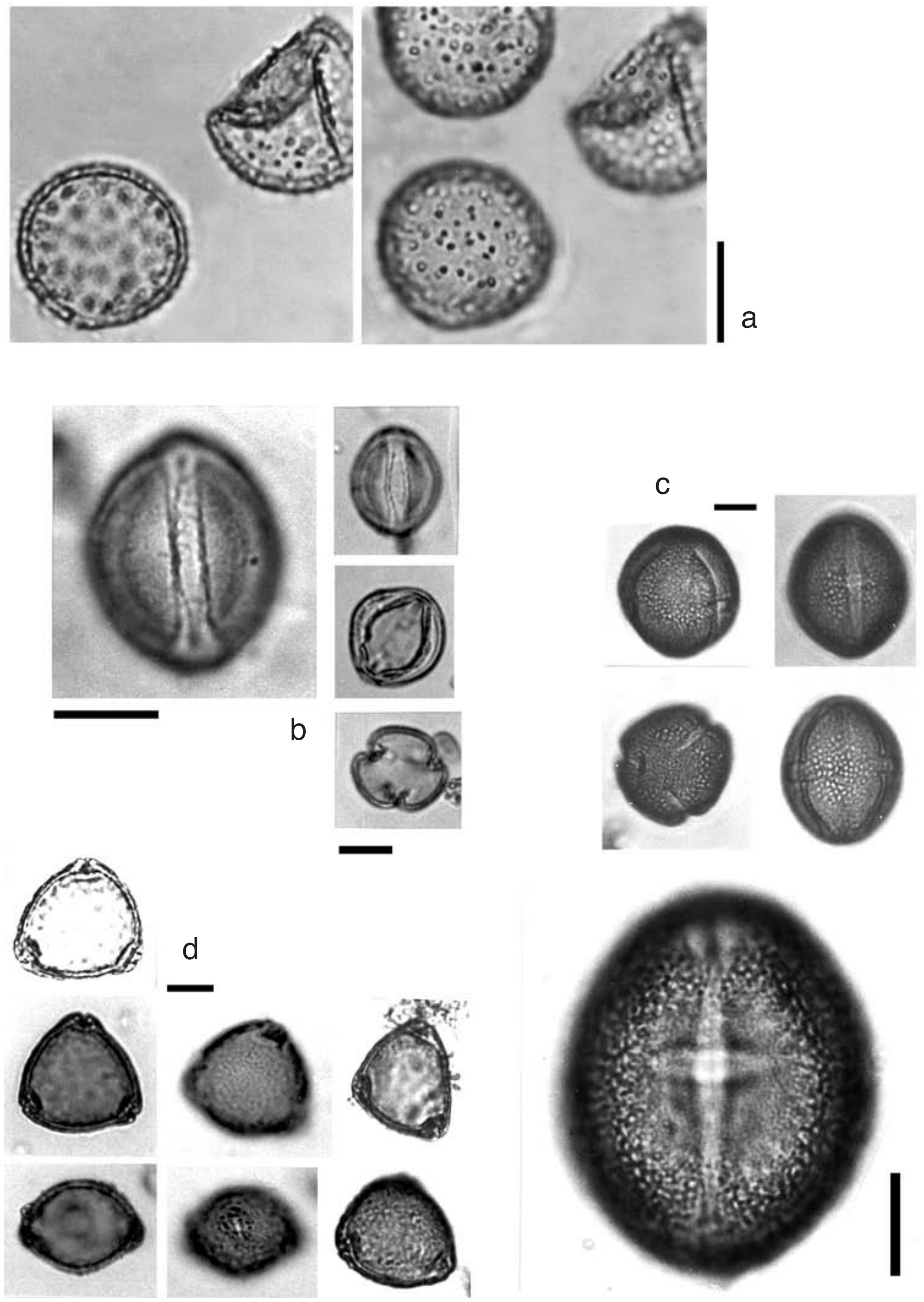

Fig. 13. Light micrographs of pollen: **a**, *Smilax australis*; **b**, *Duboisia myoporoides*; **c**, *Brachychiton acerifolius*; **d**, *Symplocos stawellii*. Scale bars = 10 µm.

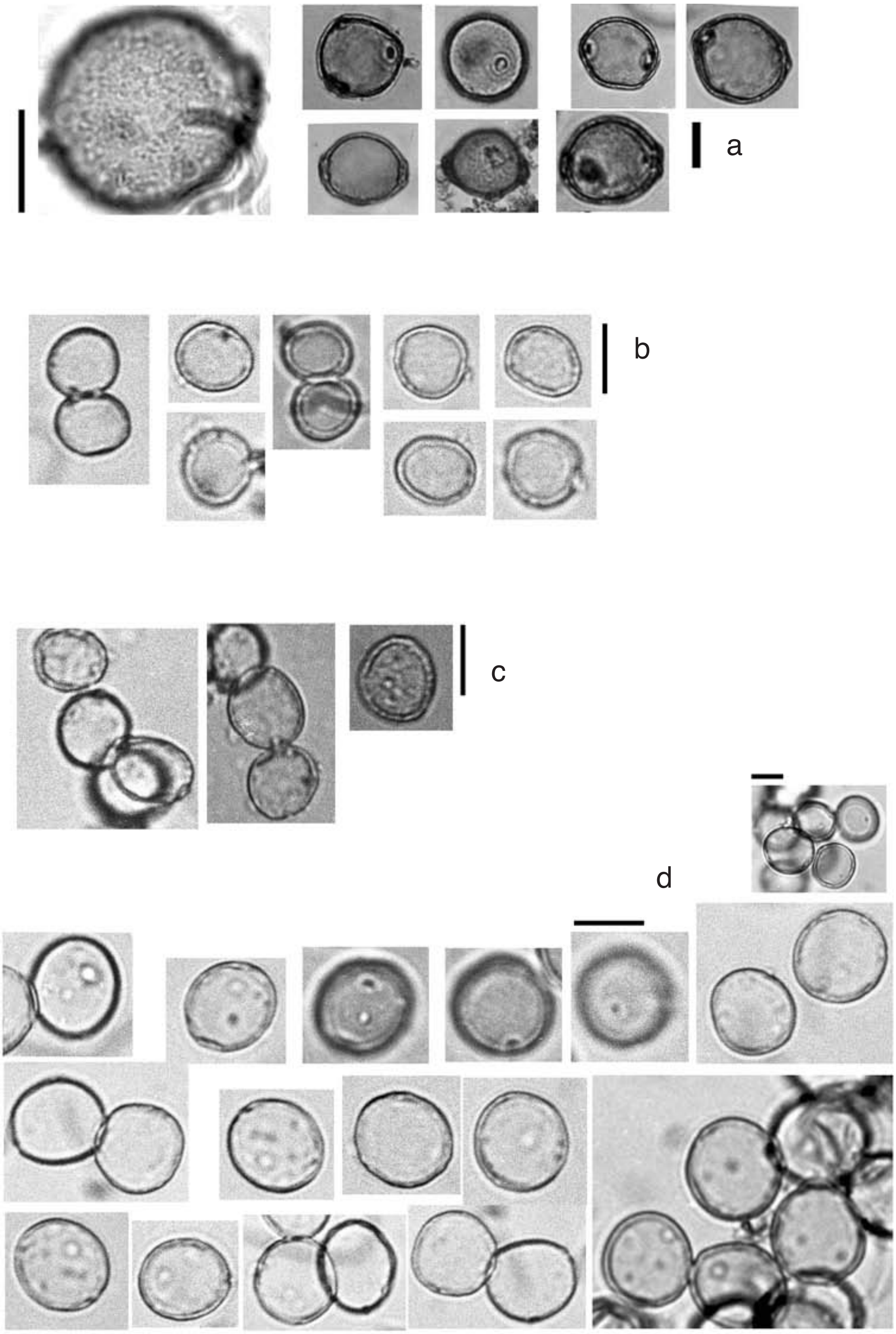

Fig. 14. Light micrographs of pollen: **a**, *Trema tomentosa* var. *viridis*; **b**, *Australina pusilla*; **c**, *Elatostema reticulatum*; **d**, *Urtica incisa.* Scale bars = 10 µm.

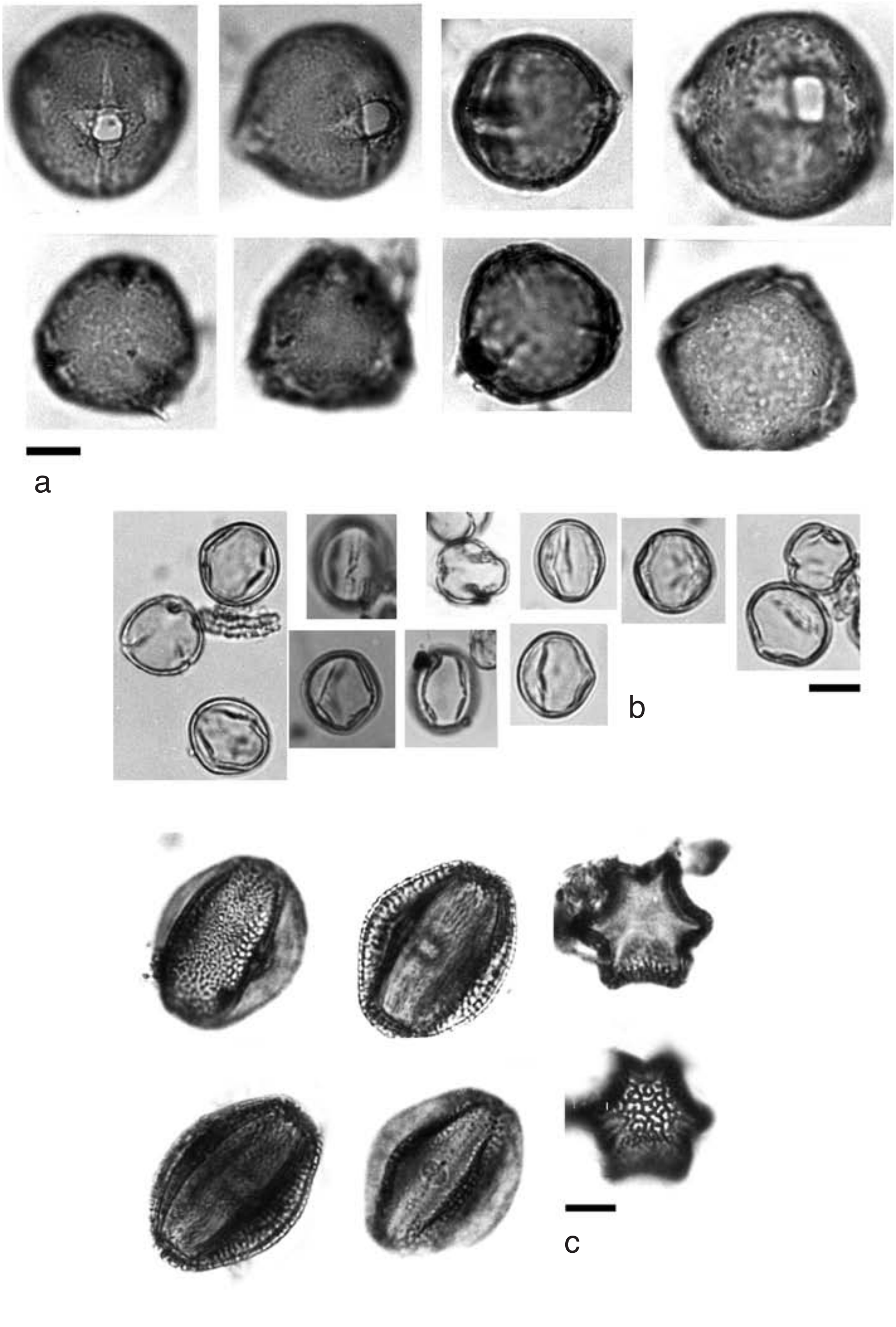

Fig. 15. Light micrographs of pollen: **a**, *Lantana camara*; **b**, *Hymenanthera dentata*; **c**, *Cissus hypoglauca*. Scale bars = 10 µm.