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A pollen morphology study from the Kelabit Highlands of Sarawak, Malaysian Borneo

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Despite the rich biodiversity of plants in the islands of southeast Asia, modern pollen reference collections are still sparse for this part of the world. With only limited availability of pollen data, the ability to answer questions, regarding climate change and environmental change, to aid archaeological investigations through the reconstruction of past vegetation, or even for modern investigations, is challenging. No palynological work had ever been carried out in the Kelabit Highlands of Sarawak, Malaysian Borneo, before this investigation. During 2007–2008, as part of the 'Cultured Rainforest Project', a number of cores were extracted for multi-proxy palaeoecological analysis, including pollen analysis. The cores produced a 50,000-year record of climate, environmental and later anthropogenic change. To aid fossil pollen identification, a modern pollen reference collection was also established. In August 2008, 253 modern plant species from a wide range of habitats were collected from in and around the villages of Bario and Pa'Dalih. Specimens were identified at the Department of Forestry Sarawak Herbarium (SAR), whilst pollen slides from all of the plant specimens were prepared at Queens University Belfast. This paper presents a detailed account of the pollen grains (176 species) collected from the Kelabit Highlands, and from SAR (25 species).

Keywords: tropical pollen; Kelabit Highlands; Sarawak; Malaysian Borneo

1. Introduction

Despite detailed pollen-morphological research carried out in Taiwan by Huang (1972), in the Philippines by Bulalacao (1997) and in Borneo by Anderson and Muller (1975), and the availability of a pollen database for Indonesia held at the Australian National University (APSA 2006–2007), reference material for the islands of Southeast Asia is still very limited and almost non-existent for the island of Borneo, which has some of the richest biodiversity on Earth with ca. 15,000 species of flowering plants and 3000 species of trees (MacKinnon et al. 1998). Between 2007 and 2009, three field trips took place in the Kelabit Highlands of Sarawak, Malaysian Borneo, as part of the 'Cultured Rainforest Project', a multi-disciplinary project involving archaeologists, anthropologists and palaeoecologists, funded by the Arts and Humanities Research Council. The main aim of the project was to investigate long-term and present-day interactions between people and the rainforest in the interior highlands of Borneo (Barker et al. 2008, 2009; Lloyd-Smith et al. 2010). As part of the palaeoecological side of the project, several cores were extracted from Pa'Buda, Pa'Dalih and Bario between 2007 and 2008 (see Figure 1) (Jones et al. 2013a, 2013b, 2014). Multi-proxi analysis was later undertaken at Queen's University Belfast, which included fossil pollen analysis. Some phytolith analysis was also undertaken at the University of Leicester (between 2010–2013 by C. Lentfer & H. Barton, unreferenced). The results have provided a 3000-year anthropogenic record, a potential 6000-year anthropogenic record and a 50,000-year environmental and climatic record (see Jones et al. 2013a, 2013b, 2014). Before this study began, no pollen reference material was available for the highlands of Borneo; to aid identification of the fossil pollen taxa, it quickly became apparent, after the 2007 field season, that a type collection of species local to the Kelabit Highlands was needed before pollen analysis could be effective. Reference material was collected by the authors in August 2008. This paper provides a morphological account of the modern pollen grains collected from the Kelabit Highlands. The main purpose of this paper is to ensure continued availability of the reference material, which might be used to aid future climatic studies and archaeological research, and possibly even for modern pollen/botanical research. These sections will be discussed in more detail in the discussion.

2. Sample area and preparation techniques

The Kelabit Highlands lies between ca. 900 and 2500 m above sea level and between 3 and 4° N and 115°00′

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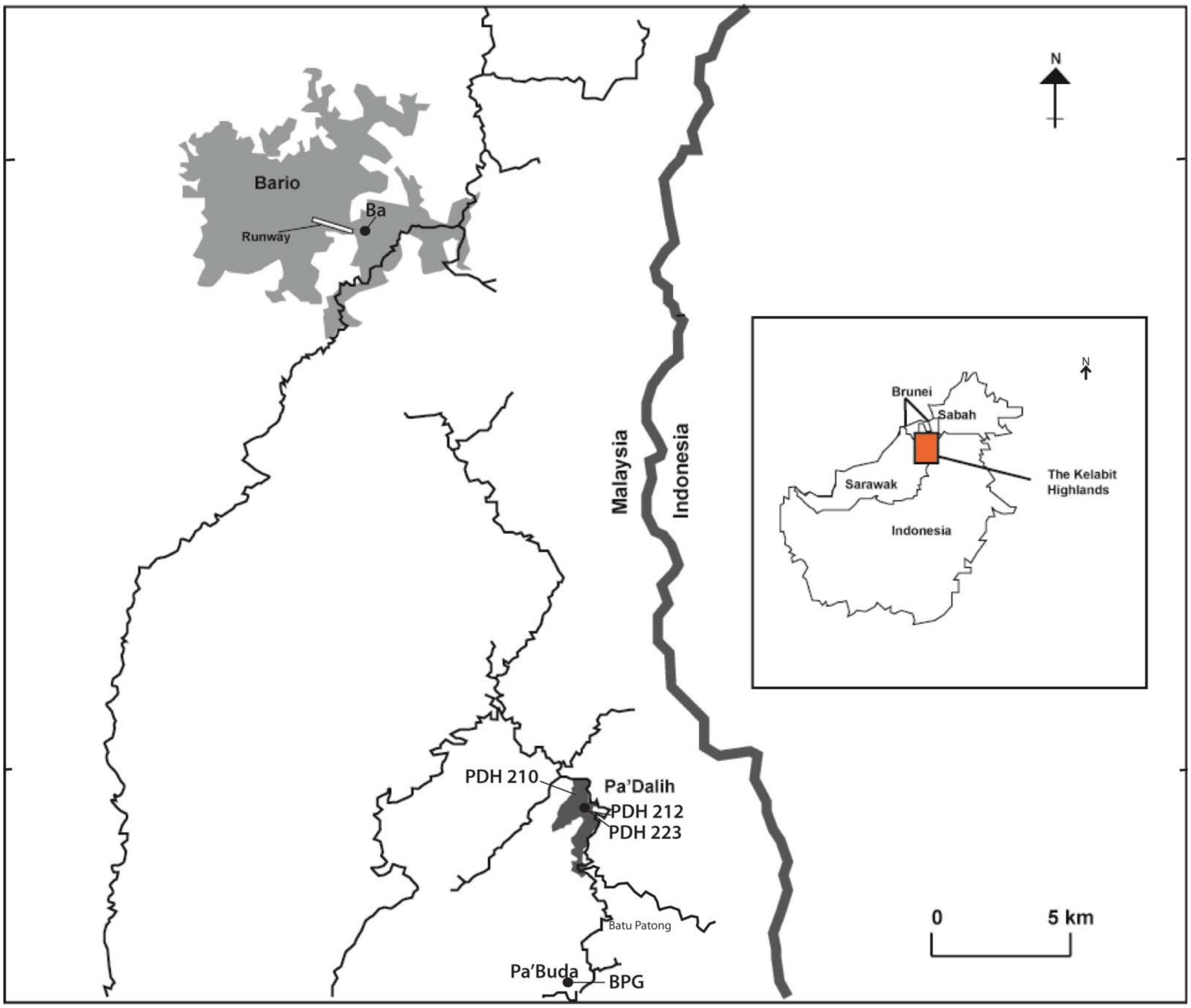

Figure 1. Location of the Kelabit Highlands; circles represent core locations. Modern pollen sampling sites are located within a 2-km radius of the Bario (Ba) and Pa'Dalih (PDH) core sites.

and 115°45′ E, in the northeastern corner of Sarawak, extending into the Kayan Mentarang region of East Kalimantan. It covers an area of about 3000 km^2. The village of Bario is situated 1064 m above sea level in a broad basin on low-angle terrain on a plateau in the northern part of the Kelabit Highlands (Figure 1). The River Dabpur, a tributary of the Baram River, is situated just over 1 km away to the east of the new runway. Pa'Dalih is a small Kelabit longhouse village in the southern part of the Kelabit Highlands at an altitude of 957 m (Figure 1), situated next to the Diit, a tributary of the Baram River.

A range of ecological locations was selected for plant collection, centered around Bario in the northern Kelabit Highlands, and Pa'Dalih in the southern Kelabit Highlands within a 2-km radius of the core sites. Samples could not be gathered from Pa'Buda due to time restrictions. Locations selected included secondary forest at various stages of succession after cultivation of hill padi, alluvial forest, wet swamp forest, buffalo pasture, grassland and riverine sites, and roadside and open ground vegetation. In total, 253 specimens of plants were collected. The specimens were then identified at the Department of Forestry Sarawak Herbarium (SAR) with the help of literature and the SAR collections, including specimens collected by Christensen (2002). Identification was to the species level wherever possible. Species names were checked online at the International Plant Names Index (IPNI) website. Specimens determined as aff. (with affinity to) and cf. (comparable to) were compared to photos of type specimens of the relevant species online at the National Herbarium Nederland website to try to resolve their identity (Hovencamp 2009a). Botanical

Research and Herbarium Management System (BRAHMS) software was used to store identity and collection data, summarize the data and generate labels for the specimens. Four pollen specimens unsupported by herbarium specimens were not identified to family, 14 specimens were not identified to genus and 39 specimens of known genus could not be identified to species partly due to the lack of a good reference collection and lack of literature. Some herbarium species were also added to the collection to provide reference material for genera that might be found in the Kelabit Highlands but could not be obtained during the field season. The plant specimens have been deposited at the SAR herbarium.

Pollen extraction was undertaken either in the field or at SAR. Sample preparation was carried out at Queens University Belfast. The anthers of all specimens collected were divided into two sections. Half were then treated with acetolysis to remove fine cellulose material and sieved through a 120- and a 6-μm sieve to remove larger and finer organic material (Moore et al. 1991). The other half were stored for future use. Some samples did not survive the acetolysis treatment and were reprepared without chemical usage. This included the Zingiberaceae, Musaceae and Costaceae families. These families have been included in this paper because they may be of interest to modern pollen analysts and, although very rare in fossil pollen records, can occasionally be identified if acetolysis is not undertaken (Jones et al. 2013b, figure 8b). Acetolysis is not always necessary, depending on the type of sediments. Acetolysis was not undertaken for any of the Kelabit Highland fossil pollen preps. This was done to preserve fragile pollen and other micro fossils in the fossil record.

After laboratory preparation of the modern pollen specimens, the pollen grains were mounted in silica gel, secured in a layer of candle wax, examined using an Olympus BX 51 high-powered microscope, photographed and described using terminology in Punt et al. (2007) and Jarzen and Nichols (1996). Each plant specimen was then assigned a type and uses, where appropriate, as follows. Type: H: herb, S: shrub, T: tree, L: liana, climber or epiphyte. Uses: E: edible, M: medicinal, R: religious, U: building and other uses. Modern pollen specimens are currently held at the University of Rovira I Virgili (URV), at the institute of IPHES (Institut Catala de Paleoecologia Humana i Evolucio Social), Tarragona, Spain.

Precise measurements of each grain are provided in Section 5. Arbitrary measurements, with an approximate representation of size, are provided in the illustrations (Plates 1–20). A pollen key is also provided below (Section 4) and represents all of the taxa described in this paper. This is with the exception of *Carallia* sp., Cucurbitaceae sp. (*Gocu*), Cucurbitaceae c (Gourd/Peria) and *Chionanthus* sp. These taxa have not been included in the pollen key, due to insufficient data; however, brief descriptions are provided in the main text.

3. Limitations

- Despite preparing some of the samples twice, using different techniques, not all the plant specimens processed produced pollen grains. This includes most of the specimens collected from the Fagaceae and Moraceae families (excluding herbarium specimens), but also some specimens belonging to other families: Apocynaceae, Begoniaceae, Clusiaceae, Dilleniaceae, Elaeocarpaceae, Ericaceae, Euphorbiaceae, Fabaceae, Malvaceae, Melastomataceae, Myrtaceae, Myrsinaceae, Orchidaceae, Pandaceae, Phormiaceae, Piperaceae, Poaceae, Polygonaceae, Proteaceae, Rubiaceae, Symplocaceae, Scrophulariaceae, Urticaceae, Vitaceae and Zingiberaceae. One explanation for this may be due to collection techniques and limited time availability. For example, some of the flowers collected may only have contained female gamophytes and not male gamophytes, or, in dioecious plants, if the male flowers were unavailable, female flowers or young buds were collected in the hope that they might contain pollen grains. The reference collection was not part of the planned 'Cultured Rainforest Project' and therefore suitable sampling periods could not be selected. This was because sample collection was timed to coincide with the main archaeological excavations and not with the main flowering season. It could be argued that perhaps using herbarium specimens would have been a better choice but herbarium specimens may not necessarily have represented the vegetation surrounding the archaeological sites being investigated at the time. Preparation/decanting techniques and preservation (e.g. the Zingiberaceae family) are further possibilities for the lack of pollen.
- Despite samples being taken from a wide range of ecological locations, the type of ecological location was not recorded in most of the samples collected. However, where ecological locations were recorded, they are included in the text.

Despite the limitations described above, in total, 84 families (according to Heywood et al. 2007), 164 genera and 201 species are represented in this paper. Of these, 176 specimens originated from the Kelabit Highlands collections and 25 from herbarium specimens – the latter may belong to lowland or highland Borneo taxa.

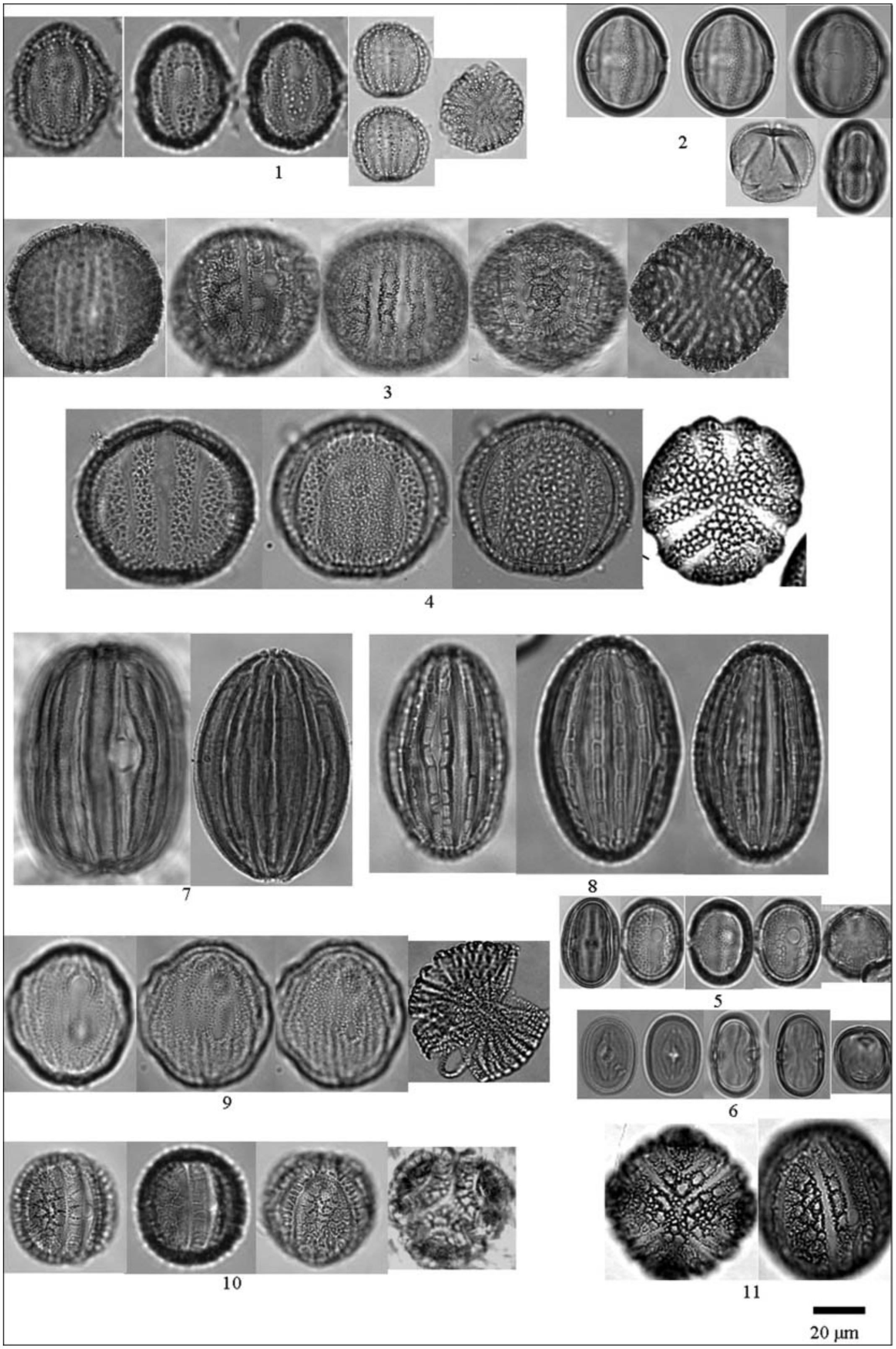

Plate 1. Photographs of pollen grains collected from the Kelabit Highlands. The reference collection is currently held at the Institut Catala de Paleoecologia Humana i Evolucio Social, Tarragona. Figure 1. *Hemigraphis* sp., 2. *Justicia gendarussa*, 3. *Peristrophe bivalvis*, 4. *Pseuderanthemum* sp., 5. *Rungia* sp., 6. *Rungia* PTNP1, 7. *Strobilanthes* sp. a, 8. *Strobilanthes* sp. b, 9. Acanthaceae sp. a, 10. Acanthaceae sp. b, 11. Acanthaceae sp. c

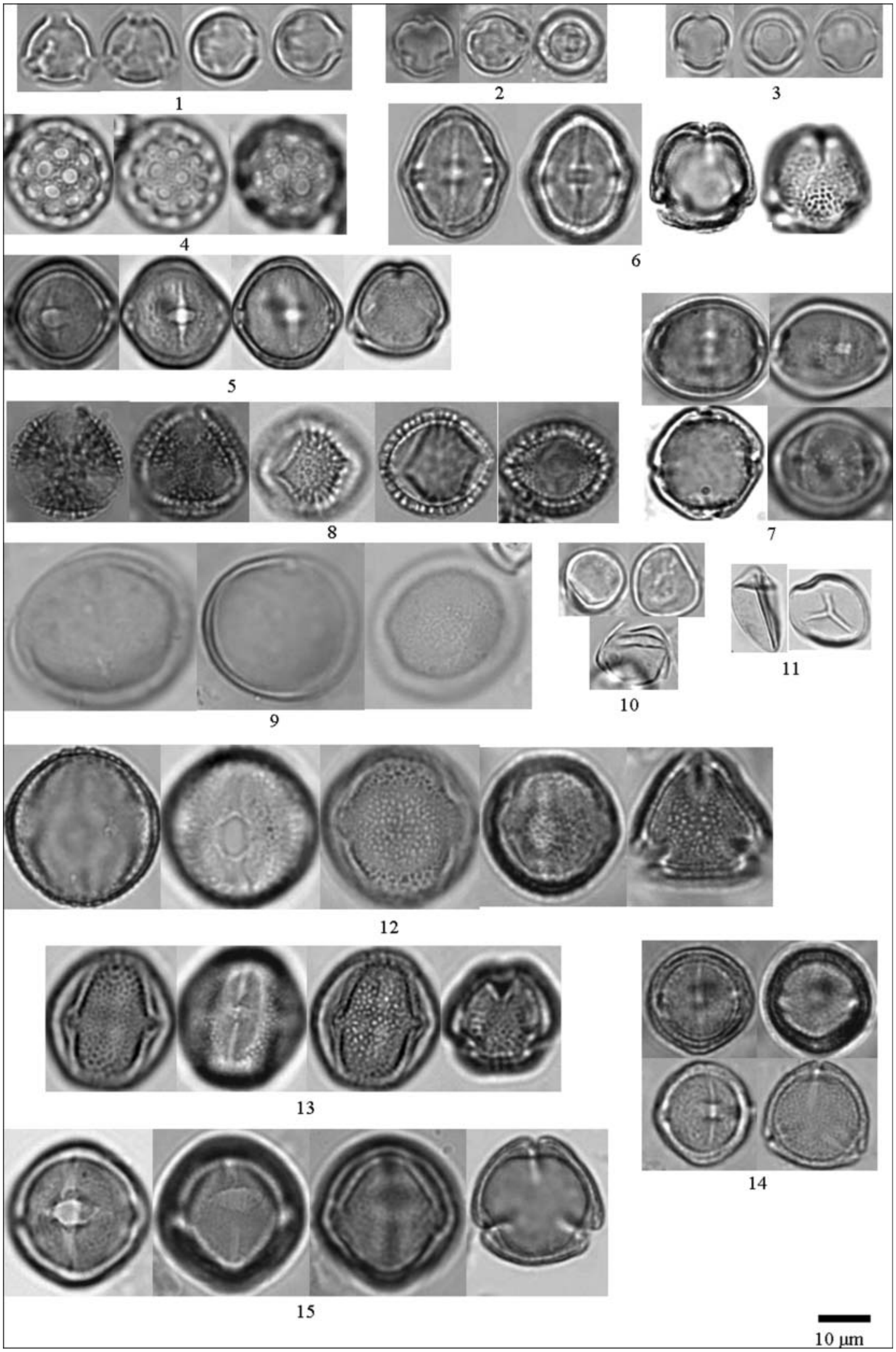

Plate 2. Photographs of pollen grains collected from the Kelabit Highlands. The reference collection is currently held at the Institut Catala de Paleoecologia Humana i Evolucio Social, Tarragona. Figure 1. *Saurauia actinidiifolia*, 2. *Saurauia glabra*, 3. *Saurauia ridleyi*, 4. *Cyathula prostrata*, 5. *Hydrocotyle javanica*, 6. *Hydrocotyle sibthorpioides*, 7. *Leuconotis anceps*, 8. *Ilex cymosa*, 9. *Alocasia princeps*, 10. *Homalomena sagittifolia*, 11. *Piptospatha grabowski*, 12. *Aralia montana*, 13. *Aralia scandens*, 14. *Arthrophyllum* sp., 15. *Schefflera avenis*.

4. Key **(Note: some grains may belong to more than one category)**

Monoporate

1. *Equatorial (EQ), polar (P) view and pore/endoaperture (A)*:
   EQ – pear shaped; A – poorly defined pore/aperture (Go to 2)
   EQ – spheroidal; P – circular, A – well defined pore (Go to 3)
2. *Pattern and grain size*:
   Reticulate; 21–28 × 27–31 μm:....***Fimbristylis globulosa*** (Plate 7, figure 3)
   Granulate; 20–30 × 25–34 μm:.......... ***Scleria purpurascens*** (Plate 7, figure 4)
3. Psilate; 25–27 μm:..................***Isachne pulchella*** (Plate 14, figure 11)

2-porate

1. *Equatorial (EQ), polar (P) view and pore/endoaperture (A):*
   EQ – oblate-spheroidal; P– circular; A – appears as a rupture rather than a distinct pore, pores circular-square (Go to 2)
   EQ – oblate-spheroidal; A – thick annulus around the pores (Go to 3)
2. *Pattern and grain size:*
   Scabrate-finely granulate; 17–25 × 19–30 μm:......................***Burmannia disticha*** (Plate 4, figure 13)
3. Verrucate and granulate; 15–18 μm:........***Trema tomentosa*** (Plate 19, figure 6)

3–4-porate

1. *Equatorial (EQ), polar (P) view and pore/endoaperture (A):*
   EQ – spheroidal; P – circular; A – circular without vestibulum. A – either aspis, other or unknown (Go to 2)
   EQ – spheroidal; P – circular; A – not circular – made up of a partially discontinuous tectum-ulcus rather than porate (Go to 3)
   EQ – spheroidal; P – circular; A – circular with vestibulum (Go to 4)
   EQ – oblate-suboblate; P – triangular, subangular or semi-angular; A– pores are circular, atrium (Go to 5)
   EQ – oblatespheroidal; P – semi-sub-angular; A – circular, atrium (Go to 6)
   EQ – peroblate-oblate; P – circular-semi-angular-triangular; A – aspis-atrium (Go to 7)
   EQ – peroblate-oblate; P – circular-semi-angular-triangular; A – vestibulum (Go to 8)
2. *Pattern and grain size*
   Granulate; 8–15 μm:......................***Artocarpus heterophyllus*** (Plate 12, figure 9)
   Scabrate; 12–15 μm:.....................***Debregeasia longifolia*** (Plate 19, figure 7)
   Granulate-scabrate, 65–68 μm.................. **cf. *Cucurbita sativus* (*Timun*)** (Plate 5, figure 5)
3. Finely reticulate; 17–20 × 18–21 μm:............... ***Chloranthus erectus*** (Plate 6, figure 4)
4. Granulate-scabrate; 16–20 μm:.................. ***Cratoxylum glaucum*** (Plate 6, figure 6);
5. Reticulate and coarse granular; 24–29 × 25–30 μm:........................***Erythina subumbrans*** (Plate 8, figure 12)
6. Reticulate with elevated muri; 38–44 μm:........ ***Vigna* sp.** (Plate 9, figure 2)
7. Granulate; 15–19 × 24–29 μm:................... ***Allophylus cobbe*** (Plate 17, figure 5)
8. Finely reticulate; 12–17 × 20–22 μm:............ ***Acranthera* sp.** (Plate 15, figure 5)

Polyporate

1. *Equatorial shape* – spheroidal, suboblate (Go to 2)
2. Pores > 80 (Go to 3)
   Pores > 10 but < 40 (Go to 4)
   Pores 10–< 10 (Go to 5)
   Unknown (Check 4 and 5)

Pattern and grain size

3. Densely perforate/micro-reticulate with suprae-chinae (> 80 pores); 93–106 μm:...........***Ipomoea batatas*** (Plate 5, figure 2)
4. Tectum granulate, sexine perforate; 18–24 × 18–24 μm:...........................***Cyathula prostrata*** (Plate 2, figure 4)
   Tectum granulate with large echinae 28 μm in length; 125 μm:..........***Abelmoscus moschatus*** (Plate 11, figure 4)
   Verrucate with compact echinae. Smaller echinae occur between the main echinae. Main echinae 4 μm, Minor echinae < 1 μm; 75–95 μm:..........***Sida rhombifolia*** (Plate 11, figure 5)
   Croton; 95–105 μm:...........***Manihot esculenta*** (Plate 11, figure 2)
   Reticulate, semi-tectate: 20–27 μm:................. ***Wikstroemia androsaemifolia*** (Plate 19, figure 3)
5. Reticulate and 24–55 μm:........ ***Ananas comosus*** (can also be 1-sulcate) (Plate 6, figure 1)
   Reticuloid: 37–48 μm:........***Persicaria minor*** (Plate 13, figure 7)

2-colpate

1. Parasyncolpate (Go to 2)
2. _Equatorial shape, pattern and grain size_
   Spheroidal. Lophoreticulate and retipilate. Colpi built up of tightly packed gemmae; 47–84 × 42–56 μm:..........***Passiflora* sp.** (Plate 13, figure 5)

3-colpate

1. _Equatorial (EQ), polar (P) view and aperture (A)_
   EQ – spheroidal; P – circular (Go to 2)
   EQ – spheroidal; P – circular; A – apertures occasionally form a geniculum (Go to 3)
   EQ – oblate-suboblate-oblatespheroidal; P – circular-semi-angular (Go to 4)
   EQ – oblate-suboblate-oblatespheroidal; P – rectangular (Go to 5)
   EQ – peroblate-oblate; P – circular-semi-angular (Go to 6)
   EQ – suboblate-oblatespheroidal-spheroidal; P – circular lobate; A – colpi geniculate (Go to 7)
   EQ – suboblate; P – circular-circular lobate; A – syncolpate (Go to 8)
   EQ – subprolate-prolate; P – circular; A – long colpi – not always linear (Go to 9)
   EQ – subprolate; P – semi-angular; A – long colpi, wide in the mesocolpia and triangular in the apocolpia (Go to 10)
2. _Pattern and grain size_
   Tectum granulate, sexine echinate: well-spaced echinae; 55–56 μm:...........**Cucurbitaceae sp. (*Kaya udan*)** (Plate 5, figure 6)
   Granulate; 22–33 μm:.............................. ***Gomphostemma javanicum*** (Plate 9, figure 12)
   Reticuloid: 35–41 μm:.....................***Persicaria chinense*** (Plate 13, figure 8)
   Reticulate; weakly defined colpi; occasionaly 4-colpate: 16–24 μm:.....................***Curanga felterrae*** (Plate 17, figure 9)
3. Granulate; 22–33 μm:..............***Gomphostemma javanicum*** (Plate 9, figure 12)
4. Microreticulate, reticulum compact and muri appear raised; 20–25 × 24–32 μm: ....***Shorea monticola*** (Plate 7, figure 7)
   Reticulate; 25–33 μm:................***Callicarpa sp.*** (Plate 9, figure 11);
   27–46 × 33–49 μm:..........***Chassalia curviflora*** (Plate 15, figure 6)
5. Reticulate; 27–46 × 33–49 μm:..........***Chassalia curviflora*** (Plate 15, figure 6)
6. Both verrucate and finely reticulate; 13–17 × 17–22 μm:.....***Vatica albiramis*** (Plate 7, figure 8)
7. Scabrate-finely granulate; 20–22 × 21–25 μm:...............................***Aeginetia indica*** (Plate 17, figure 8)
8. Reticulate; 17–26 × 25–30 μm:.................. ***Ternstroemia*** (Plate 19, figure 2)
9. Reticulate; 35.5–41 × 29–31 μm:.......***Lindernia ruelloides*** (Plate 18, figure 2)
10. Reticulate; 21–27 × 24–27 μm:............***Vitex quinata*** (Plate 19, figure 8)

4-Zonocolpate

1. _Equatorial shape (EQ), polar view (P), pattern and size_
   EQ – rectangular-subprolate with short colpi; reticulate; 28–32 × 20–25 μm: ....***Impatiens* sp.** (Plate 4, figure 8)
   EQ – oblatespheroidal; P – circular-rectangular; reticulate; 27–46 × 33–49 μm:............. ***Chassalia curviflora*** (Plate 15, figure 6)

Polycolpate

1. _Equatorial shape (EQ), polar view (P), pattern and size_
   6-colpoidate with 3 long and 3 short colpi, reticulate, peroblate in equatorial view and circular in polar view; 12–17 × 22–25 μm:.... ***Schizandra kadsura*** (Plate 17, figure 7)

3-colporate

1. _Equatorial (EQ), polar (P) view and porel endoaperture (A)_
   <u>EQ – spheroidal, P – circular</u>
   A – colpi with circular-square pores, which are large in proportion to grain size (Go to 2)
   A – colpi with circular pores, which are not large in proportion to grain size; long ectocolpi (Go to 3)
   A – colpi with circular pores; short elongated endocolpi present (Go to 4)
   A – colpi with lalongate elliptic-rectangular endoapertures, fastigium evident (Go to 5)
   A – colpi with lalongate elliptic-rectangular endoapertures, fastigium not evident (Go to 6)
   A – colpi with lalongate rectangular endoapertures. The endoapertures almost meet to form an equatorial belt. Pores are square. Apertures are apolar (Go to 7)

<u>EQ – spheroidal-prolatespheroidal, P – circular</u>

A – colpi with lanlongate elliptic-rectangular endoapertures, fastigium not evident (Go to 8)

A – colpi with lanlongate elliptic-rectangular endoapertures forming equatorial belt, fastigium present and pores are operculum (Go to 9)

A – colpi with lanlongate elliptic-rectangular endoapertures forming equatorial belt, fastigium present; pores are not operculum (Go to 10)

<u>EQ – spheroidal or subprolate, P – circular</u>

A – colpi with lanlongate elliptic-rectangular endoapertures. Distinctly raised sexine over apertures (Go to 12)

A – colpi with lanlongate elliptic-circular endoapertures. Sexine is not distinctly raised (Go to 13)

<u>EQ – spheroidal, P – semi-angular-triangular</u>

A – colpi with lanlongate elliptic-circular endoapertures. Distinctly raised sexine over apertures (Go to 11)

A – colpi with small-medium circular pores (Go to 14)

A – colpi with lanlongate elliptic-circular-square-rectangular endoapertures. Without distinctly raised sexine over apertures (Go to 15)

A – ectocolpi fastigate, forming square, often bulging endoapertures (Go to 20)

<u>EQ – prolatespheroidal-subprolate, P – circular or semi-angular</u>

A – colpi with lanlongate elliptic-circular endoapertures. Distinctly raised sexine over apertures (Go to 16)

A – colpi with lanlongate elliptic-circular endoapertures. A distinctly raised sexine is not evident over apertures (Go to 17)

A – parasyncolporate with lalongate elliptic endoapertures (Go to 18)

A – ectocolpi fastigate, endocolpi small lalongate-circular (Go to 19)

A – H-shaped endoapertures (Go to 21)

<u>EQ – prolate-perprolate, P – circular</u>

A – colpi with circular pores (Go to 22)

A – very short lolongate colpi with circular pores. Sexine distinctly raised over the pores (Go to 23)

A – colpi with lalongate elliptic-rectangular endoapertures (Go to 24)

<u>EQ – prolate-perprolate, P – circularlobate</u>

A – colpi with lalongate ellipititic endoapertures (Go to 25)

<u>EQ – prolate-perprolate, P – semi-angular</u>

A – thick ectocolpi. Many have lalongate endocolpi, although not all (Go to 26)

A – colpi with lanlongate elliptic-circular endoapertures. Without distinctly raised sexine over apertures (Go to 15)

<u>EQ – suboblate-oblatespheroidal-spheroidal; P – circular-semi-angular</u>

A – colpi with lalongate circular, elliptic or rectangular endoapertures. Ectoapertures are not short (Go to 27)

A – colpi with lalongate circular, elliptic or rectangular endoapertures. Ectoapertures are not short; large pores; sexine and nexine separate at the apertures (Go to 28)

A – colpi with lalongate rectangular-elliptic endoapertures. Operculum present – not circular. Ectoapertures are not short (Go to 29)

A – colpi with lalongate rectangular-elliptic endoapertures. Operculum present – circular. Ectoapertures are not short (Go to 30)

A – colpi with lalongate circular, elliptic or rectangular endoapertures, ectoapertures are short (Go to 31)

A – colpi with small-medium circular pores (Go to 32)

A – short lalongate colpi with circular pores, thickening around pores (Go to 33)

A – endoapertures restricted in the centre forming a lalongate bow-tie shape (Go to 34)

A – 3-colporate with a pontoperculum. Pores are large and square in shape (Go to 36)

<u>EQ – oblatespheroidal-spheroidal; P – hexagonal</u>

A – 3-colporate with lalongate elliptic endoapertures (Go to 35)

<u>EQ – oblatespheroidal-subprolate; P – triangular-semi-angular</u>

A – 3-colporate with large circular-square pores. Pores often bulging. Sexine is distinctly raised over apertures (Go to 37)

<u>EQ – peroblate-oblate-suboblate, P – semilobate-subangular-triangular</u>

A – 3-syncolporate (Go to 38)

A – 3-brevicolporate (Go to 39)

A – 3-parasyncolporate (Go to 40)

A – zonoaperturate with H-shaped endoapertures (Go to 41)

A – zonoaperturate without H-shape (Go to 42)

<u>EQ – rhomboidal-prolatespheroidal-subprolate; P – circular-semi-angular</u>

A – colpi with lanongate elliptic endoapertures (Go to 43)

2. *<u>Pattern and grain size in equatorial view</u>*

Psilate, pollen grains 10–12 μm: ***Saurauia actinidiifolia*** (Plate 2, figure 1), ***Saurauia glabra*** (Plate 2, figure 2), ***Saurauia ridleyi*** (Plate 2, figure 3);

9–10 × 10–11 μm:....................................... ***Elaeocarpus griffithii*** (Plate 7, figure 9)

3. Lacunate with gemmae on the tectum; 28–44 μm (average 30 μm): ....***Elephantopus scaber*** (Plate 4, figure 5)
   Reticulate; 26–32 × 27–37 μm:.....***Mussaenda hirsuta*** (Plate 16, figure 3)
   Baculate; 65–67 μm:..........**Cucurbitaceae sp. a** (Plate 5, figure 8)
   Granulate; 16–23 × 20–24 μm:................***Trigobalanus verticillatus*** (Plate 9, figure 6)
4. Finely reticulate; 72–78 μm:......***Trichosanthes kinabaluensis*** (Plate 5, figure 4)
5. Finely reticulate; pollen grains 20–22 × 20–23 μm:...***Arthrophyllum* sp.** (Plate 2, figure 14); 20–26 × 23–28 μm:...........***Schefflera avenis*** (Plate 2, figure 15)
6. Reticulate; 25–30 μm:.....................***Hedyotis* sp.** (Plate 16, figure 1)
   Micro reticulate; 34–45 μm:..........***Melochia corchorifolia*** (Plate 18, figure 7) Micro reticulate-scabrate; 12 × 17 μm...........***Acalypha caturus*** (Plate 8, figure 1)
7. Finely reticulate; 27–38 × 32–38 μm:.......... ***Exallage* sp.** (Plate 15, figure 7)
8. Finely reticulate; 25–26 μm:..................***Carica papaya*** (Plate 6, figure 3)
9. Striato-reticulate; 17–25 μm:......***Ixora otophora*** (Plate 16, figure 2)
10. Granulate; 22–24 μm:.............***Solanum torvum*** (Plate 18, figure 6)
11. Reticulate. Reticulum becomes smaller towards the colpi; pollen grains 27 × 32 μm:.... ....***Aralia montana*** (Plate 2, figure 12)
12. Finely reticulate; 15.25–19.5 × 21–23.5 μm:..... ***Melicope incana*** (Plate 17, figure 2)
13. Reticulate (Small-medium reticulum). Muri are simplicolumellate; 24–38 × 31–47 μm:............ ....***Viburnum sambucinum*** (Plate 6, figure 2)
    Reticulate-Muri are not simplicolumellate; 17–22 × 20–23 μm:... ....***Cratoxylum sumatranum*** (Plate 6, figure 7)
    Reticulate; 10–13 × 12–14 μm:................. ***Pericampylus glaucus*** (Plate 12, figure 8)
    Incomplete reticulate-perforate; 48–62 × 48–73 μm:.......***Grewia umbellate*** (Plate 20, figure 2)
14. Granulate and echinate; 20–23 × 23–25 μm: ***Vernonia* sp.** (Plate 4, figure 7)
15. Granulate; 20–26 μm:.......................***Euthemis minor*** Plate 14, figure 1)
    Finely reticulate/micro reticulate; 13–17 × 15–18 μm:. . ... ***Ardisia pterocaulis*** (Plate 12, figure 10); 15 × 18 μm:.. . .. ***Embelia* sp** (Plate 12, figure 11);
    34–45 μm:...............(thickening around apertures) ***Melochia corchorifolia*** (Plate 18, figure 7)
16. Reticulate; 20–25 × 25–28 μm:.........***Aralia scandens*** (Plate 2, figure 13)
17. Reticulate; 10.5–11 × 12–13 μm:............... ***Baccaurea lanceolata*** (Plate 8, figure 2);
    16–18 × 20–22 μm:.............***Euodia malayana*** (Plate 17, figure 3)
    Granulate; 11–16 × 19–22 μm:......***Castanopsis acuminatissima*** (Plate 9, figure 3)
    Psilate-scabrate; 14–18 × 16–18 μm:......... ***Aeschynanthus magnificus*** (Plate 9, figure 8)
18. Psilate-scabrate; 15–18 × 18–20 μm:......... ***Aeschynanthus longicaulis*** (Plate 9, figure 7) and occasionally.......***Aeschynanthus magnificus*** (Plate 9, figure 8)
19. Finely reticulate; 11–21 × 16–25 μm:....... ***Dichroa febrifuga*** (Plate 9, figure 9)
20. Suprastriate; 23–33 × 32–35 μm:............. ***Rubus moluccanus*** (Plate 15, figure 3)
    Finely striate; 19–22 μm:.........***Rubus rosifolia*** (Plate 15, figure 4)
21. Granulate with regularly spaced gemmate; 18–21 × 20–21 μm:... ....***Scyphostegia borneensis*** (Plate 18, figure 4)
22. Heterobrochate, pollen grains 16–25 × 24–37 μm:.............***Rungia* sp** (Plate 1, figure 5)
23. Psilate; 40–50 × 52–62.5 μm:...........***Bauhinia finlaysoniana*** (Plate 8, figure 11)
24. Scabrate; 10–13 × 15–18 μm:.............. . ..... ***Clethra longispicata*** (Plate 6, figure 5); 10–12 × 16–19 μm:...***Lithocarpus andersonii*** (Plate 9, figure 4); 8–11 × 13–20 μm:.....***Lithocarpus ewyckii*** (Plate 9, figure 5)
    Suprareticulate and perforate; 22–25 × 30–33 μm:..***Microcos erythrocarpa*** (Plate 19, figure 4)
    Reticulate; 17–20 × 37–44 μm***Triumfetta* sp** (Plate 19, figure 5)
25. Scabrate; 7–21 μm:...........***Begonia* sp.** (Plate 4, figure 9), ***Begonia* sp.** (Plate 4, figure 10)
26. Finely reticulate-perforate with a granular infratectum; 18.5–20 × 20–22.5 μm: ....***Fordia splendidissima*** (Plate 9, figure 1)
27. Clavate; 17 × 22 μm:............................ . .. ***Ilex cymosa*** (Plate 2, figure 8)
    Granulate; 18–20 μm:........................ ***Garcinia mangostana*** (Plate 6, figure 8)
    Scabrate; 12–18 × 18–23 μm:.................... ***Daphniphyllum borneense*** (Plate 7, figure 5)
    Reticulate; 15–19.5 μm:. . .. (circular pores) **Euphorbiaceae sp.** (Plate 8, figure 10)

Reticulate (thickening around apertures); 35–56 µm:.......***Psychotria robusta*** (Plate 16, figure 7)

Micro/finely reticulate; 11–13 × 13 µm:........ ***Macaranga costulata*** (Plate 8, figure 6)

Finely reticulate; 14–18 × 18–20 µm:........... ***Mallotus paniculatus*** (Plate 8, figure 7);

Finely reticulate, thickening around apertures and endoapertures almost form an equatorial belt; 17–21 µm:.............................. ***Spermacoce ocymoides*** (Plate 16, figure 8)

10–16 × 15–17 µm:........................***Chionanthus pluriflorus*** (Plate 14, figure 2

28. Reticulate; 20–24 × 20–25 µm:................ ***Pleiocarpidia borneensis*** (Plate 16, figure 5); 16–22 × 19.5–26 µm:................................ ***Pleiocarpidia* sp.** (Plate 16, figure 6)
29. Finely reticulate; 18–21 × 20–24 µm:............. ***Mallotus* sp.** (Plate 8, figure 8)
30. Finely reticulate; 14–16 × 15–17 µm:........... ***Tarenna* sp.** (Plate 16, figure 9)
31. Gemmate and granulate between the gemmae; 10–12 µm:.. ***Garcinia* sp.** (Plate 6, figure 9)
32. Granulate and echinate. Smaller echinae appear between the main echinae; 25–35 µm:........***Vernonia arborea*** (Plate 4, figure 6) Reticulate; 27–32 × 33–39 µm:.........***Fagraea racemosa*** (Plate 10, figure 4)

    Reticulate-striate reticulate. Reticulum becomes smaller at the poles; 27–28 × 28–30 µm:........ ....***Fagraea stenophylla*** (Plate 10, figure 5)
33. Scabrate; > 50 µm:.........***Durio cariatus*** (Plate 5, figure 1)
34. Scabrate; 17–19 × 19–21 µm:........................ ***Limnophila* sp.** (Plate 18, figure 1); 18–20 × 20–22 µm...........**Scrophulariaceae *sp.*** (Plate 18, figure 3)
35. Reticulate; 16–19 × 17–20 µm:..........***Melicope triphylla*** (Plate 17, figure 4)
36. Reticulate; 32.5–35 × 40–45 µm:...........***Schima noronhae*** (Plate 19, figure 1)
37. Tectum on top of a thick layer of columellae, both perforate and rugulate; 41–45 × 44–57 µm:.. ***Gordonia borneensis*** (Plate 20, figure 1)

    Rugulate; 20–30 × 26–36 µm:.......***Pyrenaria kunstleri*** (Plate 18, figure 8)
38. Granulate; 25–33 µm:........***Scurrula parasitica*** (Plate 12, figure 1);

    31–33 µm...................***Dendrophthoe pentandra*** (Plate 10, figure 6);

    42–59 µm:.................***Lepeostegeres centiflorus*** (Plate 11, figure 3)
39. Scabrate; 20–22 µm:........***Helixanthera spicata*** (Plate 10, figure 7)
40. Granulate; 12–15 × 21–24 µm:................... ***Decaspermum fruticosum*** (Plate 12, figure 12);

    10–14 × 18–20 µm:........***Psidium guajava*** (Plate 12, figure 13);

    22.5–24 × 24.5–28 µm:......***Guioa bijuga*** (Plate 17, figure 6)

    Scabrate; 10 × 11–15 µm:.......................... ***Syzygium fastigiatum*** (Plate 12, figure 14);

    9–10 × 15–18 µm:...................................... ***Syzigium subcrenatum*** (Plate 12, figure 15)
41. Granulate; 16–22 × 21–24 µm:................. ***Alphitonia excelsa*** (Plate 15, figure 1)
42. Finely reticulate; 17–23 × 23–27 µm:.......... ***Ophiorrhiza pallidula*** (Plate 16, figure 4)
43. Finely reticulate, 15–21 × 20–24 µm:.......... ***Hydrocotyle javanica*** (Plate 2, figure 5)

    Finely reticulate–perforate, 18–20 × 22–24 µm:..........***Hydrocotyle sibthorpioides*** (Plate 1, figure 6)

4-colporate

1. _Equatorial (EQ) and polar (P) view and aperture (A)_

   EQ – suboblate-oblatespheroidal; P – circular; A – lalongate circular-elliptic endoapertures (Go to 2)

   EQ – spheroidal-prolate spheroidal; P – circular; A – small circular pores (Go to 3)

   EQ – spheroidal-prolate spheroidal; P – circular; A – lalongate elliptic (Go to 4)

   EQ – prolate-perprolate; P–Rectangular; A–long colpi with circular pores (Go to 5)

   EQ–Prolatespheroidal-subprolate-rhomboidal; P – circular-semi-angular; A – lanongate elliptic (Go to 6)
2. _Pattern and grain size_

   Granulate; 18–23 × 22–26 µm:........***Leuconotis anceps*** (Plate 2, figure 7)

   Finely reticulate; thickening around apertures and endoapertures almost form an equatorial belt; 17–21 µm:..............***Spermacoce ocymoides*** (Plate 16, figure 8)
3. Reticulate and 17–21 × 20–22 µm:................ ***Glochidion monostylum*** (Plate 8, figure 5)
4. Reticulate – reticulum becomes smaller towards the colpi; sexine larger than nexine; 23–27 × 23–27 µm:..............***Citrus sp.*** (Plate 17, figure 1)

   Reticulate – reticulum heterobrochate but does not become smaller towards the colpi; 4-colporate grains also tend to be apolar; 25–30 µm:.....***Hedyotis* sp.** (Plate 16, figure 1)
5. Finely reticulate; 12–15 × 18–25 µm:.......... ***Phyllanthus urinaria*** (Plate 8, figure 9)

6. Finely reticulate; 15–21 × 20–24 μm:............ ***Hydrocotyle javanica*** (Plate 2, figure 5)
   Finely reticulate-perforate; 18–20 × 22–24 μm:..........***Hydrocotyle sibthorpioides*** (Plate 1, figure 6)

Polycolporate

1. *Equatorial (EQ), polar (P) view and pore/endoaperture (A)*
   EQ – suboblate, P – circular; A – 6–7 colporate with small circular pores (Go to 2)
   EQ – prolate-spheroidal, P – circular; A – 4–5 colporate with circular pores (Go to 3)
   EQ – prolate-spheroidal, P – circular; A – 10–12 colporate with circular pores (Go to 4)
2. *Pattern and grain size*
   Reticulate; 14.5–15 × 19–21 μm:........***Breynia racemosa*** (Plate 8, figure 3)
3. Reticulate; 23 × 29 μm:...............***Glochidion* sp.** (Plate 8, figure 4)
4. Scabrate; 30–41 × 37–46 μm:..........***Salomonia cantoniensis*** (Plate 13, figure 6)
   Scabrate; 17 × 30.5 μm:.........***Polygala paniculata*** (Plate 14, figure 12)

Heterocolporate

1. *2-colporate and 4 colpate* (Go to 2)
   3-colporate and 3 to ≥ 6 colpate (Go to 3)
   3–4 colporate and 3 to ≥6 colpate (Go to 4)
2. *Equatorial shape and pattern*
   Prolate and finely reticulate:................***Rungia* PTNP1** (Plate 1, figure 6)
3. *Equatorial (EQ), polar shape (P) and aperture (A)*
   EQ – prolate-subprolate-perprolate; P – circular; A – circular (Go to 5)
   EQ – prolate-spheroidal-prolatespheroidal; P – circular; A – circular pores; colpi are syncolpate (Go to 6)
   EQ – prolate-spheroidal-prolatespheroidal; P – circular; A – circular; colpi are not syncolpate (Go to 7)
   EQ – prolate-spheroidal-prolatespheroidal; P – interhexagonal; A – lalongate (Go to 8)
   EQ – spheroidal-oblate spheroidal; P – triangular; A – lalongate (Go to 9)
   EQ – spheroidal-oblate spheroidal; P – inter-hexagonal; A – lalongate (Go to 10)
4. *Equatorial (EQ) and polar shape (P)*
   EQ – spheroidal-prolate-spheroidal (Go to 11)
   EQ – rhomboidal and P – inter-hexagonal (go to 12)
5. *Pattern and grain size*
   Microreticulate; 54–67 × 95–102 μm:......... ***Strobilanthes sp.* a** (Plate 1, figure 7)
   Microreticulate-perforate; 30–40 × 21–26 μm:......***Justicia gendarussa*** (Plate 1, figure 2)
   Bireticulate; 33–51 × 73–93 μm:................ ***Strobilanthes sp.* b** (Plate 1, figure 8)
6. Reticulum constructed out of tightly packed columellae; 34–45 × 42–48 μm: .... **Acanthaceae *sp.* b** (Plate 1, figure 10)
7. Gemmate; 33–47 × 52–55 μm:.. .... **Acanthaceae *sp.* a** (Plate 1, figure 9)
   Reticulate and collumelate; 57–68 × 65–81 μm:......**Acanthaceae *sp.* c** (Plate 1, figure 11)
   Columellae arranged in a reticulate pattern and simplibaculate; 51–62 × 58–67 μm:........ ....***Pseuderanthemum* sp.** (Plate 1, figure 4)
   Clavate; 39–70 μm:....................................... ***Hemigraphis sp.*** (Plate 1, figure 1)
8. Scabrate; 10–13 × 16–20 μm:.........***Dissochaeta monticola*** (Plate 12, figure 3);
   9–14 × 13–15 μm:..........***Medinella crassifolia*** (Plate 12, figure 4);
   11–17 × 16–20 μm:................***Melastoma malabathricum*** (Plate 12, figure 5)
9. Scabrate; 16–18 μm:...............***Pachycentria pulverulenta*** (Plate 12, figure 6)
10. Microreticulate; 16 × 16–18 μm:............... ***Pternandra tesselata*** (Plate 12, figure 7)
11. Reticulate (Reticulum made up of free-standing columellae:....................***Peristrophe bivalvis*** (Plate 1, figure 3)
12. Granulate; Colpi form an apocolpium; sexine distinctly raised over the endoapertures:. ***Tournefortia* sp.** (Plate 4, figure 12)

Zona-aperturate

(1) *Equatorial shape, pattern and size*
Subspheroidal; coarsely granulate and perforate; 44–57 × 53–72 μm:.....................**Annonaceae *sp.*** (Plate 3, figure 1)
Spheroidal-suboblate; granulate; 21–28.5 × 25–32 μm:.............***Alocasia princeps*** (Plate 2, figure 9)
Spheroidal and reticulate; 39–42 × 40–48 μm:..... ***Areca* sp.** (Plate 3, figure 2)
Spheroidal; echinate but granulate between the echinae. Echinae are irregularly spaced; 54–75 μm:. . .**Cucurbitaceae sp.** (Plate 5, figure 7)

1-sulcate

1. *Equatorial shape*
   Spheroidal-subspheroidal-suboblate-oblate-prolatespheroidal (Go to 2)

Subprolate-prolate-perprolate (Go to 3)
Bean-shaped-spheroidal (Go to 4)

2. *Pattern and grain size*
   Finely reticulate-perforate; 24–55 μm:......... ***Ananas comosus*** (can also be pantoporate) (Plate 6, figure 1)
   14–17 × 17–19 μm:........................ . .. . .. ***Daemonorops fissa*** (Plate 3, figure 5); Finely/microreticulate; 21–33 × 30–36 μm:..... ***Ophiopogon caulescens*** (Plate 10, figure 3)
   Scabrate; 10–14 × 12–15 μm:. . ... ***Homalomena sagittifolia***) (Plate 2, figure 10); 7–11 × 10–13 μm;........................ . .***Piper umbellatum*** (Subspheroidal) (Plate 14, figure 10)
   Granulate; 35–50 × 46–70 μm:. . .....***Cocos nucifera*** (Plate 3, figure 4); 25–27 × 27–30 μm:... ***Licuala valida*** (Plate 3, figure 7)
   Granulate-rugulate; 26–31 × 32–40 μm:........ ***Curculigo latifolia*** (Plate 9, figure 10)
   Echinate-clavate; 21–23 × 27–30 μm:.......... ***Korthalsia rostrata*** (Plate 4, figure 1); gemmate; 12–19 μm (occasionally 3-sulcate):...............................***Smilax leucophylla*** (Plate 18, figure 5)
   Clavate; 25–31 × 33–38 μm:........***Oncosperma horridum*** (Plate 4, figure 2)
   Tectum psilate, sexine urceolated; 30–34 × 33–42 μm:.............. ***Pinanga aristata*** (Plate 4, figure 3) Foveolate; 17–23 × 20–27 μm:...... ***Calamus marginatus*** (Plate 3, figure 3)
3. Hamulate and reticulate; 49–64 × 36–43 μm:... ***Eugeissona utilis*** (Plate 3, figure 6)
   Gemmate-regularly spaced; 25–27 × 20–24 μm:................***Asparagus* sp.** (Plate 4, figure 4);
   Gemmate-irregularly spaced; 15–21 × 21–26 μm:............. ***Floscopa scandens*** (Plate 7, figure 1)
   Granulate; 19–28 × 38–44 μm:..................... ....***Amischotolype griffithii*** (Plate 6, figure 10); 11–13 × 12–18 μm:......................... **Commelinaceae sp**. (Plate 7, figure 2)
   Verrucate with coarse granulate pattern; 11–17 × 26–30 μm:.......***Cyanotis ciliata*** (Plate 6, figure 11)

2-sulcate

1. *Equatorial shape, pattern and grain size*
   Subspheroidal-prolate; granulate; 10–13 × 13–18 μm:.................***Dioscorea bulbifera*** (Plate 7, figure 6)

Trichotomosulcate

1. *Equatorial view and pattern*
   Spheroidal-suboblate-prolatespheroidal and granulate; 11–15 × 15–22 μm:
   ....***Piptospatha grabowski*** (Plate 2, figure 11)

Tetrad

1. *Size*
   28–48 μm (Go to 2)
   23–28 μm (Go to 3)
   85–90 μm (Go to 4)
2. *Pattern*
   Granulate:......................................***Vaccinium laurifolium*** (Plate 7, figure 12), ***Vaccinium coriaceum*** (Plate 7, figure 11), ***Rhododendron durionifolium*** (Plate 7, figure 10)
3. Gemmate:............. . .. .***Nepenthes stenophylla*** (Plate 12, figure 16)
4. Psilate-granulate with pronounced apertures (labrum):***Ludwigia octovalvis*** (Plate 13, figure 3)

Polyad

1. *Polyad shape*
   Spheroidal, individual grains – square to rectangular (Go to 2)
   Square-semiangular (Go to 3)
   Pear-bell-triangular (Go to 4)
   Long rectangular-ellipse. Individual grains are subspheroidal/rectangular with 1-sulcate (Go to 5)
2. *Pattern and grain size*
   Granulate-scabrate; 80–100 μm: the polyad consists of 16 Individual grains – 21–23 × 25–35 μm:..
   ......***Pithecellobium clypearia*** (Plate 13, figure 1)
3. Reticulate; 28–33 × 35–54 μm. Individual grains – 17–21 × 24–28 μm:.......................................
   ....***Arundina graminifolia*** (Plate 14, figure 6)
   Scabrate-granulate; 20–38 × 31–52 μm. Individual grains – 11–22 × 15–22 μm:
   ....***Coelogyne* sp.** (Plate 14, figure 7)
   Scabrate-granulate; 28–54 μm. Individual grains – 17–21 × 24–28 μm:
   ....***Pholidota imbricata*** (Plate 14, figure 9)
4. Microreticulate (reticulum made up of tightly packed, free-standing columellae); 112.5–150 μm; individual grains – 10–17 × 15–23 μm:.......***Habenaria* sp.** (Plate 13, figure 4)
   Granulate-scabrate; 34–43 × 40–70 μm. Individual grains – 15–25 × 21–30 μm:
   ***Phaius* sp.** (Plate 14, figure 8)

5. Granulate and perforate; 70–75 × 137–235 μm (length varies); individual grains – 42–54 × 46–54 μm:........***Xyris complanata*** (Plate 20, figure 3)

Inaperturate

1. Equatorial shape
   Subspheroidal-spheroidal (Go to 2)
   Suboblate (Go to 3)
   Polyad (Go to **Polyad**)
2. Pattern and grain size
   Psilate and foveolate infratectum with a clavate supra-tectal layer; Size: > 100 μm:..... ***Annona muricata*** (Plate 11, figure 1)
   Granulate; 57–87 μm:.........***Musa* sp.** (Plate 13, figure 2); 75–99 μm:.......***Hornstedtia pininga*** (Plate 20, figure 7)
   Coarse granulate; 34–62 μm:.....**Zingiberaceae sp.** (Plate 20, figure 9); 64–92 μm:................ ***Etlingera brevilabrum*** (Plate 20, figure 5)
   Granulate with gemmae; 29–42 μm:.......... ***Globba propinqua*** (Plate 20, figure 6); 41–65 μm:............***Alpinia nieuwenhuizii*** (gemmae: 3.5 μm) (Plate 20, figure 4); 68–80 μm:.................***Costus speciosus*** (gemmae: 5 μm) (Plate 5, figure 3)
   Psilate-granulate with moderately-well spaced echinae; 25–35 × 30–45 μm:........................ ***Litsea crassifolia*** (Plate 10, figure 1)
   Psilate with densely spaced echinae; 18–18 × 18–31 μm:... ....***Litsea subumbelliflora*** (Plate 10, figure 2)
   Psilate plates arranged in a reticulate pattern; 47–99 μm:......................***Zingiber albiflorum*** (Plate 20, figure 8)
3. Granulate; 24–32 μm:........***Phrynium maximum*** (Plate 12, figure 2)

Spores

Monolete

Gemmate-irregularly spaced, 16–36 × 36–47 μm:... *Stenochlaena palustris* (Plate 4, figure 11)

Trilete

1. Equatorial shape
   Circular-semi angular (Go to 2)
2. Pattern and grain size
   Psilate-granulate; 35–46 μm:.....***Ophioglossum intermedium*** (Plate 14, figure 5)
   Verrucate-rugulate; 24–34 μm:.................... ***Helmynthostachys zeylanica*** (Plate 14, figure 4)

5. Pollen morphological descriptions

5.1. *Acanthaceae*

Hemigraphis sp.: N3°45′26.5″; E115°26′35.3″(Plate 1, figure 1).

Type: H, S. *Grain*: heterocolpate with 3-colporate; circular pores and > 6 pseudocolpi. *Exine*: intectate, exine thin. The exine forms several longitudinal ribs, which are made up of clavae. These coalesce at the equator. *Pattern*: clavate of varying sizes. *Clavate width*: 1–2.5 μm. *Clavate length*: 1.5–2.3 μm. *Polar view*: circular. *Equatorial view*: spheroidal. Size: *Tectum*: 1.5 μm. *Equatorial view length and width*: 39–70 μm. *Pore*: 10–12.5 μm. *Furrow width*: 3–5 μm.

Justicia gendarussa: N3°43′39.6″; E115°29′25.0″ (Plate 1, figure 2). Shrub found in secondary forest near to Pa'Dalih.

Type: H, S. Uses: M, R (Christensen 2002). *Grain*: heterocolpate with 3-colporate; lalongate pores and six pseudocolpi. Colpi extend almost the full length of grain. *Exine*: tectate-perforate; Tectum completely developed over columellae. Two distinct wall layers; *Sexine*: 1.4–1.85 μm at the equator and 1.4–1.5 μm at the poles; nexine tends to be slightly smaller: 1.5–1.7 μm at the equator and 1.14–1.5 μm at the poles. *Pattern*: microreticulate-perforate. *Polar view*: circular. *Equatorial view*: prolate-subprolate. Size: *Tectum*: 1–2 μm. *Equatorial view length and width*: 30–40 × 21–26 μm. *Pore*: 1.5–4 μm.

Peristrophe bivalvis N3°33′38.9″; E115°33′23.6″ (Plate 1, figure 3).

Type: H. Uses: E, U (Christensen 2002). *Grain*: heterocolpate with 3–4-colporate; circular pores and > 6-colpate. *Exine*: intectate with free columellae. *Columellae length*: 4.6–5.1 μm; *Nexine*: 1.8–2 μm. *Pattern*: columellae tightly arranged in a reticulate pattern (with large reticulum). Reticula are longitudinally oriented in ribs. These follow a distinct pattern: Each rib has a width spanning one reticulum (3–6 μm) and is seperated by a furrow. Ribs mainly occur in groups of two, these coalesce at the poles. Ribs are then followed by a wider reticulate area composed of free-standing columellae, spanning two reticula at the poles and three reticula at the equator. *Polar view*: circular. *Equatorial view*: spheroidal-prolate-spheroidal. Size: *Tectum*: 4–5 μm. *Equatorial view length and width*: 60–75 × 66–80 μm. *Pore*: 6–8 μm. *Furrow width*: 3–6 μm. *Reticulum*: 3–6 × 5–6 μm.

Pseuderanthemum sp.: N3°33′38.9″; E115°33′23.6″ (Plate 1, figure 4).

Type: H, S. Uses: E (Christensen 2002). *Grain*: heterocolpate with 3-colporate and 6-colpate. The colporate apertures contain circular pores and long elongated endoapertures, extending almost the full length of the grain. The six colpi are shorter than the

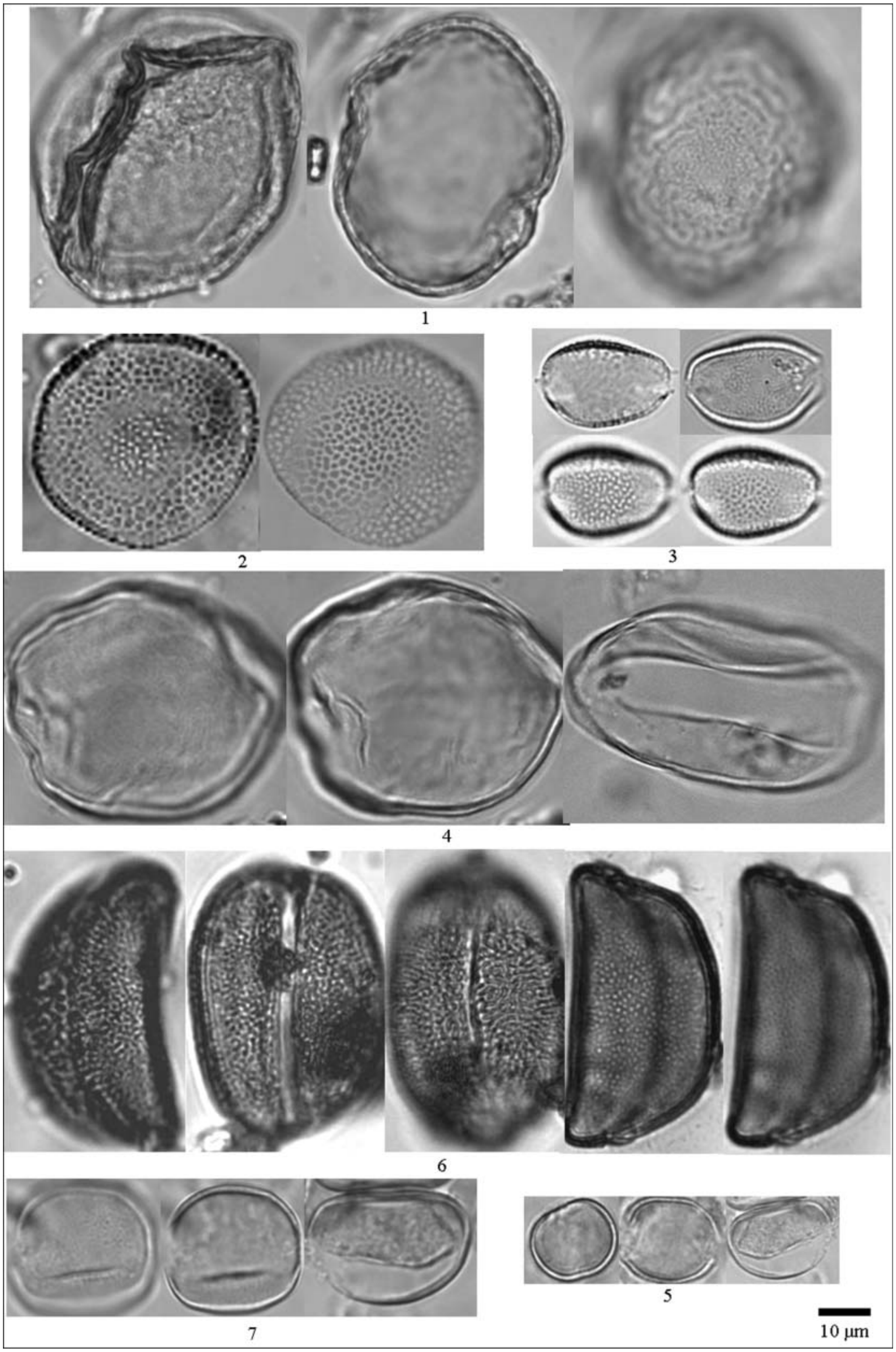

Plate 3. Photographs of pollen grains collected from the Kelabit Highlands. The reference collection is currently held at the Institut Catala de Paleoecologia Humana i Evolucio Social, Tarragona. Some of the pollen grains were also collected from the Sarawak herbarium (SAR) at Kuching. Figure 1. Annonaceae sp., 2. *Areca*, 3. *Calamus marginatus*, 4. *Cocos nucifera*, 5. *Daemonorops fissa*, 6. *Eugeissona utilis*, 7. *Licuala valida*.

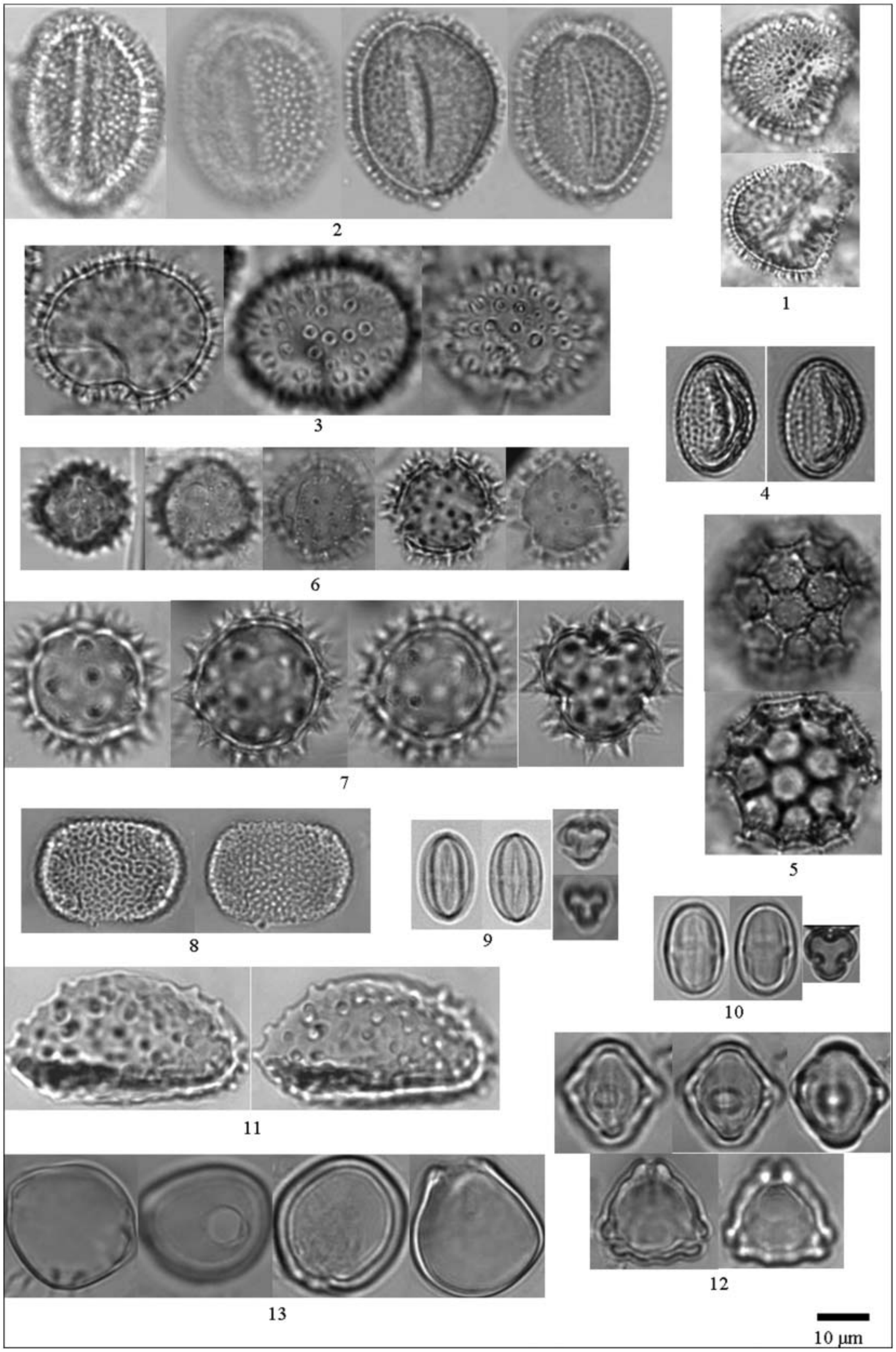

Plate 4. Photographs of pollen grains and fern spores collected primarily from the Kelabit Highlands. Some of the pollen grains were also collected from the Sarawak herbarium (SAR) at Kuching. The pollen reference collection is currently held at the Institut Catala de Paleoecologia Humana i Evolucio Social, Tarragona. Figure 1. *Korthalsia rostrata*, 2. *Oncosperma horridum*, 3. *Pinanga aristata*, 4. *Asparagus* sp., 5. *Elephantopus scaber*, 6. *Vernonia arborea*, 7. *Vernonia* sp., 8. *Impatiens* sp., 9. *Begonia* sp., 10. *Begonia* sp., 11. *Stenochlaena palustris*, 12. *Tournefortia* sp., 13. *Burmannia disticha*.

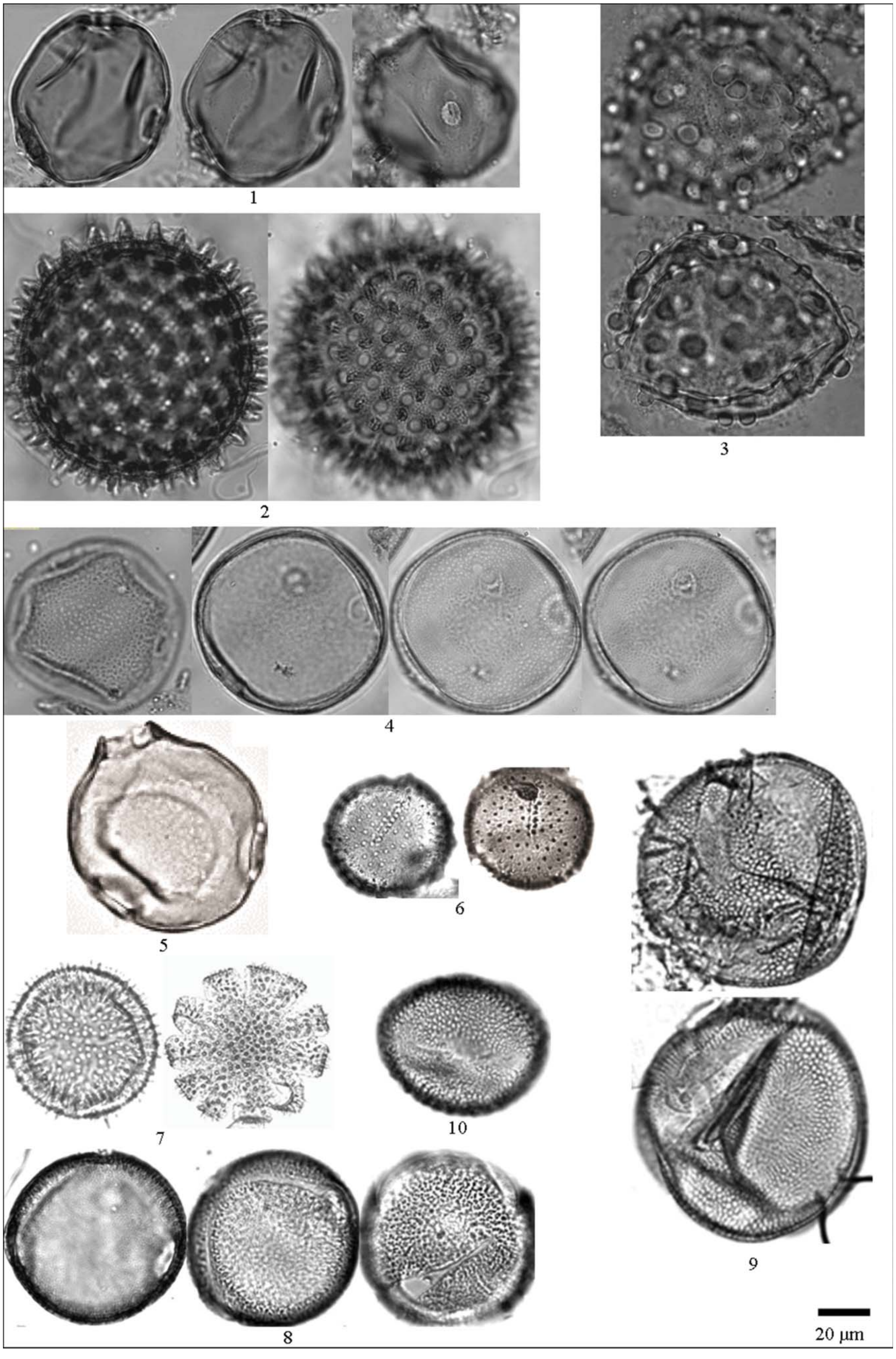

Plate 5. Photographs of pollen grains and fern spores collected primarily from the Kelabit Highlands. Some of the pollen grains were also collected from the Sarawak herbarium (SAR) at Kuching. The pollen reference collection is currently held at the Institut Catala de Paleoecologia Humana i Evolucio Social, Tarragona. Figure 1. *Durio cariatus*, 2. *Ipomoea batatas*, 3. *Costus speciosus*, 4. *Trichosanthes kinabaluensis*, 5. Cucurbitaceae sp*. cf. Cucurbita sativus* (*Timun*), 6. Cucurbitaceae sp. (*Kaya udan*), 7. Cucurbitaceae sp. (*Gocu*), 8. Cucurbitaceae sp. a., 9. Cucurbitaceae sp. b., 10. Cucurbitaceae sp. c. (Gourd/Peria).

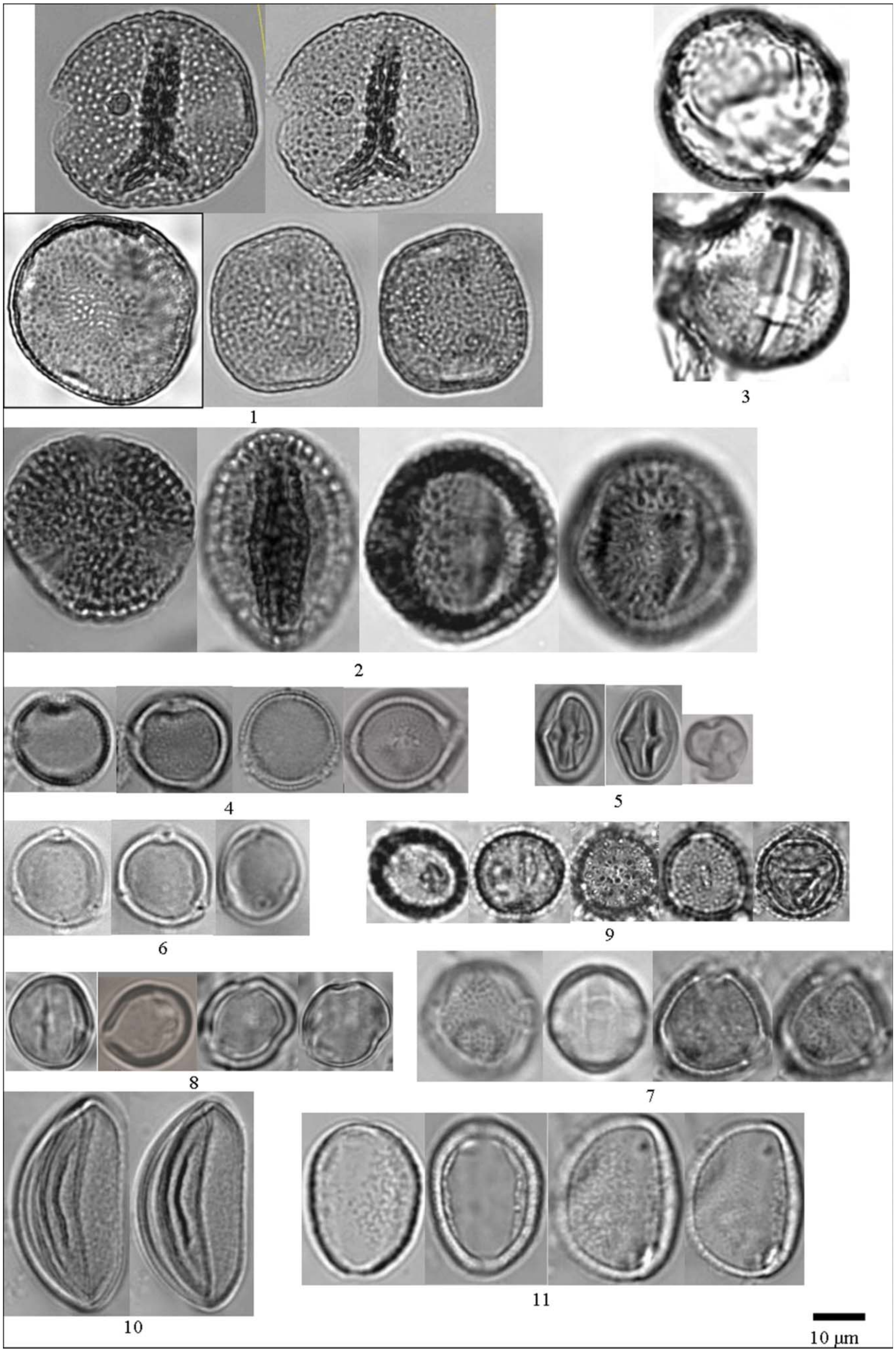

Plate 6. Photographs of pollen grains collected primarily from the Kelabit Highlands. Some of the pollen grains were also collected from the Sarawak herbarium (SAR) at Kuching. The pollen reference collection is currently held at the Institut Catala de Paleoecologia Humana i Evolucio Social, Tarragona. Figure 1. *Ananas comosus*, 2. *Viburnum sambucinum*, 3. *Carica papaya*, 4. *Chloranthus erectus*, 5. *Clethra longispicata*, 6. *Cratoxylum glaucum*, 7. *Cratoxylum sumatranum*, 8. *Garcinia mangostana*, 9. *Garcinia* sp., 10. *Amischotolype griffithii*, 11. *Cyanotis ciliata*.

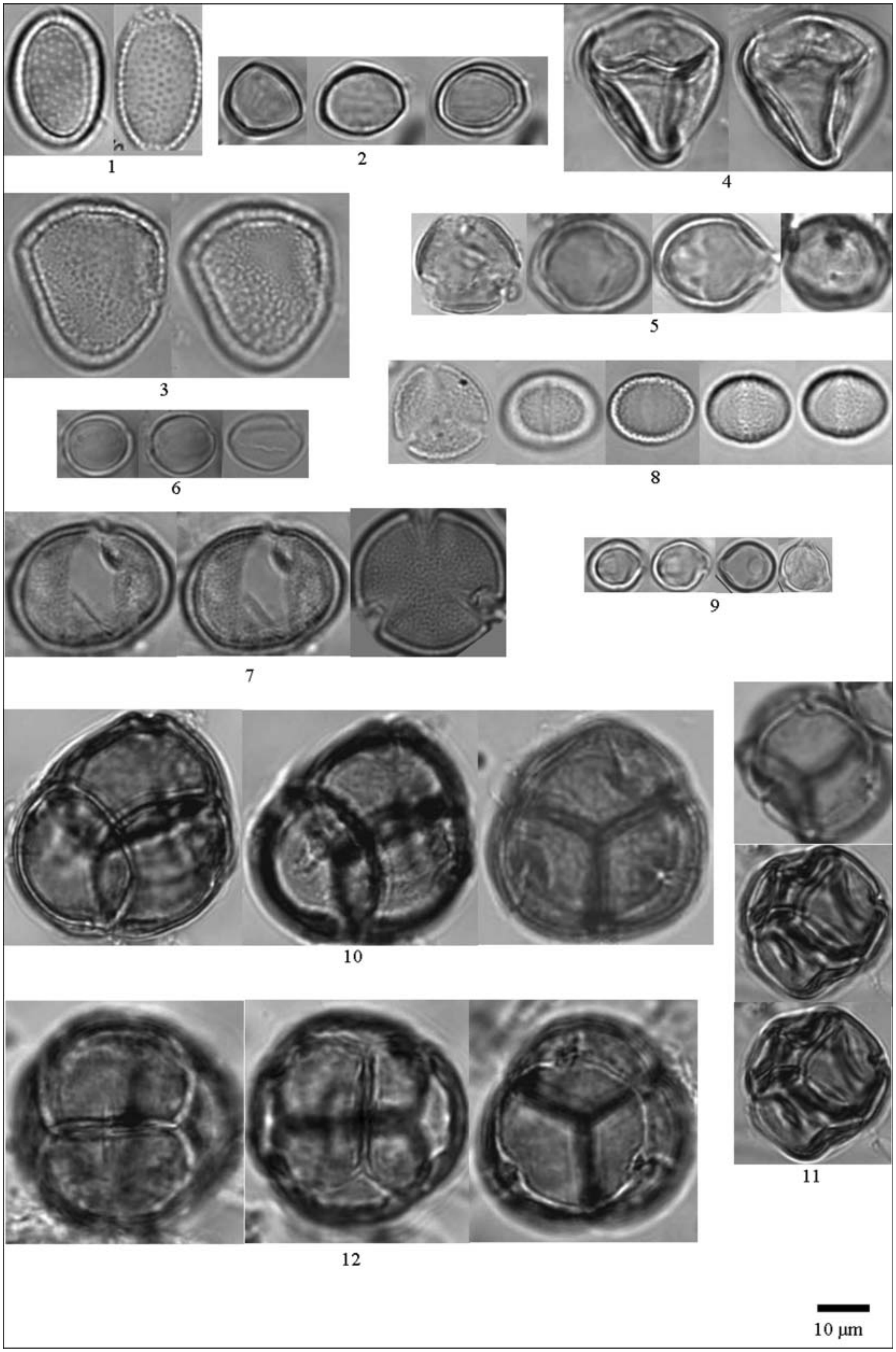

Plate 7. Photographs of pollen grains collected primarily from the Kelabit Highlands. Some of the pollen grains were also collected from the Sarawak herbarium (SAR) at Kuching. The pollen reference collection is currently held at the Institut Catala de Paleoecologia Humana i Evolucio Social, Tarragona. Figure 1. *Floscopa scandens*, 2. Commelinaceae sp., 3. *Fimbristylis globulosa*, 4. *Scleria purpurascens*, 5. *Daphniphyllum borneense*, 6. *Dioscorea bulbifera*, 7. *Shorea monticola*, 8. *Vatica albiramis*, 9. *Elaeocarpus griffithii*, 10. *Rhododendron durionifolium*, 11. *Vaccinium coriaceum*, 12. *Vaccinium laurifolium*.

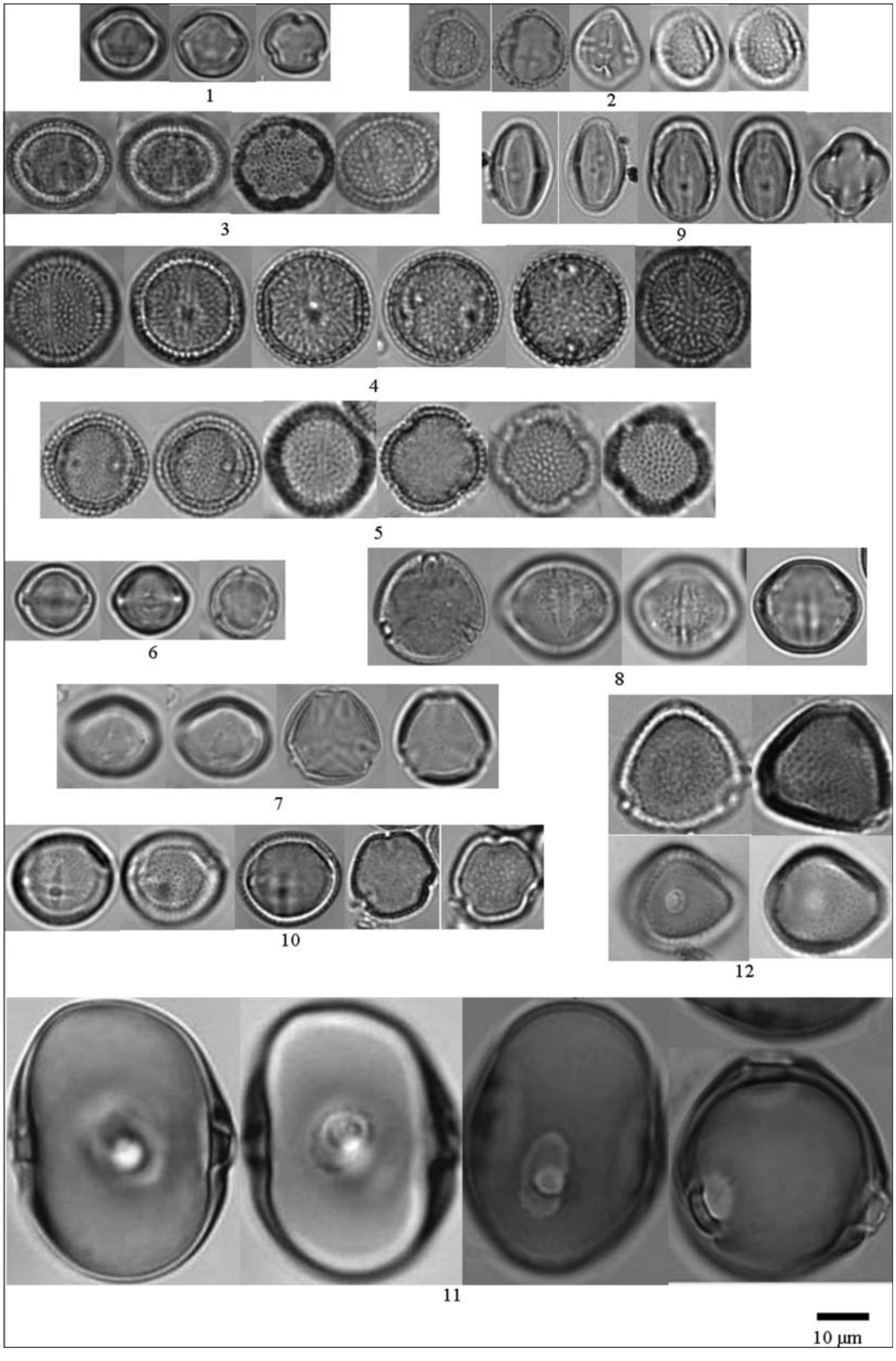

Plate 8. Photographs of pollen grains collected primarily from the Kelabit Highlands. Some of the pollen grains were also collected from the Sarawak herbarium (SAR) at Kuching. The pollen reference collection is currently held at the Institut Catala de Paleoecologia Humana i Evolucio Social, Tarragona. Figure 1. *Acalypha caturus*, 2. *Baccaurea lanceolata*, 3. *Breynia racemosa*, 4. *Glochidion* sp., 5. *Glochidion monostylum*, 6. *Macaranga costulata*, 7. *Mallotus paniculatus*, 8. *Mallotus* sp., 9. *Phyllanthus urinaria*, 10. Euphorbiaceae sp., 11. *Bauhinia finlaysoniana*, 12. *Erythina subumbrans*.

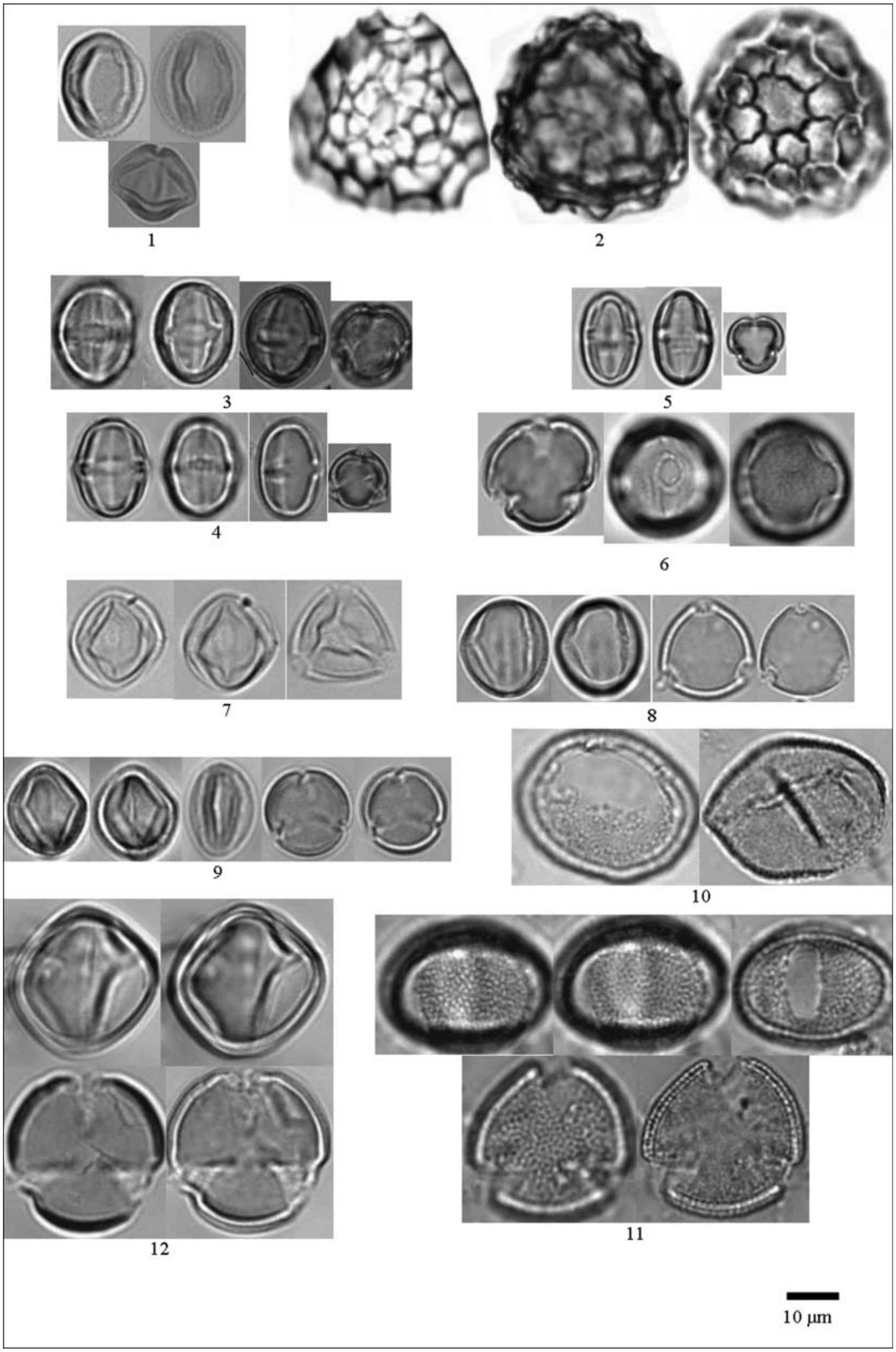

Plate 9. Photographs of pollen grains collected primarily from the Kelabit Highlands. Some of the pollen grains were also collected from the Sarawak herbarium (SAR) at Kuching. The pollen reference collection is currently held at the Institut Catala de Paleoecologia Humana i Evolucio Social, Tarragona. Figure 1. *Fordia splendidissima*, 2. *Vigna* sp., 3. *Castanopsis acuminatissima*, 4. *Lithocarpus andersonii*, 5. *Lithocarpus ewyckii*, 6. *Trigobalanus verticillatus*, 7. *Aeschynanthus longicaulis*, 8. *Aeschynanthus magnificus*, 9. *Dichroa febrifuga*, 10. *Curculigo latifolia*, 11. *Callicarpa* sp., 12. *Gomphostemma javanicum*.

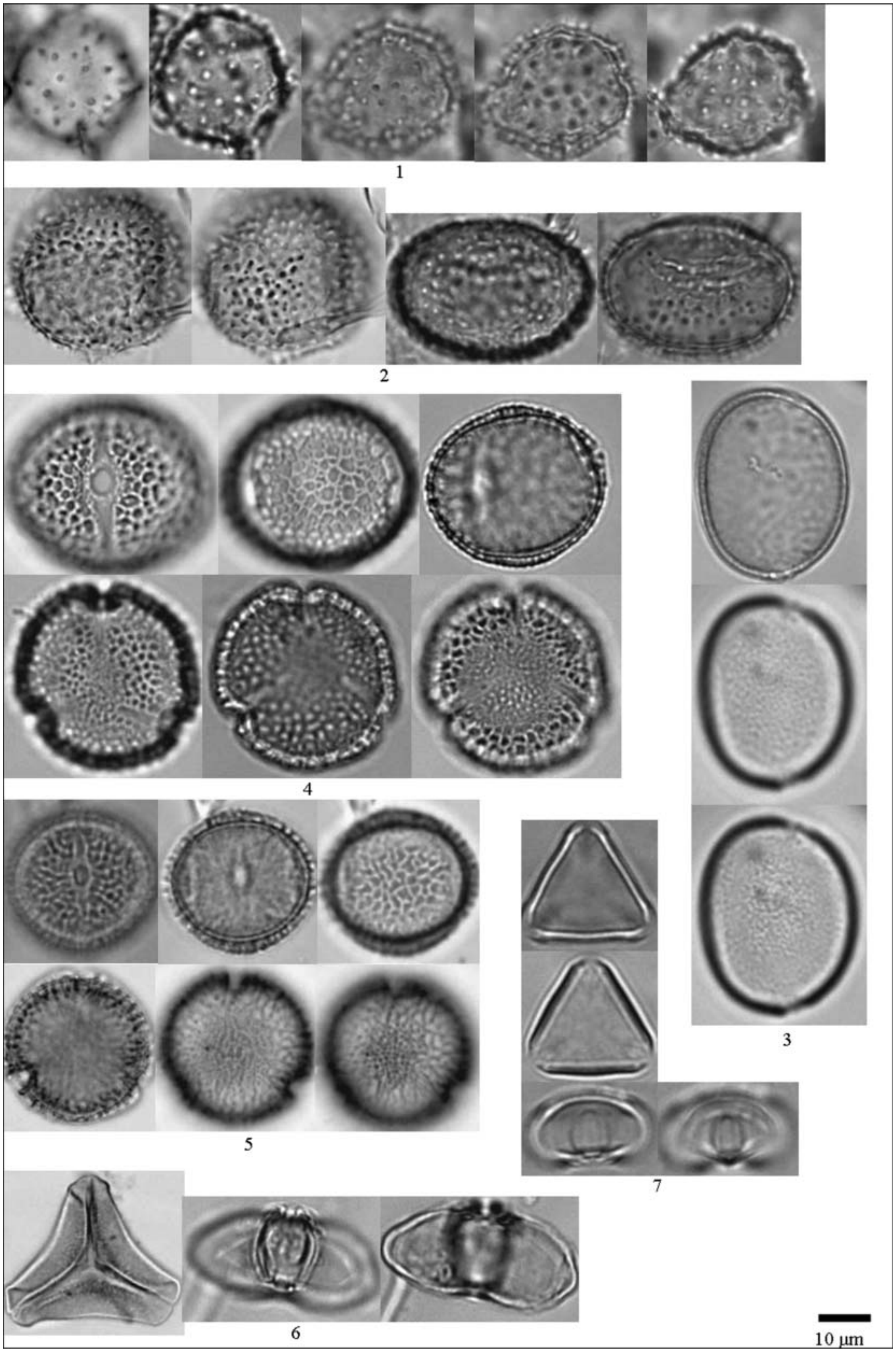

Plate 10. Photographs of pollen grains collected primarily from the Kelabit Highlands. Some of the pollen grains were also collected from the Sarawak herbarium (SAR) at Kuching. The pollen reference collection is currently held at the Institut Catala de Paleoecologia Humana i Evolucio Social, Tarragona. Figure 1. *Litsea crassifolia*, 2. *Litsea subumbelliflora*, 3. *Ophiopogon caulescens*, 4. *Fagraea racemosa*, 5. *Fagraea stenophylla*, 6. *Dendrophthoe pentandra*, 7. *Helixanthera spicata*.

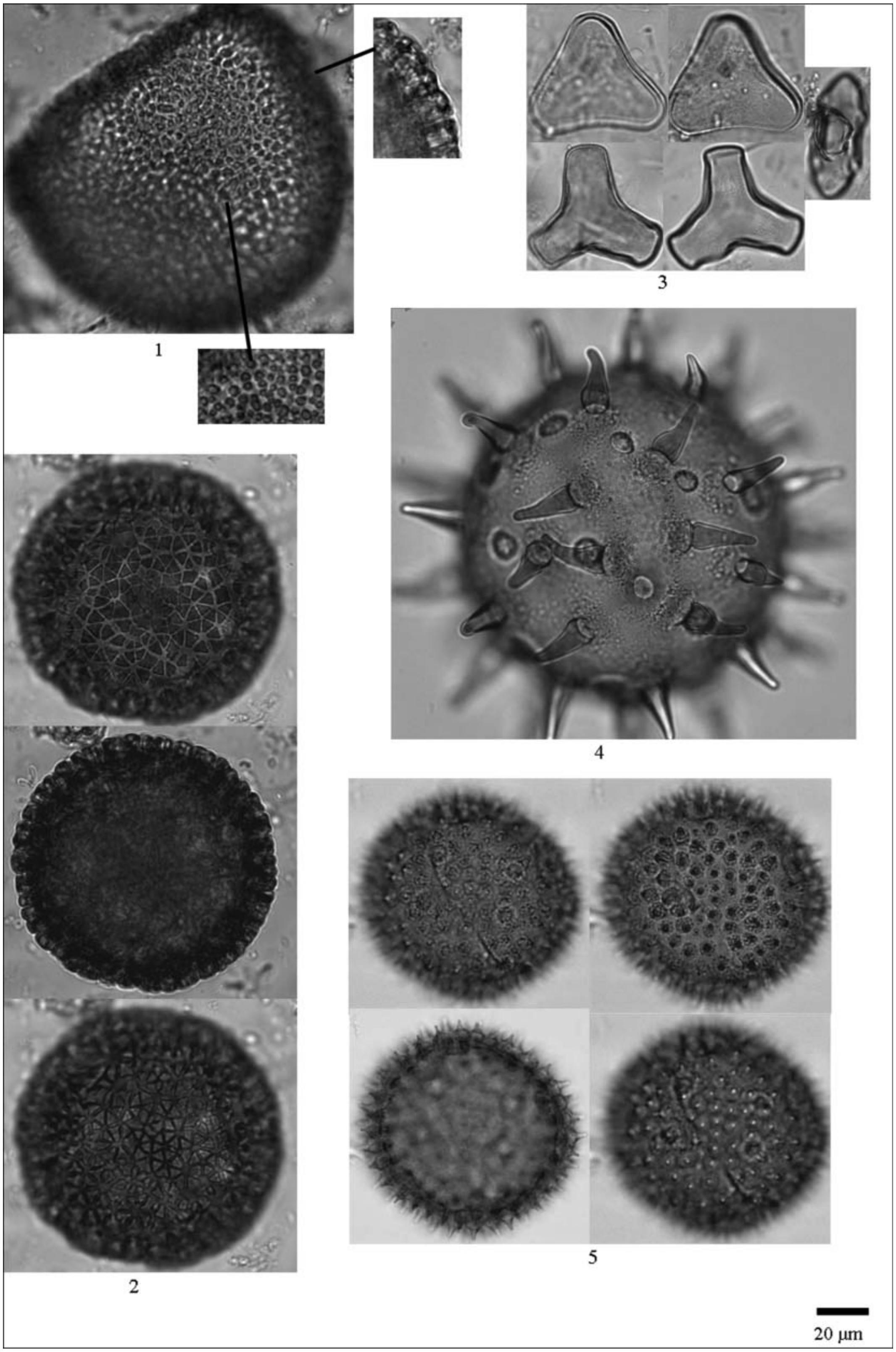

Plate 11. Photographs of pollen grains collected primarily from the Kelabit Highlands. Some of the pollen grains were also collected from the Sarawak herbarium (SAR) at Kuching. The pollen reference collection is currently held at the Institut Catala de Paleoecologia Humana i Evolucio Social, Tarragona. Figure 1. *Annona muricata*, 2. *Manihot esculenta*, 3. *Lepeostegeres centiflorus*, 4. *Abelmoscus moschatus*, 5. *Sida rhombifolioa*.

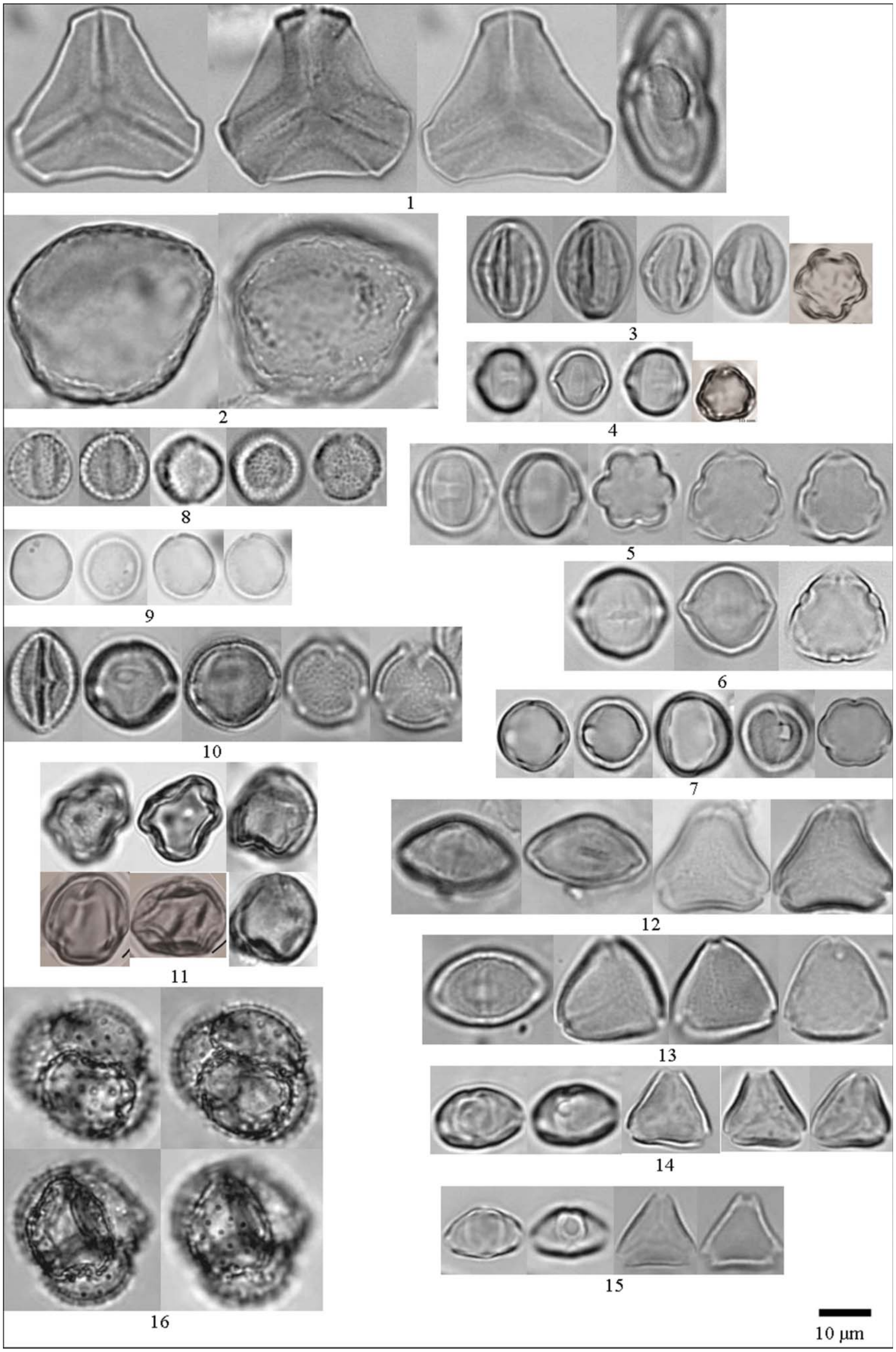

Plate 12. Photographs of pollen grains collected primarily from the Kelabit Highlands. Some of the pollen grains were also collected from the Sarawak herbarium (SAR) at Kuching. The pollen reference collection is currently held at the Institut Catala de Paleoecologia Humana i Evolucio Social, Tarragona. Figure 1. *Scurrula parasitica*, 2. *Phrynium maximum*, 3. *Dissochaeta monticola*, 4. *Medinella crassifolia*, 5. *Melastoma malabathricum*, 6. *Pachycentria pulverulenta*, 7. *Pternandra tesselata*, 8. *Pericampylus glaucus*, 9. *Artocarpus heterophyllus*, 10. *Ardisia pterocaulis*, 11. *Embelia* sp., 12. *Decaspermum fruticosum*, 13. *Psidium guajava*, 14. *Syzygium fastigiatum*, 15. *Syzigium subcrenatum*, 16. *Nepenthes stenophylla*.

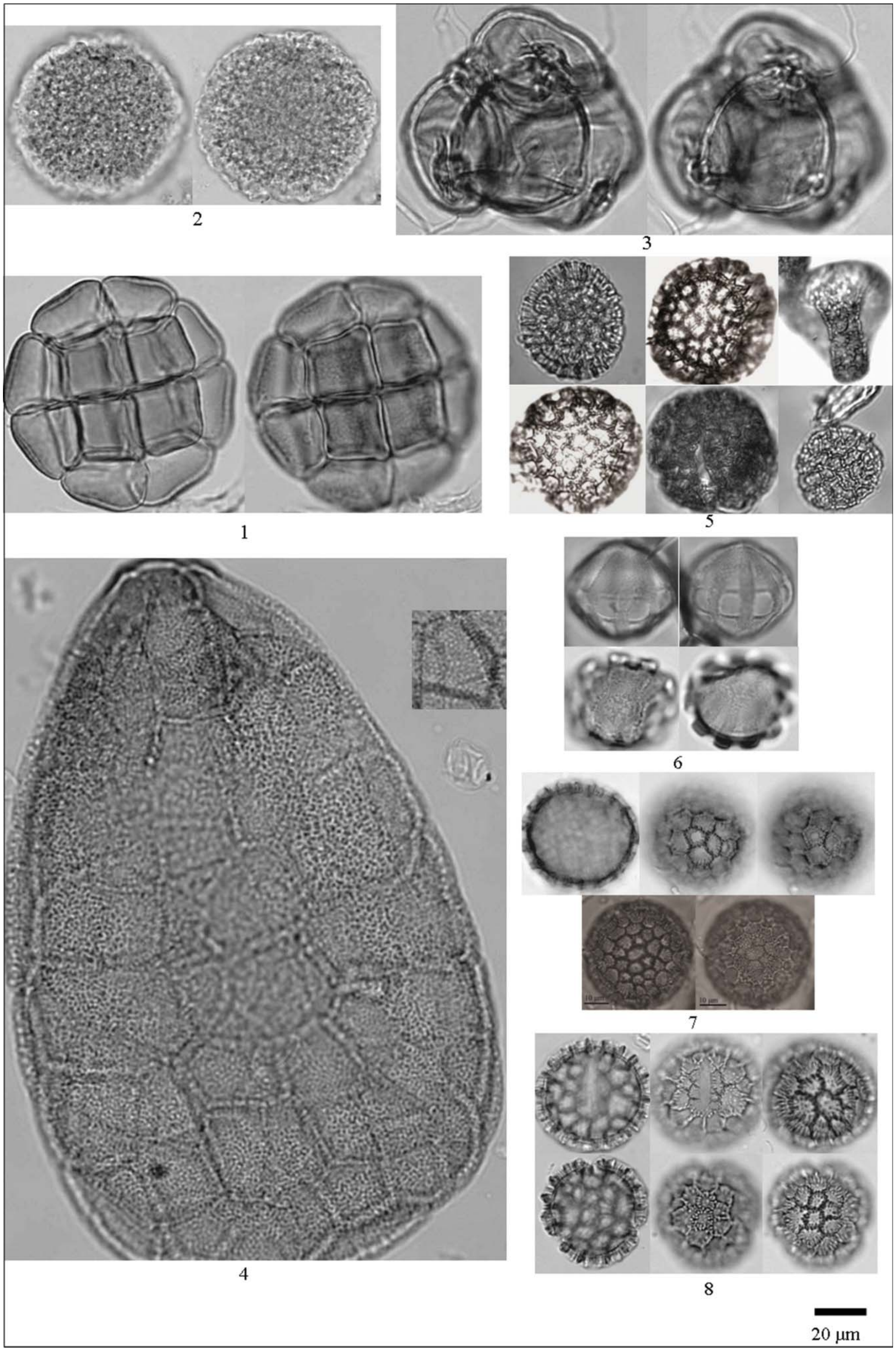

Plate 13. Photographs of pollen grains collected primarily from the Kelabit Highlands. Some of the pollen grains were also collected from the Sarawak herbarium (SAR) at Kuching. The pollen reference collection is currently held at the Institut Catala de Paleoecologia Humana i Evolucio Social, Tarragona. Figure 1. *Pithecellobium clypearia*, 2. *Musa sp*., 3. *Ludwigia octovalvis*, 4. *Habenaria* sp., 5. *Passiflora* sp., 6. *Salomonia cantoniensis*, 7. *Persicaria minor*, 8. *Persicaria chinense*.

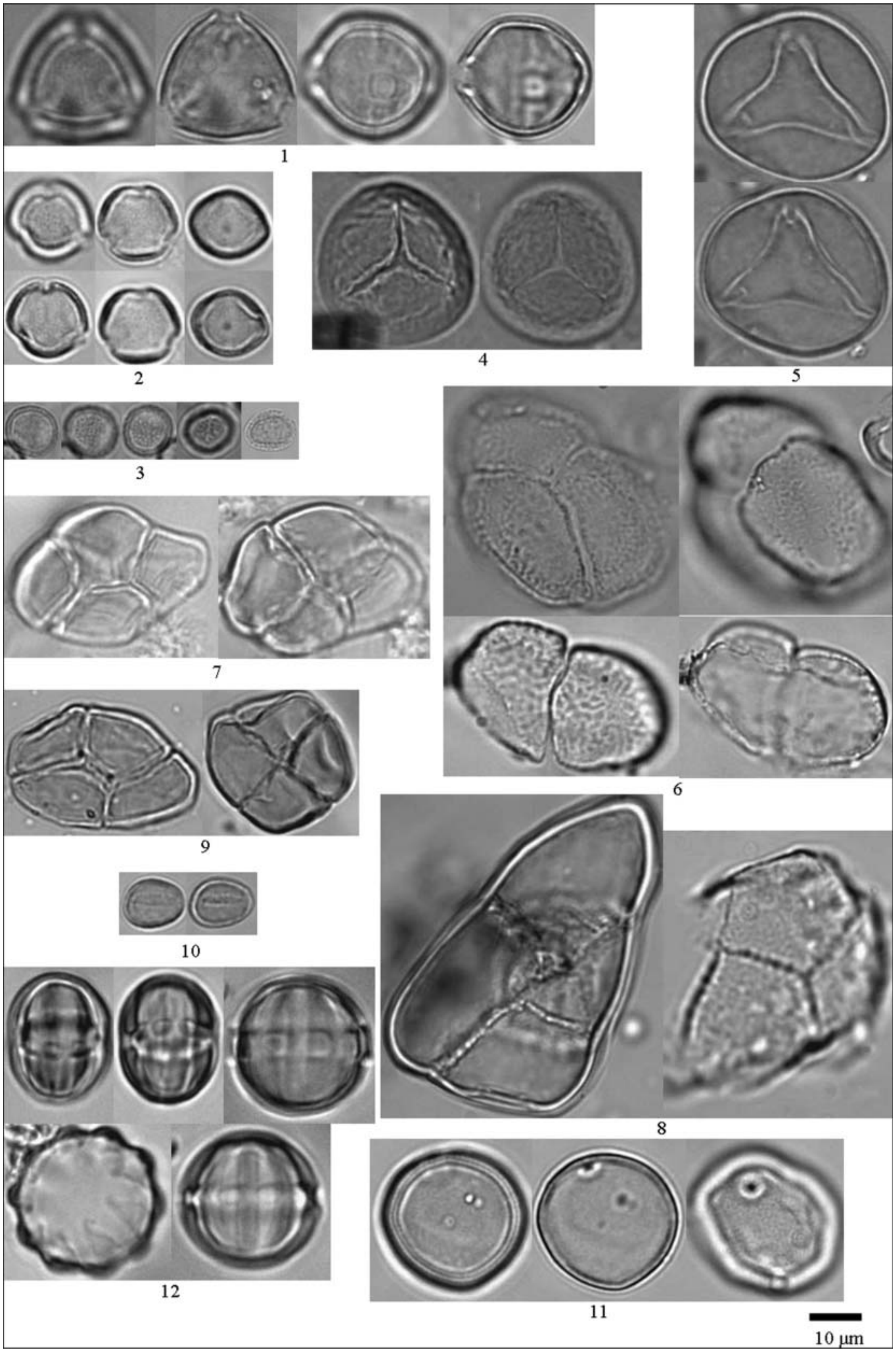

Plate 14. Photographs of pollen grains and spores collected primarily from the Kelabit Highlands. Some of the pollen grains were also collected from the Sarawak herbarium (SAR) at Kuching. The pollen reference collection is currently held at the Institut Catala de Paleoecologia Humana i Evolucio Social, Tarragona. Figure 1. *Euthemis minor*, 2. *Chionanthus pluriflorus*, 3. *Chionanthus* sp., 4. *Helmynthostachys zeylanica*, 5. *Ophioglossum intermedium*, 6. *Arundina graminifolia*, 7. *Coelogyne* sp., 8. *Phaius* sp., 9. *Pholidota imbricata*, 10. *Piper umbellatum*, 11. *Isachne pulchella*, 12. *Polygala paniculata*.

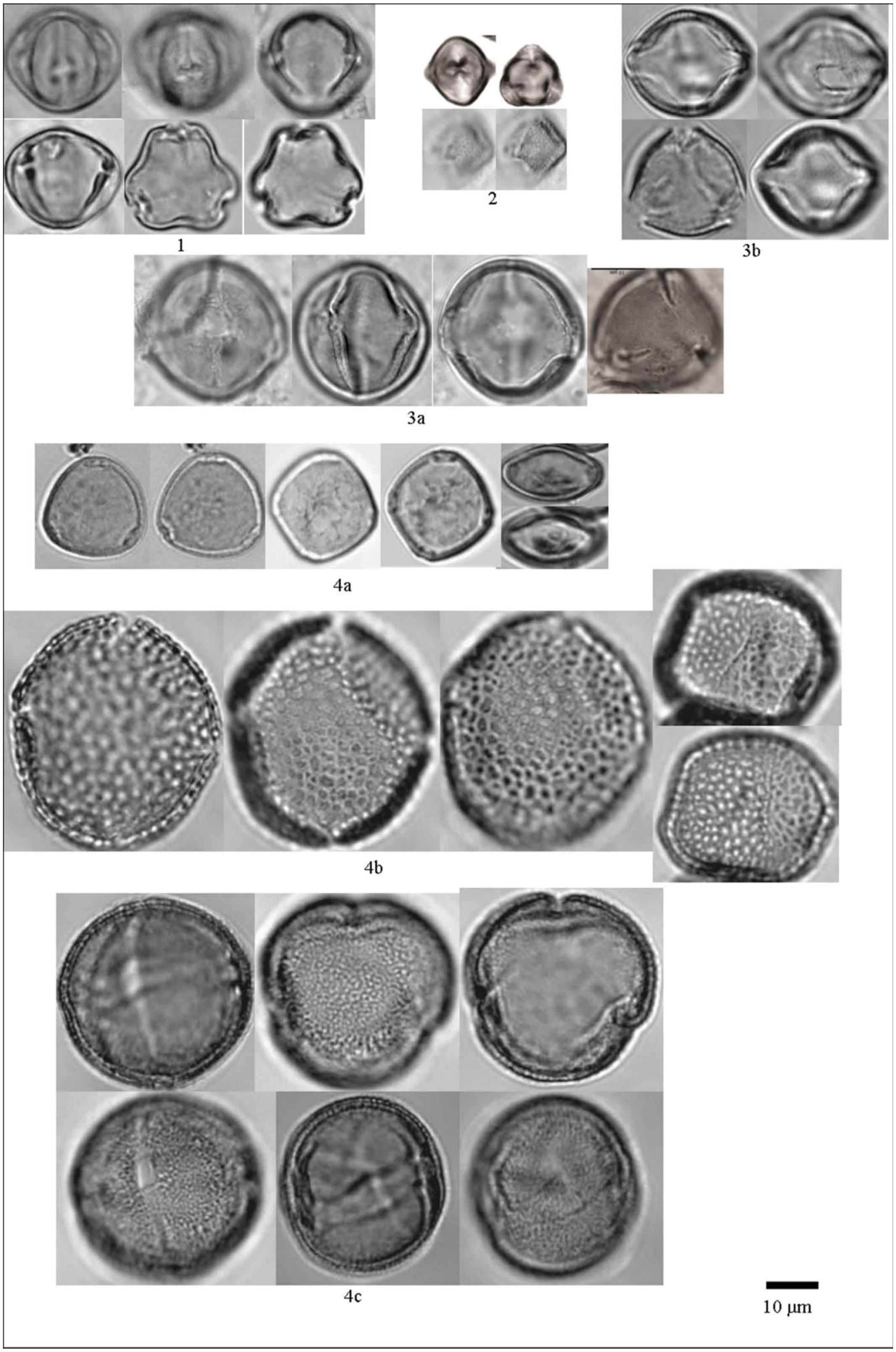

Plate 15. Photographs of pollen grains collected primarily from the Kelabit Highlands. Some of the pollen grains were also collected from the Sarawak herbarium (SAR) at Kuching. The pollen reference collection is currently held at the Institut Catala de Paleoecologia Humana i Evolucio Social, Tarragona. Figure 1. *Alphitonia excelsa*, 2. *Carallia* sp., 3. *Rubus moluccanus*, 4. *Rubus rosifolia*, 5. *Acranthera* sp., 6. *Chassalia curviflora*, 7. *Exallage* sp.

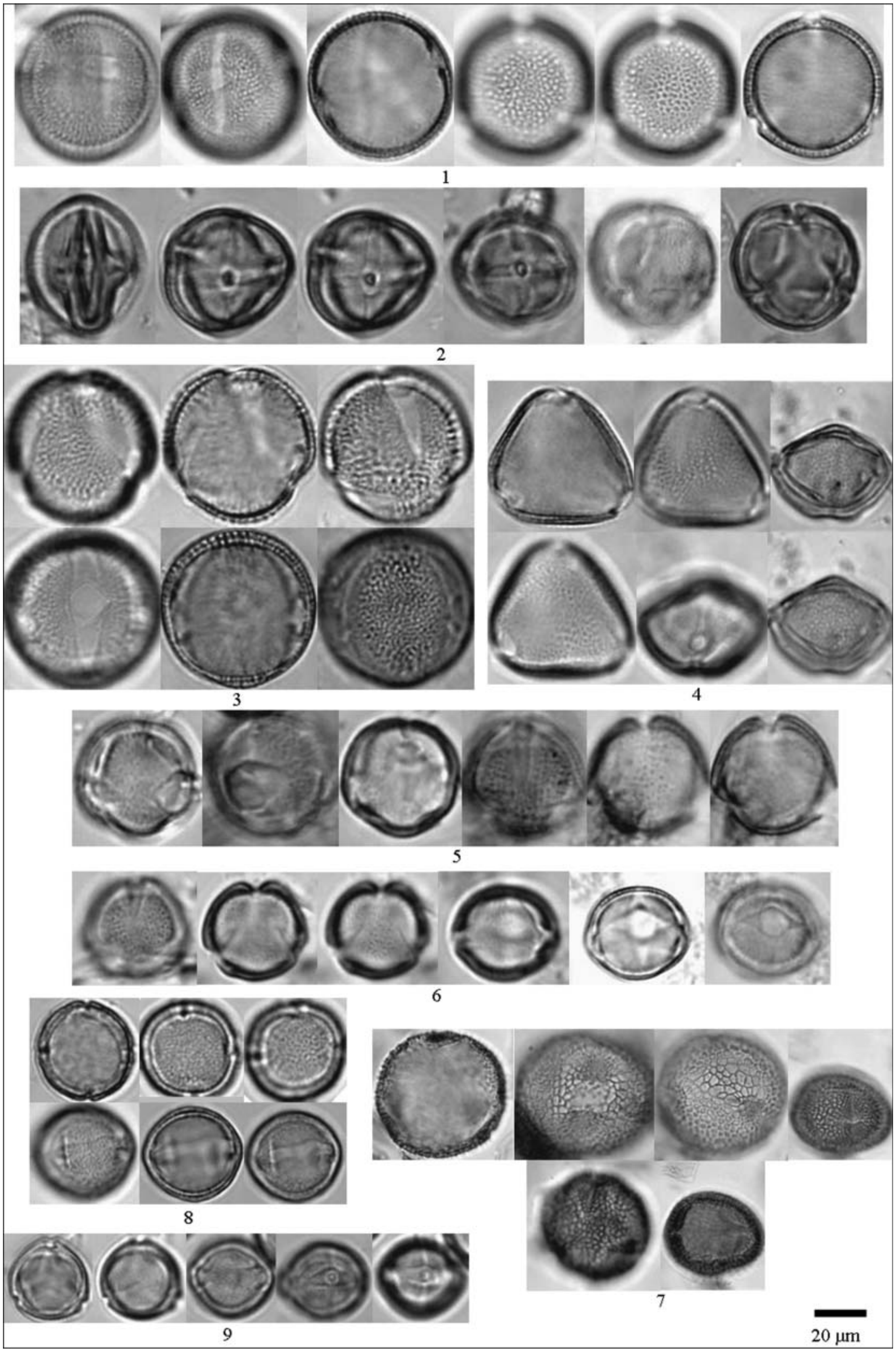

Plate 16. Photographs of pollen grains collected primarily from the Kelabit Highlands. Some of the pollen grains were also collected from the Sarawak herbarium (SAR) at Kuching. The pollen reference collection is currently held at the Institut Catala de Paleoecologia Humana i Evolucio Social, Tarragona. Figure 1. *Hedyotis* sp., 2. *Ixora otophora*, 3. *Mussaenda hirsuta*, 4. *Ophiorrhiza pallidula*, 5. *Pleiocarpidia borneensis*, 6. *Pleiocarpidia* sp., 7. *Psychotria robusta*, 8. *Spermacoce ocymoides*, 9. *Tarenna* sp.

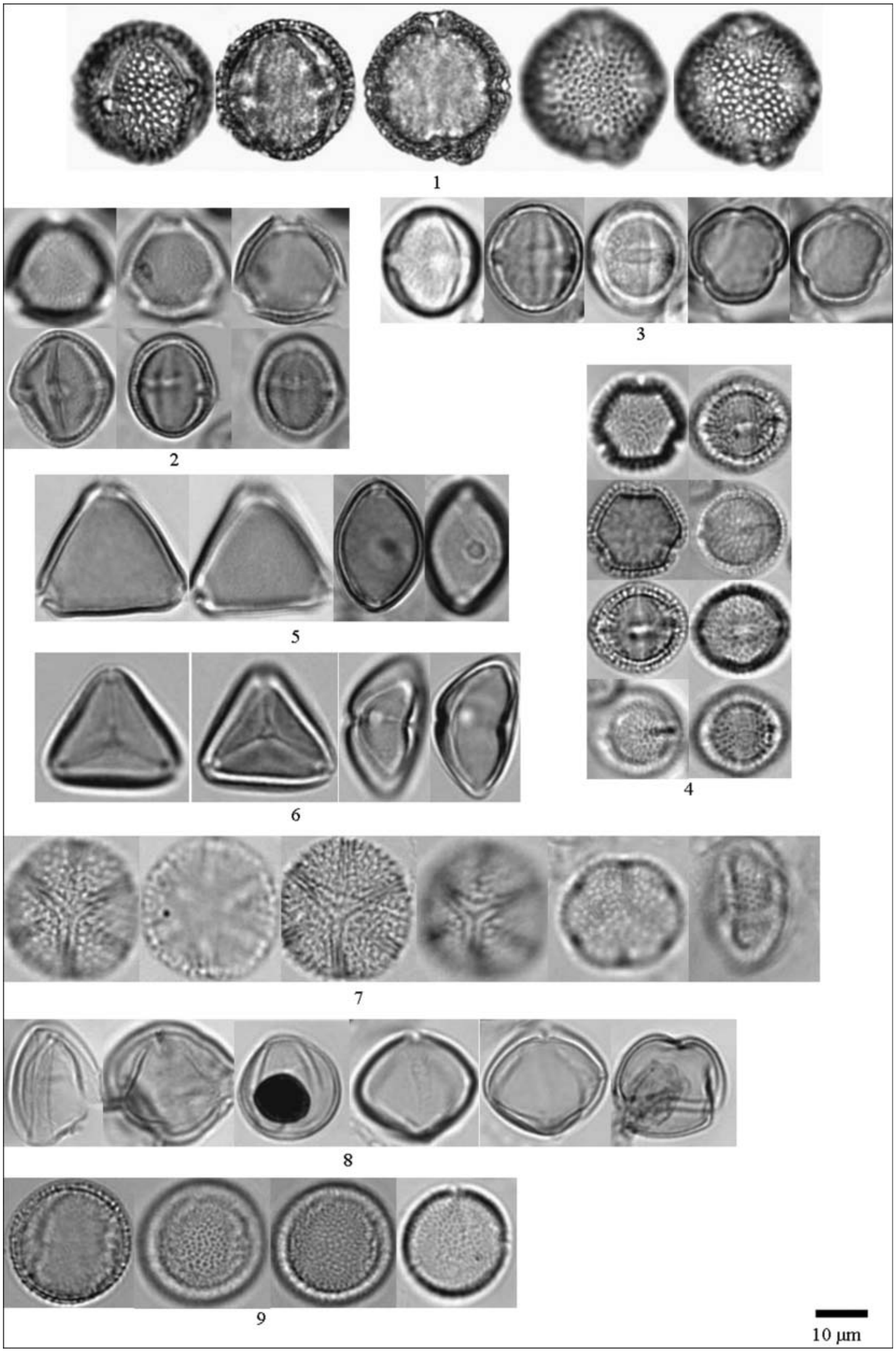

Plate 17. Photographs of pollen grains collected primarily from the Kelabit Highlands. Some of the pollen grains were also collected from the Sarawak herbarium (SAR) at Kuching. The pollen reference collection is currently held at the Institut Catala de Paleoecologia Humana i Evolucio Social, Tarragona. Figure 1. *Citrus* sp., 2. *Melicope incana*, 3. *Euodia malayana*, 4. *Melicope triphylla*, 5. *Allophylus cobbe*, 6. *Guioa bijuga*, 7. *Schizandra kadsura*, 8. *Aeginetia indica*, 9. *Curanga fel-terrae*.

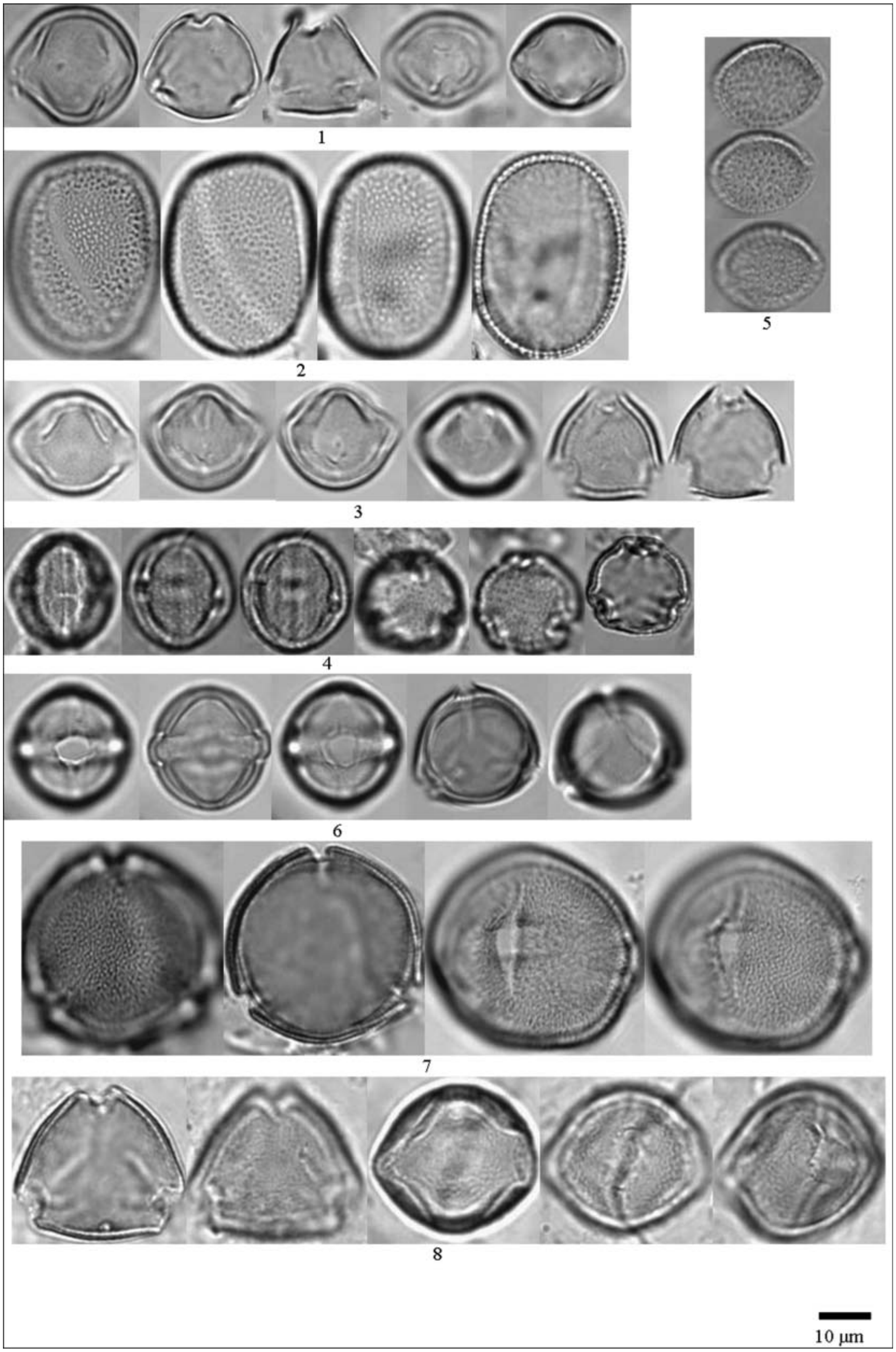

Plate 18. Photographs of pollen grains collected primarily from the Kelabit Highlands. Some of the pollen grains were also collected from the Sarawak herbarium (SAR) at Kuching. The pollen reference collection is currently held at the Institut Catala de Paleoecologia Humana i Evolucio Social, Tarragona. Figure 1. *Limnophila* sp., 2. *Lindernia ruelloides*, 3. Scrophulariaceae sp., 4. *Scyphostegia borneensis*, 5. *Smilax leucophylla*, 6. *Solanum torvum*, 7. *Melochia corchorifolia*, 8. *Pyrenaria kunstleri*.

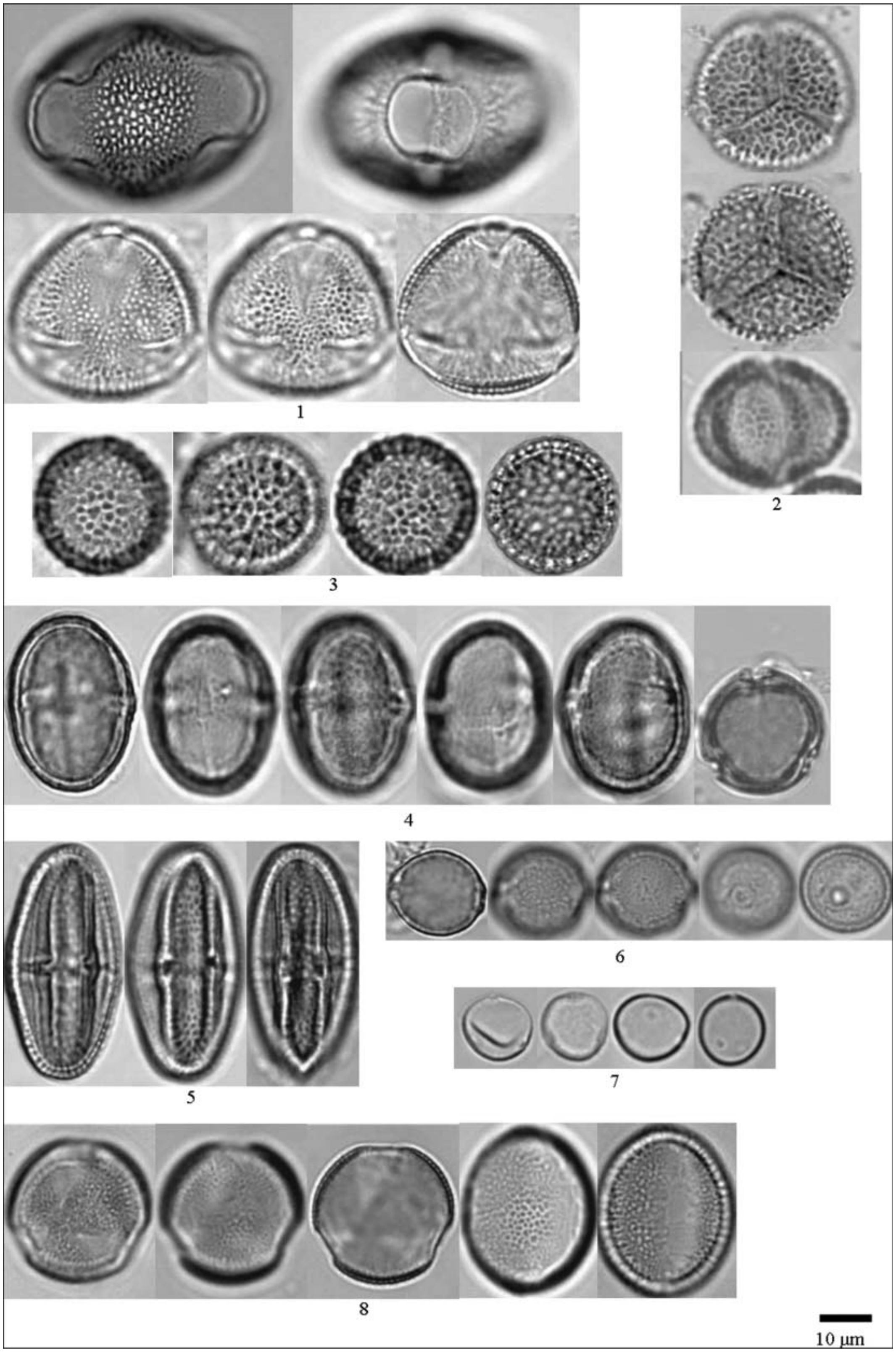

Plate 19. Photographs of pollen grains collected primarily from the Kelabit Highlands. Some of the pollen grains were also collected from the Sarawak herbarium (SAR) at Kuching. The pollen reference collection is currently held at the Institut Catala de Paleoecologia Humana i Evolucio Social, Tarragona. Figure 1. *Schima noronhae*, 2. *Ternstroemia* sp., 3. *Wikstroemia androsaemifolia*, 4. *Microcos erythrocarpa*, 5. *Triumfetta* sp., 6. *Trema tomentosa*, 7. *Debregeasia longifolia*, 8. *Vitex quinata*.

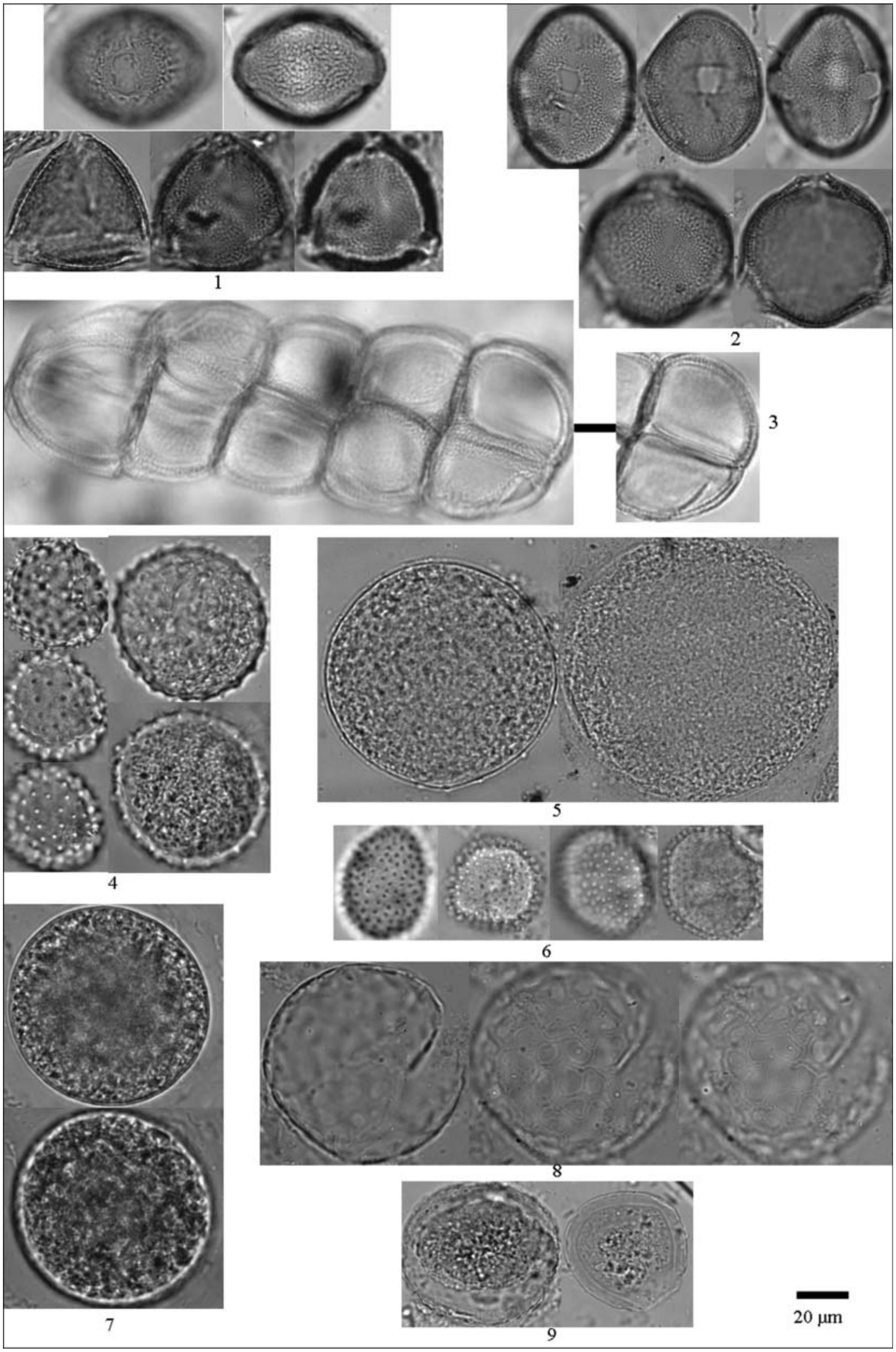

Plate 20. Photographs of pollen grains collected primarily from the Kelabit Highlands. Some of the pollen grains were also collected from the Sarawak herbarium (SAR) at Kuching. The pollen reference collection is currently held at the Institut Catala de Paleoecologia Humana i Evolucio Social, Tarragona. Figure 1. *Gordonia borneensis*, 2. *Grewia umbellata*, 3. *Xyris complanata*, 4. *Alpinia nieuwenhuizii*, 5. *Etlingera brevilabrum*, 6. *Globba propinqua*, 7. *Hornstedtia pininga*, 8. *Zingiber albiflorum*, 9. Zingiberaceae sp.

colporate endoapertures, extending $^{3}/_{4}$ the length of the grain. *Exine*: semi-tectate. There is a slight thinning of the sexine around the ectoapertures. *Pattern*: columellae arranged in a reticulate pattern (medium reticulum) and simplibaculate. *Polar view*: circular. *Equatorial view*: spheroidal. Size: *Sexine*: 2.6–3.5 μm. *Nexine*: 1 μm. *Equatorial view length and width*: 51–62 × 58–67 μm. *Pore*: 6–11 μm. *Furrow*: 4–5 μm. *Baculum*: 3 μm.

Rungia sp.: N3°33′38.9″; E115°33′23.6″ (Plate 1, figure 5).

Type: H, S. Uses: E (Christensen 2002). *Grain*: 3-colporate with large circular pores. *Exine*: semi-tectate to tectate-perorate with enlarged perforations forming a reticulate sculpture on the tectum. *Pattern*: reticulate-heterobrochate. Longitudinal bands of small lumina are present either side of each aperture, followed by bands of much larger lumina. Further away from the apertures lumina are small. *Polar view*: circular. *Equatorial view*: prolate. Size: *Exine*: 1–2 μm. *Equatorial view length and width*: 16–25 × 24–37 μm. *Pore*: 2–6 μm. *Reticulum width*: 5–< 1 μm. *Furrow width*: 4–6 μm.

Rungia PTNP1: N3°33′38.9″; E115°33′23.6″ (Plate 1, figure 6).

Type: H, S. *Grain*: heterocolpate-4-pseudocolpate and 2-colporate with circular pores. *Exine*: tectate-perforate. Exine thickens slightly around the pore. *Pattern*: sexine appears finely reticulate < 1 μm. Floor of the lumina appears scabrate. *Polar view*: circular. *Equatorial view*: prolate. Size: *Tectum*: 1–2 μm. *Equatorial view length and width*: 18–20 × 23–30 μm. *Pore*: 2–5 μm.

Strobilanthes sp. a: N3°33′38.9″; E115°33′23.6″ (Plate 1, figure 7; grains only present in equatorial view). A herb found in secondary forest.

Type: H. *Grain*: heterocolpate with 3-colporate; circular pores and 6- to > 6- pseudocolpate. *Exine*: tectate-perforate and divided into longitudinal ribs/folds. Endocolpi occur between longitudinal folds. *Pattern*: sexine is microreticulate. *Equatorial view*: prolate-perprolate. Size: *Tectum*: 1 μm. *Equatorial view*: 54–67 × 95–102 μm. *Pore*: 6–7 μm. *Furrow width*: 4–7 μm.

Strobilanthes sp. b: N3°33′38.9″; E115°33′23.6″ (Plate 1, figure 8; grains only present in equatorial view).

Type: H. *Grain*: heterocolpate with 3-colporate; circular pores and 6- to > 6- pseudocolpate. *Exine*: tectate-perforate and divided into longitudinal ribs. *Pattern*: bireticulate-A suprareticulum supported by a microreticulate-perforate tectum. Each rib contains a coarse longitudinal ladder of suprareticulum with perforate lumina. *Equatorial view*: prolate-perprolate. Size: *Exine* (including suprareticulum): 3–4.3 μm. *Equatorial view*: 33–51 × 73–93 μm. *Pore*: 6 × 16 μm. *Furrow width*: 3–4 μm. *Reticulum width*: 4–5 μm.

Acanthaceae sp. a: N3°44′09″; E115°28′42″ (Plate 1, figure 9).

Type: H, S. *Grain*: heterocolpate with 3-colporate; circular pores and > 6 pseudocolpi. *Exine*: intectate. The exine forms several longitudinal ribs. *Pattern*: made up of free-standing columellae, gemmate in appearance, which coalesce at the poles. This pollen grain appears very similar to *Hemigraphis* sp., although columellae are more tightly packed. *Polar view*: circular. *Equatorial view*: prolate-spheroidal. Size: *Exine*: 2 μm. *Equatorial view*: 33–47 × 52–55 μm. *Pore*: 8 × 9 μm. *Annulus thickness*: 2 μm. *Furrow width*: 2 μm.

Acanthaceae sp. b N3°34′08″; E115°33′19″ (Plate 1, figure 10).

Type: H, S. *Grain*: heterocolpate with 3-syncolporate; circular pores and 6-zonacolpate. The six colpi join to form three rings, either side of the syncolporae. Exine: tectate to semi-tectate. *Pattern*: reticulate, reticulum constructed out of tightly packed columellae. This grain appears similar to *Pachystachys* (described by Scotland & Vollesen 2000): *Polar view*: circular. *Equatorial view*: spheroidal-prolatespheroidal. Size: *Exine*: 1 μm. *Equatorial view*: 34–45 × 42–48 μm. *Pore*: 5–6 μm. *Baculae*: 4 μm. *Reticulum width*: 3–4 μm.

Acanthaceae sp. c: N3°33′33″; E115°33′05″ (Plate 1, figure 11).

Type: H. *Grain*: heterocolpate with 3–4-colporate; circular pores and 6–8-colpate. *Exine*: semi-tectate. Colpi almost meet at poles. *Pattern*: reticulate and columellate. Reticulum arranged in longitudinal ribs which coalesce at the poles. This grain shares some morphological similarities with *Peristrophe bivalvis* in that both pollen grains contain ribs with a reticulate pattern, one reticulum in width between apertures. The ribs recorded in this grain, however, do not occur in groups of two. The ribs present on this grain occur individually between the colporae and the colpi, followed by a wider reticulate area. *Polar view*: circular. *Equatorial view*: prolate-spheroidal. Size: *Exine*: 2 μm. *Equatorial view*: 57–68 × 65–81 μm. *Pore*: 5–8 × 17–20 μm. *Furrow width*: 3 μm. *Longitudinal rectangle*: 2–5 μm.

5.2. *Actinidiaceae*

Saurauia actinidiifolia: N3°43′4″; E115°29′25″ (Plate 2, figure 1).

Type: S, T. *Grain*: 3-colporate with large circular-square pores. *Aperture type*: atrium-long extending apertures. Exine: tectate. Sexine and nexine are equal in width and columellae are indistinct. *Pattern*: psilate. *Polar view*: circular. *Equatorial view*: spheroidal. Size: *Exine*: < 0.5–0.5 μm. *Equatorial view*: 10–11 μm. *Pore*: 2.5–3 μm.

Saurauia glabra: N3°43′57″; E115°41′3″ & N3°33′33″; E115°33′05″ (Plate 2, figure 2).

Type: S, T. *Grain*: 3-colporate with large circular-square pores. *Aperture type*: atrium-long. Exine: tectate. Sexine and nexine are equal in width and columellae are indistinct. *Pattern*: psilate. *Polar view*: circular. *Equatorial view*: spheroidal. Size: *Exine*: 0.5 μm. *Equatorial view*: 11–12 μm. *Pore*: 3–3.5 μm.

Saurauia ridleyi: N3°43′57″; E115°29′41″ (Plate 2, figure 3).

Type: S, T. *Grain*: 3-colporate with large circular-square pores. *Aperture type*: atrium-long. Exine: tectate. Sexine and nexine are equal in width and columellae are indistinct. *Pattern*: psilate. *Polar view*: circular. *Equatorial view*: spheroidal. Size: *Exine*: < 0.5 μm *Equatorial view*: 11–12 μm. *Pore*: 3–3.5 μm.

Elaeocarpus griffithii is very similar in morphological appearance to *Saurauia*. Dressler & Bayer (2004) also describe similar pollen occuring in Theaceae, Clethraceae and Ochnaceae. Note: using a light microscope, it was not possible to separate the different species of *Saurauia* based on morphological characteristics.

5.3. *Amaranthaceae*

Cyathula prostrata: N3°33′33″; E115°33′05″ (Plate 2, figure 4).

Type: H. *Grain*: polyporate (ca. 25–30 pores). *Pore type*: undetermined. *Exine*: tectate-perforate. Pattern: sexine both granulate and perforate. *Polar view*: circular. *Equatorial view*: spheroidal. Size: *Tectum*: 1–1.5 μm. *Equatorial view*: 18–24 $\times$ 18–24 μm. *Pore*: 1.5–3 μm.

5.4. *Annonaceae*

Annona muricata: N3°33′33″; E115°33′05″ (Plate 11, figure 1). Found amongst fruit trees at the back of a long house in Pa'Dalih.

Type: T. Uses: E (Christensen 2002). *Grain*: tetrad-aperture type unidentified. *Exine*: thick and semi-tectate *Pattern*: psilate and foveolate infratectum with a clavate supra-tectal layer. *Equatorial view*: subspheroidal. Size: *Equatorial view*: 105–130 $\times$ 142–167 μm. *Exine*: 10–14 μm. *Sexine*: 8.7–9 μm, comprising of incomplete tectum: 2–2.5 μm, *Columellae*: 6.2–6.5 μm in length and 1.5–1.7 μm in width, nexine 4–4.5 μm.

Annonaceae sp.: N3°45′27″; E115°26′35″ (Plate 3, figure 1).

Type: S, T. *Grain*: Zona-aperaturate. *Exine*: tectate-perforate, columellae indistinct. *Pattern*: coarsely granulate and perforate. *Equatorial view*: subspheroidal-spheroidal. Size: *Tectum*: 1 μm. *Equatorial view*: 44–57 $\times$ 53–72 μm (average ca. 50 $\times$ 60 μm).

5.5. *Apiaceae*

Hydrocotyle javanica: N3°45′27″; E115°26′35″ (Plate 2, figure 5).

Type: H. *Grain*: 3–4 colporate with lalongate elliptic endoapertures; pores bulge at the equator and are slightly costate. *Exine*: tectate-perforate. Sexine and nexine generally equal in width. Tectum completely covers columellae, columellae indistinct. *Pattern*: finely reticulate. *Polar view*: circular-semi angular. *Equatorial view*: prolatespheroidal-subprolate-rhomboidal. Size: *Tectum*: 1–1.5 μm. *Equatorial view*: 15–21 $\times$ 20–24 μm (average ca. 18.6 $\times$ 21 μm). *Pore*: 2–4 $\times$ 6 μm.

Hydrocotyle sibthorpioides: N3°33′33″; E115°33′05″ (Plate 2, figure 6).

Type: S, T. Uses: M (Christensen 2002). *Grain*: 3-colporate with lalongate elliptic endoapertures; pores slightly costate and bulge at the equator. *Exine*: tectate-perforate. Tectum completely covers columellae. Sexine increases at the poles. *Pattern*: finely reticulate. Size of the reticulum is slightly larger than that of *Hydrocotyle javanica*. *Polar view*: circular-semi angular. *Equatorial view*: prolatespheroidal-subprolate-rhomboidal. Size: *Tectum*: 1.5–2 μm (occasionally 3 μm). *Equatorial view*: 18–20 $\times$ 22–24 μm. *Pore*: 1–3 $\times$ 5–6 μm.

5.6. *Apocynaceae*

Leuconotis anceps: N3°43′57″; E115°41′3″ (Plate 2, figure 7).

Type: L. Uses: E, U (Christensen 2002). *Grain*: 4-colporate with lalongate elliptic endoapertures. Endoapertues occasionaly shaped in a bow tie formation. *Exine*: tectate, columellae indistinct. Sexine and nexine of equal width, although sexine increases in thickness towards the colpi. *Pattern*: granulate. *Polar view*: circular. *Equatorial view*: suboblate. Size: *Tectum*: 1 μm. *Equatorial view*: 18–23 $\times$ 22–26 μm. *Pore*: 1.5–2 μm.

5.7. *Aquifoliaceae*

Ilex cymosa: N3°45′27″; E115°26′35″ (Plate 2, figure 8).

Type: S, T. Uses: M, U (Christensen 2002). *Grain*: 3-colporate with lalongate circular-elliptic endoapertures. Colpi are marginate (columellae reduce in size towards the colpi). *Exine*: intectate with free-standing columellae. *Pattern*: clavate. *Polar view*: circular. *Equatorial view*: suboblate. Size: *Tectum*: 0.81 μm. *Equatorial view*: 17 $\times$ 22 μm. *Pore*: 1.5–2.5 $\times$ 4.5–8 μm. *Clava size*: 1–1.5 μm.

5.8. *Araceae*

Alocasia princeps: N3°45′27″; E115°26′35″ (Plate 2, figure 9).

Type: H, S. Uses: E, R (Christensen 2002). *Grain*: zonasulcate. *Exine*: tectate-perforate, columellae indistinct; aperture encircles the whole grain. Exine shows a distinct bulge around the apertures. *Pattern*: granulate. *Equatorial view*: spheroidal-suboblate. Size: *Tectum*: 2.5 μm. *Equatorial view*: 21–28.5 × 25–32 μm.

Homalomena sagittifolia: N3°45′27″; E115°26′35″ (Plate 2, figure 10).

Type: H, S. Uses: M, E, R (Christensen 2002; Wong et al. 2006). *Grain*: 1 sulcate. Sulcus varies in shape, sometimes gaping, sometimes straight and sometimes rounded. *Exine*: intectate. *Pattern*: scabrate. *Equatorial view*: spheroidal-suboblate-prolatespheroidal. Size: *Polar view*: 10–14 × 12–15 μm.

Piptospatha grabowski: N3°33′39″; E115°33′24″ (Plate 2, figure 11).

Type: H. Uses: E (Christensen 2002). *Grain*: trichotomosulcate. *Exine*: intectate. *Pattern*: granulate. *Equatorial view*: spheroidal-suboblate-prolatespheroidal. Size: *Polar view*: 11–15 × 15–22 μm.

5.9. Araliaceae

Aralia montana: N3°34′08″; E115°33′19″ (Plate 2, figure 12).

Type: S. *Grain*: 3-colporate with lalongate elliptic-circular endoapertures. Ectoapertures long-narrow. Sexine is distinctly raised above endoapertures. Fastigium is not present. *Exine*: tectate-perforate-semi-tectate. *Pattern*: reticulate-heterobrochate. Reticulum becomes smaller towards the colpi. *Polar view*: semiangular-triangular. *Equatorial view*: spheroidal. Size: *Exine*: 1.5 μm. *Equatorial view*: 27 × 32 μm. *Pore*: 5.5–6 × 6–9 μm.

Aralia scandens: N3°34′08″; E115°33′19″ (Plate 2, figure 13).

Type: T, S. *Grain*: 3-colporate with lalongate elliptic-circular endoapertures. Ectoapertures long-narrow. Sexine is distinctly raised above endoapertures. Fastigium is not present. *Exine*: tectate-perforate to semi-tectate. *Pattern*: reticulate-homobrochate. *Polar view*: circular. *Equatorial view*: prolatespheroidal-subprolate. *Aperture*: Size: *Tectum*: 1 μm. *Equatorial view*: 20–25 × 25–28 μm. *Pore*: 2–2.5 × 5–6 μm.

Arthrophyllum sp.: N3°33′33″; E115°33′05″ (Plate 2, figure 14).

Type: T, S. Uses: U (Christensen 2002). *Grain*: 3-colporate. Ectoapertures long-narrow, endoapertures lalongate rectangular. A fastigium is present. *Exine*: tectate-perforate. *Pattern*: finely reticulate. *Polar view*: circular. *Equatorial view*: spheroidal. Size: *Tectum*: 1–2 μm. *Equatorial view*: 20–22 × 20–23 μm. *Pore*: 2–3 × 5–6 μm.

Schefflera avenis: N3°45′27″; E115°26′35″ (Plate 2, figure 15).

Type: T, S. *Grain*: 3-colporate. Ectoapertures long-narrow, endoapertures lalongate elliptic. A fastigium is present. *Exine*: tectate-perforate. Pattern: finely reticulate. *Polar view*: circular. *Equatorial view*: prolate spheroidal-subprolate. Size: *Tectum*: 2 μm. *Equatorial view*: 20–26 × 23–28 μm. *Pore*: 1–4 × 6–12 μm.

5.10. Arecaceae

Areca (Herbarium, Plate 3, figure 2).

Type: T. Uses: M, R, E (Christensen 2002). Morphology: *Grain*: zona aperturate. *Exine*: semi-tectate, columellae are not visible. *Pattern*: reticulate, reticulum are heterobrochate. *Equatorial view*: spheroidal. Size: *Tectum*: 0.5–1 μm. *Equatorial view*: 39–42 × 40–48 μm. *Lumina range*: 0.9–2.1 μm.

Calamus marginatus (Herbarium, Plate 3, figure 3).

Type: S. Uses: U, E, M (Christensen 2002). Morphology: *Grain*: 1-sulcate, aperture extends to either end of grain, ends of sulcus gaping. *Exine*: tectate-perforate. *Pattern*: foveolate-finely reticulate. *Equatorial view*: subspheroidal-spheroidal. Size: *Equatorial view*: 17–23 × 20–27 μm.

Cocos nucifera (Herbarium, Plate 3, figure 4).

Type: T. Uses: E, U (Christensen 2002). Morphology: *Grain*: 1-sulcate. Sulcate wall is thin and broken. Sulcate ends are rounded. *Exine*: tectate, both sexine and nexine are visible. Columellae short, almost indistinct. *Pattern*: granulate. *Equatorial view*: subspheroidal. Size: *Exine*: 1–1.8 μm. *Equatorial view*: 35–50 × 46–70 μm.

Daemonorops fissa: N3°33′239″; E115°33′24″ (Plate 3, figure 5).

Type: T, S. Uses: E, U (Christensen 2002). Morphology: *Grain*: 1-sulcate, sulcate ends gaping. Aperture extends the full length of grain. *Exine*: tectate-perforate. *Pattern*: appears both scabrate and very finely reticulate-perforate. *Equatorial view*: subspheroidal. Size: *Exine*: 1 μm. *Equatorial view*: 14–17 × 17–19 μm.

Eugeissona utilis: N3°34′08″; E115°33′19″ (Plate 3, figure 6). Collected from a burnt flower in a sago forest, adjacent to a perupun, close to the village of Pa'Dalih.

Type: T. Uses: E, U (Christensen 2002). Morphology: *Grain*: 1-sulcate. Aperture extends the full length of grain and divdes the front part of the grain into two semi-circles. The two halves can often be seen under a light microscope as folded, giving the shape of one large semi-circle. *Exine*: semi-tectate. *Pattern*: hamulate at the front, but reticulate to the rear of the grain, facing away from the aperture. *Equatorial view*: subprolate. Size: *Exine*: 2.8–4 μm. *Equatorial view*: 49–64 × 36–43 μm.

Korthalsia rostrata: (Herbarium, Plate 4, figure 1).

Type: L. Uses: U (Christensen 2002). Morphology: *Grain*: 1-sulcate. Sulcate ends are rounded. *Exine*: intectate. *Pattern*: echinate-clavate, the spines are quite rounded, tightly and unevenly clustered. *Equatorial view*: subspheroidal-spheroidal. Size: *Equatorial view*: 21–23 × 27–30 μm.

Licuala valida (Herbarium, Plate 3, figure 7).

Type: T. Uses: R, U, E (Christensen 2002). Morphology: *Grain*: 1-sulcate, sulcate rounded at ends of grain. *Exine*: tectate, columellae indistinct. *Pattern*: granulate. *Equatorial view*: subspheroidal. Size: *Exine*: 1.5–1.6 μm. *Equatorial view*: 25–27 × 27–30 μm.

Oncosperma horridum (Herbarium, Plate 4, figure 2).

Type: T. Uses: E, U (Christensen 2002). Morphology: *Grain*: 1-sulcate, rounded at ends. *Exine*: tectate. *Pattern*: clavate. Clavae supratectal. *Equatorial view*: subspheroidal. Size: *Equatorial view*: 25–31 × 33–38 μm. *Exine*: 1.3–1.7 μm.

Pinanga aristata (Herbarium, Plate 4, figure 3).

Type: T. Uses: E (Christensen 2002). Morphology: *Grain*: 1-sulcate. *Exine*: tectate. *Pattern*: the supra-sculpure is urceolate and the tectum is psilate between the urn-shaped elements (Ferguson, et al. 1983). *Equatorial view*: subspheroidal. Size: *Exine*: 1 μm. *Equatorial view*: 30–34 × 33–42 μm. *Urceolae processes*: 1.5–2 μm.

5.11. *Asparagaceae*

Asparagus sp.: N3°45′27″; E115°26′35″ (Plate 4, figure 4). Found on the former grass runway at Bario.

Type: H. Morphology: *Grain*: 1-sulcate, rounded at ends. *Exine*: semi-tectate. Pattern: the sculpture is psilate between regularly spaced gemmae. *Equatorial view*: subprolate-prolate. Size: *Exine*: 0.8–1 μm. *Equatorial view*: 25–27 × 20–24 μm. *Floscopa scandens* is very similar although gemmae are irregularly spaced.

5.12. *Asteraceae*

Elephantopus scaber: N3°43′4″; E115°29′25″ (Plate 4, figure 5).

Type: T. Uses: M (Avani & Neeta 2005). Morphology: *Grain*: 3-colporate with circular pores. *Exine*: tectate *Pattern*: lacunate with gemmae on the tectum. *Polar view*: circular. *Equatorial view*: spheroidal. Size: *Equatorial view*: pollen grains ranged from 28–44 μm (average 30 μm). *Pore*: 7.3–10 × 10–11 μm.

Vernonia arborea: N3°43′4″; E115°29′25″ & N3°34′08″; E115°33′19″ (Plate 4, figure 6).

Type: T. Uses: U (Christensen 2002). Morphology: *Grain*: 3-colporate with circular pores. *Exine*: tectate. Columellae distinct. *Pattern*: granulate and echinate. Smaller echinae appear in between the main echinae. *Polar view*: semi-angular. *Equatorial view*: suboblate-oblate spheroidal. Size: *Exine*: 1 μm. *Equatorial view*: pollen grains ranged from 25–35 μm. *Pore*: 6 μm. *Main echinae*: 5–6 μm *Sub echinae*: 0.5–1 μm.

Vernonia sp.: N3°43′4″; E115°29′25″ (Plate 4, figure 7).

Type: T. Morphology: *Grain*: 3-colporate with circular pores. *Exine*: tectate. Columellae distinct. *Pattern*: granulate and echinate. Spines are also granulate, particularly around the base of the spines. *Polar view*: semi-angular. *Equatorial view*: spheroidal. *Aperture type*: Size: *Exine*: 1–2 μm. *Equatorial view*: 20–23 × 23–25 μm. *Pore*: 3–5 × 5–6 μm. *Main echinae*: 5 μm.

5.13. *Balsaminaceae*

Impatiens sp.: N3°33′33″; E115°33′05″ (Plate 4, figure 8).

Type: H. Uses: Found in a vegetable garden in Pa'Dalih. Morphology: *Grain*: 4-colpate, colpi short. *Exine*: semi-tectate. *Pattern*: reticulate. *Equatorial view*: subprolate-rectangular. Size: *Tectum*: 1 μm. *Equatorial view*: 28–32 × 20–25 μm.

5.14. *Begoniaceae*

Begonia sp.: N3°34′08″; E115°33′19″ (Plate 4, figure 9). Found in secondary forest.

Type: H. Uses: E, M (Christensen 2002). Morphology: *Grain*: 3-colporate. Lalongate elliptic endoapertures with long thin ectoapertures. *Exine*: tectate-perforate. Columellae indistinct. Pattern: scabrate. *Polar view*: circularlobate. *Equatorial view*: prolate-perprolate. Size: *Tectum*: 0.5–1 μm. *Equatorial view*: 9–12 × 17–21 μm. *Pore*: 2 × 4–5 μm.

Begonia sp.: N3°34′39″; E115°33′24″ (Plate 4, figure 10). Found in secondary forest.

Type: H. Uses: E, M (Christensen 2002). Morphology: *Grain*: 3-colporate. Lalongate elliptic endoapertures with long thin ectoapertures. *Exine*: tectate-perforate. Columellae indistinct. *Pattern*: scabrate. *Polar view*: circularlobate. *Equatorial view*: prolate-perprolate. Size: *Equatorial view*: 7–9 × 15–18 μm. *Pore*: 1 × 1.5 μm.

5.15. *Bombacaceae*

Durio cariatus: (Herbarium) (Plate 5, figure 1).

Type: T. Uses: E, U (Christensen 2002). Morphology: *Grain*: 3-colporate, pores circular, colpi short lalongate. Apertures are both costate and marginate in that there is a pronounced thickening around the nexine and a change in shape of the sexine, which extends over the nexine. *Exine*: tectate-perforate; columellae are distinct. *Pattern*: scabrate. *Polar view*: circular. *Equatorial view*: oblate spheroidal-oblate. Size: *Tectum*: 2 μm. *Equatorial view*: 55–66 × 58–68 μm. *Pore*: 7–9 μm.

5.16. Boraginaceae

Tournefortia sp.: N3°33′33″; E115°33′05″ (Plate 4, figure 12).

Type: H. Morphology: *Grain*: heterocolpate with 3-ectocolporate and 3-psudocolpate. Colpi form an apocolpium. Endoapertures lalongate elliptic. A thickening occurs around the pores with the sexine distinctly raised over the endoapertures. A thin layer of ektexine covers the endoapertures. *Exine*: tectate-perforate. Columellae are short but distinct. *Polar view*: interhexagonal. *Equatorial view*: rhomboidal. *Pattern*: granulate. Size: *Equatorial view*: 18–20 × 19–21 μm. *Pore*: 3–4 × 5 μm.

5.17. Bromeliaceae

Ananas comosus: N3°45′27″; E115°26′35″ (Plate 6, figure 1). Taken from a pineapple field.

Type: S. Uses: E, U, M (Christensen 2002). Morphology: *Grain*: appears to be either 1-sulcate or polyaperaturate (< 10) with circular aperatures. Sulcate ends are either straight or triangular. *Exine*: Tectate-perforate to semi-tectate; columellae distinct. *Pattern*: finely reticulate-perforate. *Equatorial view*: spheroidal-suboblate. Size: *Exine*: 1.5 μm. *Equatorial view*: 24–55 μm (average: 40 μm).

5.18. Burmanniaceae

Burmannia disticha: N3°44′23″; E115°29′01″ (Plate 4, figure 13).

Type: H. Morphology: *Grain*: 2-porate. Aperture appears as a rupture rather than a distinct pore. Pores are circular-square. *Exine*: tectate; columellae short-indistinct. *Polar view*: circular. *Equatorial view*: oblate-spheroidal. *Pattern*: scabrate-finely granulate. *Aperture*: Size: *Tectum*: 1 μm. *Equatorial view*: 17–25 × 19–30 μm. *Pore*: 4–10 μm.

5.19. Caprifoliaceae

Viburnum sambucinum: N3°45′27″; E115°26′36″ (Plate 6, figure 2).

Type: S, T. Morphology: *Grain*: 3-colporate. Ectoapertures long, endoapertures-lalongate, although difficult to see under light microscope. *Exine*: semi-tectate. *Polar view*: circular. *Equatorial view*: prolate spheroidal-subprolate. *Pattern*: reticulate (small-medium reticulum). Muri are simplicolumellate. *Aperture*: Size: *Tectum*: 2.5 μm. *Equatorial view*: 24–38 × 31–47 μm. *Pore*: 1–1.5 × 4–5 μm.

5.20. Caricaceae

Carica papaya: N3°45′27″; E115°26′35″ (Plate 6, figure 3). Found growing next to a house in Bario.

Type: S, T. Uses: E, M (Christensen 2002). Morphology: *Grain*: 3-colporate with lalongate rectangular endoapertures. *Exine*: tectate-perforate. Sexine and nexine appear equal in width. *Polar view*: circular. *Equatorial view*: spheroidal-prolatespheroidal. *Pattern*: finely reticulate. Size: *Tectum*: 0.5–0.8 μm. *Equatorial view*: 25–26 μm. *Pore length*: 8 μm.

5.21. Clethraceae

Clethra longispicata: N3°34′08″; E115°33′19″ (Plate 6, figure 5).

Type: S, T. Uses: U (Christensen 2002). Morphology: *Grain*: 3-colporate with lalongate elliptic-rectangular endoapertures. *Exine*: tectate; columellae indistinct, although this is quite difficult to determine. *Polar view*: circular. *Equatorial view*: prolate. *Pattern*: scabrate. Size: *Exine*: 1 μm. *Equatorial view*: 10–13 × 15–18 μm. *Pore*: 1.5–2 × 2–3 μm.

5.22. Chloranthaceae

Chloranthus erectus: N3°43′4″; E115°29′25″ (Plate 6, figure 4).

Type: S, T. Morphology: *Grain*: 3-porate. Irregularly shaped pores, which are made up of a partially discontinuous tectum. Ulcus rather than porate. *Exine*: semi-tectate; nexine and sexine of equal thickness and quite distinct; columellae distinct and tightly packed. *Polar view*: circular. *Equatorial view*: spheroidal. *Pattern*: finely reticulate. Size: *Exine*: 0.5–0.8 μm. *Equatorial view*: 17–20 × 18–21 μm. *Pore*: 1.5–4 μm.

5.23. Clusiaceae

Cratoxylum glaucum: N3°45′27″; E115°26′35″ (Plate 6, figure 6).

Type: S, T. Morphology: *Grain*: 3-porate with circular pores. *Aperture type*: vestibulum. *Exine*: tectate-perforate; columellae indistinct. *Polar view*: circular. *Equatorial view*: spheroidal. *Pattern*: scabrate. Size: *Equatorial view*: 16–20 μm. *Pore*: 1 μm.

Cratoxylum sumatranum: N3°34′08″; E115°33′19″ (Plate 6, figure 7).

Type: T. Morphology: *Grain*: 3-colporate with lalongate elliptic endoapertures. *Exine*: semi-tectate. *Polar view*: circular. *Equatorial view*: spheroidal. *Pattern*: reticulate-homobrochate. Size: *Exine*: 2 μm. *Equatorial view*: 17–22 × 20–23 μm. *Pore*: 3–4 × 6–12 μm.

Garcinia mangostana: N3°33′39″; E115°33′19″ (Plate 6, figure 8).

Type: T. Uses: E (Christensen 2002). Morphology: *Grain*: 3-colporate with lalongate rectangular endoapertures. Long ectocolpi. *Exine*: tectate; columellae indistinct. *Polar view*: circular. *Equatorial view*: spheroidal-oblate spheroidal. *Pattern*: granulate. Size: *Equatorial view*: 18–20 μm. *Pore*: 2 × 4 μm.

Garcinia sp. (Herbarium) (Plate 6, figure 9)

Morphology: *Grain*: 3-colporate. Lalongate elliptic-rectangular endoapertures and very short ectocolpi. *Exine*: intectate, constructed of free standing columellae. Columellae are well spaced. *Polar view*: circular. *Equatorial view*: spheroidal-oblate spheroidal. *Pattern*: gemmate and granulate between the gemmae. Size: *Gemmate processes*: 1 μm. *Equatorial view*: 10–12 μm. *Pore*: 1 μm.

5.24. Commelinaceae

Amischotolype griffithii: N3°34′08″; E115°33′19″ (Plate 6, figure 10).

Type: H. Morphology: *Grain*: 1-sulcate. Sulcate ends sharp edged. *Exine*: tectate-perforate; columellae distinct. *Polar view*: prolate. *Equatorial view*: prolate-perprolate. *Pattern*: granulate. Size: *Exine*: 1.5–2 μm. *Equatorial view*: 19–28 × 38–44 μm.

Cyanotis ciliata: N3°45′27″; E115°26′35″ (Plate 6, figure 11).

Type: H. Morphology: *Grain*: 1-sulcate. Sulcate ends sharp edged to gaping. *Exine*: tectate-perforate. Columellae indistinct, exine thin. *Polar view*: prolate. *Equatorial view*: prolate-perprolate. *Pattern*: verrucate with coarse granulate pattern. Size: *Exine*: 1 μm. *Equatorial view*: 11–17 × 26–30 μm.

Floscopa scandens: N3°45′27″; E115°26′36″ (Plate 7, figure 1).

Type: H. Morphology: *Grain*: 1-sulcate. Sulcate ends gaping. *Polar view*: prolate. *Equatorial view*: prolate-perprolate. Exine: intectate with free standing columellae. *Pattern*: gemmate, gemmae are irregular but well spaced, psilate between the gemmae. Size: *Equatorial view*: 15–21 × 21–26 μm. *Gemmae*: 1–1.2 μm. This grain is quite similar to *Asparagus* sp., although gemmae spacing in *Asparagus* sp. appears regular, almost in rows.

Commelinaceae sp.: N3°45′27″; E115°26′35″ (Plate 7, figure 2).

Type: H. Morphology: *Grain*: 1-sulcate. Sulcate ends straight-gaping. *Exine*: tectate, exine thin. *Polar view*: prolate. *Equatorial view*: prolate-perprolate. *Pattern*: granulate. Size: *Equatorial view*: 11–13 × 12–18 μm.

5.25. Convolvulaceae

Ipomoea batatas: N3°44′09″; E115°28′33″ (Plate 5, figure 2).

Type: S. Uses: E (Christensen 2002). Morphology: *Grain*: polyporate (over 80 pores). *Exine*: tectate-perforate. *Equatorial view*: spheroidal. *Pattern*: the tectum is densely perforate/microreticulate with a supra-echinate sculpture. The echinae are slightly thicker at the base and smaller-rounded on the spine. Size: *Tectum*: 3 μm. *Equatorial view*: 93–106 μm. *Pore*: 4.5–6 μm. *Columellae*: 2 μm. *Echinae*: 7–10 μm.

5.26. Costaceae

Costus speciosus: N3°33′33″; E115°33′05″ (Plate 5, figure 3).

Type: H, S. Uses: E, M (Delin & Larsen 2000; Christensen 2002). Morphology: *Grain*: inaperturate. *Exine*: intectate. *Equatorial view*: spheroidal-subspheroidal. *Pattern*: granulate with very large gemmae. Size: *Exine*: 1.5 μm. *Equatorial view*: 68–80 μm. *Gemmae*: 5 μm.

5.27. Cucurbitaceae

(All of the cucurbitaceaes were taken from different vegetable gardens in Pa'Dalih.

Trichosanthes kinabaluensis: N3°45′27″; E115°26′35″ (Plate 5, figure 4).

Type: H. Uses; E, M (Christensen 2002). Morphology: *Grain*: 3-colporate. Circular ectoapertures with short elongated endoapertures. Apertures marginate with sexine slightly longer than the nexine. *Exine*: semi-tectate. *Polar view*: circular. *Equatorial view*: spheroidal. *Pattern*: finely reticulate. Size: *Polar view*: Tectum 0.5–1 μm. *Equatorial view*: 72–78 μm. *Pore*: 8–12 μm.

Cucurbitaceae sp. *cf. Cucurbita sativus* (*Timun*): N3°33′33″; E115°33′05″ (Plate 5, figure 5).

Type: H, Uses: E (Christensen 2002). Morphology: *Grain*: 3-porate. *Aperture type*: aspis. *Exine*: tectate. *Polar view*: circular. *Equatorial view*: spheroidal. *Pattern*: granulate-scabrate. *Aperture*: circular. Size: *Equatorial view*: 65–68 μm. *Pore*: 10 μm.

Cucurbitaceae sp. (*Kaya udan*): N3°33′33″; E115°33′05″ (Plate 5, figure 6).

Type: H. Morphology: *Grain*: 3-colpate. *Exine*: tectate-perforate. *Polar view*: circular. *Equatorial view*: spheroidal. *Pattern*: sexine echinate but granulate between the echinae. The echinae are well and regularly spaced. *Equatorial view*: 55–56 μm.

Cucurbitaceae sp. (*Gocu*): N3°33′33″; E115°33′05″ (Plate 5, figure 7).

Type: H. Uses: E (a green spiked vegetable). Morphology: *Grain*: polycolpate/zona aperturate. This remains uncertain as only two grains were recorded. More grains are needed for a more accurate determination. *Exine*: tectate-perforate. *Polar view*: circular. *Equatorial view*: spheroidal. *Pattern*: echinate but granulate between the echinae. Echinae are irregularly spaced. *Equatorial view*: 54–75 μm. *Tectum*: 1.5 μm.

Cucurbitaceae sp a.: N3°33′33″; E115°33′05″ (Plate 5, figure 8).

Type: H. Uses: E (a white vegetable). Morphology: *Grain*: 3-colporate with long ectocolpi and circular pores. *Exine*: intectate-columellae free-standing. Columellae tightly packed but irregularly spaced. *Polar view*: circular. *Equatorial view*: spheroidal. *Pattern*: baculate. Size: *Equatorial view*: 65–67 μm. *Pore*: 10–10.5 μm.

Cucurbitaceae sp b.: N3°33′33″; E115°33′05″ (Plate 5, figure 9).

Type: H. Uses: E (a green striped vegetable). Morphology: *Grain*: 3-colporate with circular pores. *Exine*: semi-tectate. *Polar view*: circular. *Equatorial view*: spheroidal. *Pattern*: reticulate-heterobrochate. Size: *Equatorial view*: 68.5–103 μm.

Cucurbitaceae sp. c.: N3°33′33″; E115°33′05″ (Gourd/Peria) (Plate 5, figure 10).

Type: H. Uses: E (described by one of the residents in Pa'Dalih as a cultivated, bitter vegetable).

Morphology: *Grain*: 3-colpate (uncertainty in aperture type, as limited number of grains and apertures difficult to distinguish). *Exine*: semi-tectate. *Equatorial view*: spheroidal-prolate-spheroidal. *Pattern*: reticulate-homobrochate. Size: *Equatorial view*: 67–74 × 52–55 μm.

5.28. *Cyperaceae*

Fimbristylis globulosa: N3°45′27″; E115°26′35″ (Plate 7, figure 3).

Type: H. Uses: U (Christensen 2002). Morphology: *Grain*: 1-aperturate/poorly defined pore. *Exine*: semi-tectate; columellae indistinct and exine thin. *Equatorial view*: pear-shaped. *Pattern*: reticulate. Size: *Equatorial view*: 21–28 × 27–31 μm.

Scleria purpurascens: N3°43′57″; E115°41′3″ (Plate 7, figure 4).

Type: H. Uses: M (Christensen 2002). Morphology: *Grain*: 1-aperturate/poorly defined pore. *Exine*: tectate; columellae indistinct. *Equatorial view*: pear-shaped. *Pattern*: granulate. Size: *Equatorial view*: 20–30 × 25–34 μm.

5.29. *Daphniphyllaceae*

Daphniphyllum borneense (Herbarium) (Plate 7, figure 5).

Type: T. Morphology: *Grain*: 3-colporate with lalongate elliptic endoapertures. *Exine*: tectate-perforate. Sexine is thicker than the nexine but reduces in size towards the apertures. A thin layer of ektectine covers the endoapertures. *Polar view*: circular. *Equatorial view*: suboblate-oblate spheroidal. *Pattern*: scabrate. Size: *Equatorial view*: 12–18 × 18–23 μm. *Pore*: 1.5–2.5 μm.

5.30. *Dioscoreaceae*

Dioscorea bulbifera: N3°43′4″; E115°29′25″ (Plate 7, figure 6).

Type: L. Uses: M (Christensen 2002), E (Schultz 1993). Morphology: *Grain*: 2-sulcate. Sulcae extend the entire length of grain. Sulcae ends straight. *Exine*: tectate perforate. *Equatorial view*: subspheroidal-prolate. *Pattern*: granulate. Size: *Equatorial view*: 10–13 × 13–18 μm.

5.31. *Dipterocarpaceae*

Shorea monticola (Herbarium) (Plate 7, figure 7).

Type: T. Uses: U. Morphology: *Grain*: 3-colpate. *Exine*: tectate-perforte. Columellae are distinctly visible under the reticulum. Sexine decreases towards the colpi. *Polar view*: circular-semi angular. *Equatorial view*: oblate-suboblate. *Pattern*: microreticulate. The reticulum appears compact and the muri appears slightly raised. On three species of *Shorea*, examined by Gardner et al. (2012), a croton pattern was also identified on the microreticulum, using an electron microscope. This may not be visible, however, under light microscope. Size: *Tectum*: 0.7–0.8 μm. *Columellae*: 0.8–1.30.8 μm. *Polar view*: 20–25 × 24–32 μm.

Vatica albiramis (Herbarium) (Plate 7, figure 8).

Type: T. Morphology: *Grain*: 3-colpate. *Exine*: Tectate-perforte; sexine decreases slightly towards the colpi. Columellae indistinct. *Polar view*: circular-semi angular. *Equatorial view*: peroblate-oblate. *Pattern*: appears both verrucate and finely reticulate. The croton pattern described by Gardner et al. (2012) may also be present on this species, occurring on the muri of the reticulum, which might explain the slightly raised/verrucate appearance, although the croton pattern itself is not visible under light microscope. Size: *Polar view*: *Equatorial view*: 13–17 × 17–22 μm.

5.32. *Elaeocarpaceae*

Elaeocarpus griffithii: N3°43′55″; E115°29′18″ (Plate 7, figure 9). Tree in secondary forest.

Type: T. Uses: E, M (Hovencamp 2009a). Morphology: *Grain*: 3-colporate with large circular to square pores. *Aperture type*: atrium-short. *Exine*: tectate. Sexine and nexine are equal in width and columellae are indistinct. *Polar view*: circular. *Equatorial view*: spheroidal. *Pattern*: psilate. Size: *Exine*: 0.9–1 μm. *Equatorial view*: 9–10 × 10–11 μm. *Pore*: 2.15–3.7 μm. This species is almost identical to the genus *Saurauia* and probably cannot be separated using a light microscope. This species however does appear to have a slightly thicker exine and the grain size is occasionally smaller. Kodela (2006) also reports the genus

Elaeocarpus from New South Wales. This grain is again almost identical except the pores are reported to be minute and that there is a slightly protruding exine.

5.33. *Ericaceae*

Rhododendron durionifolium: N3°44′15″; E115°29′44″ (Plate 7, figure 10). Found in kerangas forest close to a road in Bario.

Type: S, T. Morphology: *Grain*: Tetrad-3-colporate. Aperatures are fastigium. *Exine*: tectate, columellae indistinct. Sexine and nexine are the same thickness, although a thickening of the nexine occurs around the apertures. *Pattern*: granulate. Size: *Exine*: 1.5 μm. *Equatorial view*: 35–48 μm.

Vaccinium coriaceum: N3°44′17″; E115°29′44″ (Plate 7, figure 11). Found at the edge of kerangas forest at the side of a road in Bario.

Type: S, T. Morphology: *Grain*: Tetrad-3-colporate (3–4 grains). Aperatures are fastigium. *Exine*: tectate, columellae indistinct. Sexine and nexine are of the same thickness with no change in thickness around the apertures. *Pattern*: granulate. Size: *Exine*: 1 μm. *Equatorial view*: 28–32 μm.

Vaccinium laurifolium: N3°43′55″; E115°29′18″ (Plate 7, figure 12). Found at the edge of kerangas forest at the side of a road in Bario.

Type: S. Morphology: *Grain*: Tetrad-3-colporate (3–4 grains), colporate. Aperatures are fastigium. *Exine*: tectate, columellae indistinct. Sexine and nexine are of the same thickness with no change in thickness around the apertures. *Pattern*: granulate. Size: *Exine*: 1 μm. *Equatorial view*: 37–42 μm.

5.34. *Euphorbiaceae*

Acalypha caturus: N3°33′33″; E115°33′05″ (Plate 8, figure 1).

Type: T. Morphology: *Grain*: 3-colporate with lalongate elliptic-rectangular endoapertures. *Exine*: tectate-perforate, columellae indistinct. *Polar view*: circular. *Equatorial view*: spheroidal. *Pattern*: microreticulate-scabrate. Size: *Exine*: 1 μm. *Equatorial view*: 12 × 17 μm. *Pore*: 1–1.5 × 4–5 μm.

Baccaurea lanceolata: N3°33′39″; E115°33′24″ (Plate 8, figure 2).

Type: S, T. Uses: E, M (Christensen 2002; Haegens & van Welzen 2010). Morphology: *Grain*: 3-colporate with lalongate elliptic endoapertures. A slight thickening of the exine around the apertures, although quite difficult to see. *Exine*: semi-tectate. *Polar view*: circular. *Equatorial view*: prolate spheroidal. *Pattern*: reticulate-homobrochate. Size: *Exine*: 1 μm. *Equatorial view*: 10.5–11 × 12–13 μm.

Breynia racemosa: N3°34′08″; E115°33′19″ (Plate 8, figure 3).

Type: T, S. Morphology: *Grain*: 6–7-colporate with small circular pores. *Exine*: semi-tectate, columellae distinct. *Polar view*: circular. *Equatorial view*: suboblate. *Pattern*: reticulate-homobrochate. Size: *Exine*: 1.5 μm. *Equatorial view*: 14.5–15 × 19–21 μm. *Pore*: 1.8 μm. *Space between the lumina*: 0.7 μm.

Glochidion sp.: N3°45′27″; E115°26′36″ (Plate 8, figure 4).

Type: T. Uses: U (Christensen 2002). Morphology: *Grain*: 5-colporate with small circular pores. *Exine*: semi-tectate. *Polar view*: circular. *Equatorial view*: prolate spheroidal. *Pattern*: reticulate-heterobrochate. Size: *Equatorial view*: 23–26 × 25–29 μm. *Space between the lumina*: 1–1.6 μm.

Glochidion monostylum: N3°34′08″; E115°33′19″ (Plate 8, figure 5).

Type: T. Uses: U (Christensen 2002). Morphology: *Grain*: 4-colporate with small circular pores. *Polar view*: circular. *Equatorial view*: spheroidal. *Pattern*: reticulate-heterobrochate. Size: *Exine*: 1.5–2 μm. *Equatorial view*: 17–21 × 20–22 μm. *Pore*: 1 μm. *Space between the lumina*: 0.7–1.4 μm.

Note: Breynia racemosa is very similar to *Glochidion*, although *Glochidion* seems to be less colporate than *Breynia*. Sagun & Van der Ham (2003) describe *Glochidion* as 3–6-colporate and *Breynia* as 12-colporate.

Macaranga costulata: N3°34′08″; E115°33′19″ & N3°43′57″; E115°41′3″ (Plate 8, figure 6).

Type: T. Uses: U (Christensen 2002). Morphology: *Grain*: 3-colporate with lalongate elliptic endoapertures. Endoapertures are long, almost forming an equatorial belt. *Exine*: tectate-perforate, columellae indistinct. Apertures are costate in that the nexine is much thicker around the apertures. *Polar view*: circular. *Equatorial view*: oblate-spheroidal. *Pattern*: microreticulate. Size: *Exine*: 1 μm. *Equatorial view*: 11–13 × 13 μm. *Pore*: 1.5–4 μm.

Mallotus paniculatus: N3°34′08″; E115°33′19″ (Plate 8, figure 7).

Type: S, T. Uses: U (Christensen 2002). Morphology: *Grain*: 3-colporate with lalongate elliptic endoapertures. Ectoapertures are wide at the mesocolpia and appear triangular at the apocolpia. *Exine*: tectate-perforate, columellae indistinct. The sexine reduces in thickness towards the apertures. *Polar view*: circular-semi angular. *Equatorial view*: oblate-spheroidal. *Pattern*: finely reticulate. Size: *Exine*: 1–1.5 μm. *Equatorial view*: 14–18 × 18–20 μm. *Pore*: 3–4 × 6 μm.

Mallotus sp.: N3°33′39″; E115°33′24″ (Plate 8, figure 8).

Type: S, T. Morphology: *Grain*: 3-colporate. *Endoaperture*: rectangular with a thick operculum. Apertures are also costate, with a distinct thickening of the nexine. *Exine*: tectate-perforate, columellae indistinct. *Polar view*: circular. *Equatorial view*: oblate-spheroidal. *Pattern*: finely reticulate. Size: *Exine*: 1 μm. *Equatorial view*: 18–21 × 20–24 μm. *Pore*: 3–5 × 5–6 μm.

Manihot esculenta: N3°44′17″; E115°29′44″ (Plate 11, figure 2). A tree in a garden, Bario.

Type: S, T. Uses: E (Christensen 2002). Morphology: *Grain*: polyporate. *Exine*: tectum discontinuous with triangular supra-tectal elements arranged in a croton pattern. *Polar view*: circular. *Equatorial view*: spheroidal. *Pattern*: tectum psilate; supra-tectal elements: croton and psilate. Size: *Equatorial view*: 95–105 μm. *Pore*: 4–6 μm. Similar to *Baloghia inophylla* reported by Kodela (2006), which is also a Euphorbiaceae, although much smaller 27.6–-37.2 μm. Nowicke (1994) describes 69 species of Euphorbiaceae, which all have a similar croton morphology, with triangular supratectal elements attached to a network of muri having short or irregular columellae. This includes *Manihot esculenta*. The triangular elements can, however, be psilate, striate, furrowed and ridged, or pitted and with echinate, rounded or long attenuate apices. They may or may not have muri and modified columellae and some can also be inaperaturate.

Phyllanthus urinaria: N3°34′08″; E115°33′19″ (Plate 8, figure 9).

Type: S. Uses: M (Christensen 2002). Morphology: *Grain*: 4-colporate with circular pores and long elongated colpi. *Exine*: tectate-perforate, columellae distinct. *Pattern*: finely reticulate. *Polar view*: rectangular. *Equatorial view*: prolate-peoprolate. Size: *Tectum*: 1 μm. *Equatorial view*: 12–15 × 18–25 μm. *Pore*: 1–2 μm.

Euphorbiaceae sp.: N3°33′33″; E115°33′05″ (Plate 8, figure 10).

Type: S, T. Morphology: *Grain*: 3-colporate with lalongate elliptic endoapertures and circular pores. *Exine*: semi-tectate. *Pattern*: reticulate-heterobrochate, lumina quite small. *Polar view*: circular-semi angular. *Equatorial view*: spheroidal-oblatespheroidal. Size: *Equatorial view*: 15–19.5 μm. *Pore*: 6 × 1 μm.

5.35. Fabaceae

Bauhinia finlaysoniana: N3°33′39″; E115°33′24″ (Plate 8, figure 11). Found wrapped around a tree in secondary forest, Bario.

Type: T. Uses: R, U (Christensen 2002). Morphology: *Grain*: 3-colporate. *Aperture*: circular pores with short lolongate colpi. Endoaperture margins appear rough. Pore margins appear smooth. Colpi are invaginated. *Exine*: tectate, columellae indistinct. Both the sexine and nexine are equal in thickness. Nexine, however, shows a pronounced thickening around the apertures and is also shorter than the sexine. The sexine extends over the nexine at the apertures. A thin layer of ektexine also covers the pores. *Pattern*: psilate. *Polar view*: circular. *Equatorial view*: prolate. Size: *Tectum*: 1 μm. *Equatorial view*: 40–50 × 52–62.5 μm. *Pore*: 7.5 μm. *Furrow*: 10–14 × 17.5–8 μm.

Erythina subumbrans: N3°33′33″; E115°33′05″ (Plate 8, figure 12).

Type: L. Morphology: Grain: 3-porate. *Aperture type*: atrium. *Aperture*: circular. *Exine*: semi-tectate. Both the sexine and nexine are of equal thickness. Exine is thick. *Pattern*: coarse granular and hetero-reticulate. Muri of the reticulum appear slightly raised. Ektexine protrudes out over the pores. *Polar view*: subangular-angular. *Equatorial view*: oblate-suboblate. Size: *Equatorial view*: 24–28.5 × 24.5–29.5 μm. *Exine*: 1.6–2.9 μm.

Fordia splendidissima: N3°34′08″; E115°33′19″ (Plate 9, figure 1).

Type: T, S, L. Uses: U (Christensen 2002). Morphology: *Grain*: 3-colpate–3-colporate. Thick ectocolpi with a bulge in the equatorial exine (geniculum). Many of the grains show lalongate endocolpi, although not all. *Exine*: tectate-perforate. Sexine and nexine of equal thickness. Exine thin. *Pattern*: finely reticulate-perforate with a granular infratectum. *Polar view*: semi-angular. *Equatorial view*: prolate, although some spheroidal. Size: *Equatorial view*: 18.5–20 × 20–22.5 μm. *Exine*: 1.3–1.5 μm.

Pithecellobium clypearia: N3°44′17″; E115°29′44″ (Plate 13, figure 1).

Type: T, S. Morphology: *Grain*: polyad (of 16). *Exine*: tectate to tectate-perforate; columellae indistinct. Nexine and seine generally of equal thickness, although sometimes the sexine is slightly thicker. *Polyad shape*: spheroidal. *Individual grain shape*: square-rectangular. *Pattern*: granulate. Size: *Polyad*: 80–100 μm. *Individual grains*: 21–23 × 25–35 μm. *Pore*: 2.5–3 μm. *Exine*: 1.5–2.3 μm.

Vigna sp.: N3°33′33″; E115°33′05″ (Plate 9, figure 2). Close to a foot path in Pa'Dalih.

Type: H, L. Uses: E (Christensen 2002). Morphology: *Grain*: 3-porate. *Aperture type*: atrium. *Aperture*: circular. *Exine*: tectate. *Pattern*: suprareticulate with elevated muri. *Polar view*: semi-sub-angular. *Equatorial view*: oblate-spheroidal. Size: *Equatorial view*: 38–44 μm.

5.36. Fagaceae

Castanopsis acuminatissima (Herbarium) (Plate 9, figure 3).

Type: T. Uses: E (Christensen 2002). Morphology: *Grain*: 3-colporate with lalongate elliptic endoapertures. Ectoapertures long and elongated. A thickening of the nexine around the apertures. *Exine*: tectate-perforate, columellae short but distinct. *Pattern*: granulate. *Polar view*: circular. *Equatorial view*: subprolate.

Size: *Exine*: 1.8 μm. *Equatorial view*: 11–16 × 19–22 μm. *Pore*: 1–2 × 5–6.5 μm.

Lithocarpus andersonii (Herbarium) (Plate 9, figure 4).

Type: T, S. Morphology: *Grain*: 3-colporate with lalongate elliptic endoapertures. Ectoapertures long and elongated. A thickening of the nexine around apertures. *Exine*: tectate-perforate, columellae short but distinct. *Pattern*: scabrate. *Polar view*: circular. *Equatorial view*: prolate-perprolate. Size: *Exine*: 1 μm. *Equatorial view*: 10–12 × 16–19 μm. *Pore*: 2 × 3 μm.

Lithocarpus ewyckii: N3°33′39″; E115°33′24″ (Plate 9, figure 5).

Type: T, S. Uses: E (Christensen 2002). Morphology: *Grain*: 3-colporate with lalongate elliptic endoapertures. Ectoapertures long and elongated. A thickening of the nexine around apertures. *Exine*: tectate-perforate, columellae indistinct. *Pattern*: scabrate. *Polar view*: circular. *Equatorial view*: prolate-perprolate. Size: *Equatorial view*: 8–11 × 13–20 μm. *Pore*: 1 × 3 μm.

Trigobalanus verticillatus (Herbarium) (Plate 9, figure 6).

Type: T. Morphology: *Grain*: 3-colporate with circular pores with short lalongate endoapertures. Endoapertures are not always visible. Ectoapertures long and wide (width: 2.75–4.4 μm). *Exine*: tectate-perforate, columellae indistinct. Nexine thicker than the sexine. Exine marginate in that sexine is longer than the nexine around the apertures. *Pattern*: granulate. *Polar view*: circular. *Equatorial view*: spheroidal. *Aperture*: circular. Size: *Exine*: 2–3 μm. *Equatorial view*: 16–23 × 20–24 μm. *Pore*: 1.5–5 × 3–6 μm.

5.37. Gesneriaceae

Aeschynanthus longicaulis (Herbarium) (Plate 9, figure 7).

Type: L. Morphology: *Grain*: 3-parasyncolporate, pores indistinct. Colpi long, connecting at the poles to form a wide apocolpium. Endocolpi are lalongae elliptic. *Exine*: tectate-tectate-perforate. Nexine and sexine are of equal thickness. *Pattern*: psilate-scabrate. *Polar view*: circular-semi-angular. *Equatorial view*: subprolate. Size: *Exine*: 1 μm. *Equatorial view*: 15–18 × 18–20 μm. *Pore*: < 1–1 × 2 μm.

Aeschynanthus magnificus: N3°43′47″; E115°29′29″ (Plate 9, figure 8).

Type: S, L. Uses: U (Christensen 2002). Morphology: *Grain*: 3-colporate, occasionally parasyncolporate. Ectocolpi generally do not meet at poles. Endocolpi are small lalongate elliptic. *Exine*: tectate, exine thin, sexine and nexine difficult to separate. Columelllae indistinct. *Pattern*: psilate-scabrate. *Polar view*: circular-semi-angular. *Equatorial view*: subprolate. Size: *Exine*: 1 μm. *Equatorial view*: 14–18 × 16–18 μm. *Pore*: 1–1.5 × 2.5 μm.

5.38. Hydrangeaceae

Dichroa febrifuga: N3°34′08″; E115°33′19″ (Plate 9, figure 9).

Type: S, L. Uses: M (Christensen 2002). Morphology: *Grain*: 3-colpate or 3-colporate. Ectocolpi geniculum or fastigium, endocolpi small lalongate-circular. *Exine*: tectate-perforate. Sexine reduces in thickness towards the colpi. Columellae distinct. *Pattern*: finely reticulate, *Polar view*: circular, *Equatorial view*: prolatespheroidal-prolate. Size: *Exine*: 1 μm. *Equatorial view*: 11–21 × 16–25 μm. *Pore*: 1–1.5 × 2–2.5 μm.

5.39. Hypoxidaceae

Curculigo latifolia: N3°43′4″; E115°29′25″ and 3°33′39″; 115°33′24″ (Plate 9, figure 10).

Type: H, S. Uses: E, U (Christensen 2002; Shaari 2005). Morphology: *Grain*: 1-sulcate. Sulcate ends pointed-irregularly shaped. *Exine*: semi-tectate. Sexine slightly thicker than the nexine. Columellae distinct. *Pattern*: granulate-rugulate. *Equatorial view*: subspheroidal. Size: *Exine*: 1.5–2 μm. *Equatorial view*: 26.5–31 μm x 32–40 μm.

5.40. Lamiaceae

Callicarpa sp.: N3°45′27″; E115°26′35″ (Plate 9, figure 11).

Type: S, T. Morphology: *Grain*: 3-colpate with wide, medium-long ectocolpi. *Exine*: semi-tectate, columellae distinct. Nexine and sexine of equal thickness, although sexine reduces in thickness towards the colpi. *Pattern*: reticulate-homobrochate, lumina small. *Polar view*: circular. *Equatorial view*: oblate. Size: *Tectum*: 2 μm. *Equatorial view*: 25–33 μm.

Gomphostemma javanicum: N3°34′08″; E115°33′19″ (Plate 9, figure 12).

Type: H. Morphology: *Grain*: 3-colpate. Occasionally colpi form a geniculum. *Exine*: tectate, columellae visible but not distinct. Nexine and sexine of equal thickness, although sexine reduces in thickness towards the colpi. *Pattern*: granulate. *Polar view*: circular. *Equatorial view*: spheroidal. Size: *Tectum*: 2.5–3 μm. *Equatorial view*: 22–33 μm.

5.41. Lauraceae

Litsea crassifolia: N3°43′55″; E115°29′18″ (Plate 10, figure 1).

Type: S, T. Morphology: *Grain*: inaperturate. *Exine*: intectate, exine thin, nexine and sexine indistinguishable. *Pattern*: psilate-granulate, with moderately-well spaced echinae. *Equatorial view*: subspheroidal-spheroidal. Size: *Equatorial view*: 25–35 × 30–45 μm.

Litsea subumbelliflora: N3°43′4″; E115°29′25″ (Plate 10, figure 2).

Type: S, T. Morphology: *Grain*: inaperturate. *Exine*: intectate, exine thin, nexine and sexine indistinguishable. *Pattern*: psilate with densely spaced echinae. *Equatorial view*: subspheroidal-spheroidal. Size: *Equatorial view*: 18 × 18–18 × 31 μm.

5.42. Liliaceae

Ophiopogon caulescens: N3°34′08″; E115°33′19″ (Plate 10, figure 3).

Type: S, T. Morphology: *Grain*: 1-sulcate. Sulcate ends gaping. *Exine*: tectate-perforate, columellae short but distinct. Sexine thicker than the nexine. *Pattern*: microreticulate. *Equatorial view*: subspheroidal. Size: *Exine*: 1 μm. *Equatorial view*: 21–33 × 30–36 μm.

5.43. Loganiaceae

Fagraea racemosa: N3°44′17″; E115°29′44″ (Plate 10, figure 4).

Type: S, T. Uses: U (Christensen 2002). Morphology: *Grain*: 3-colporate with circular pores. *Exine*: semi-tectate, columellae distinct and appear slightly larger in the apocolpia. The nexine and sexine appear equal in thickness around the mesocolpia, although the sexine is sometimes slightly thicker. *Pattern*: reticulate-heterobrochate. Lumina are larger than *Fagraea stenophylla* but become smaller in the apocolpia region. Reticulum do not appear simplicolumellate. *Polar view*: circular. *Equatorial view*: suboblate-oblate spheroidal. Size: *Exine*: 2.5–4 μm. *Equatorial view*: 27–32 × 33–39 μm. *Pore*: 2.5–4 μm. *Mesocolpia reticulum*: 1.2–3.75 *Apocolpia reticulum*: 0.5–1.3 μm.

Fagraea stenophylla: N3°33′39″; E115°33′24″ (Plate 10, figure 5).

Type: T, S. Morphology: *Grain*: 3-colporate with circular pores. *Exine*: semi-tectate, columellae distinct and appear slightly larger around the apocolpia and apertures. The nexine is slightly smaller than the sexine and remains uniform in size. *Pattern*: reticulate-heterobrochate. In the apocolpia region the reticulum appear almost striate in their arrangement. Lumina become smaller in the apocolpia region. Reticulum also appear simplicolumellate. *Polar view*: circular. *Equatorial view*: suboblate-oblate spheroidal. Size: *Tectum*: 2–2.5 μm. *Equatorial view*: 27–28 × 28–30 μm. *Pore*: 3–4 μm. *Mesocolpia reticulum*: 0.7–3.2 μm *Apocolpia reticulum*: 0.7–1.8 μm.

5.44. Loranthaceae

Dendrophthoe pentandra: N3°34′08″; E115°33′19″ (Plate 10, figure 6).

Type: S, T. Uses: E, M (Christensen 2002). Morphology: *Grain*: 3-syncolporate. *Exine*: tectate. Sexine and nexine equal in thickness. Columellae indistinct. *Pattern*: granulate. *Polar view*: semilobate-subangular. *Equatorial view*: peroblate, Size: *Exine*: 1–1.2 μm. *Equatorial view*: 31–33 μm.

Helixanthera spicata: N3°44′17″; E115°29′44″ (Plate 10, figure 7).

Type: S, L. Morphology: *Grain*: 3-brevicolporate, short colpi. *Exine*: tectate. Sexine slightly larger than the nexine. Sexine thins towards the apertures. Columellae indistinct. *Pattern*: scabrate. *Polar view*: semilobate-subangular. *Equatorial view*: peroblate. Size: *Exine*: 1 μm. *Equatorial view*: 20–22 μm.

Lepeostegeres centiflorus: N3°45′27″; E115°26′35″ (Plate 11, figure 3).

Type: S, L. Morphology: *Grain*: 3-syncolporate. *Exine*: tectate to tectate-perforate. Sexine slightly smaller than the nexine. Columellae indistinct. *Pattern*: granulate. *Polar view*: semilobate-triangular. *Equatorial view*: peroblate. Size: *Exine*: 2 μm. *Equatorial view*: 42–59 μm.

Scurrula parasitica: N3°33′33″; E115°33′05″ (Plate 12, figure 1).

Type: S, L. Uses; E, M (Christensen 2002). Morphology: *Grain*: 3-syncolporate. *Exine*: tectate. Sexine and nexine difficult to distinguish. Columellae indistinct. *Pattern*: granulate. *Polar view*: semilobate-triangular. *Equatorial view*: peroblate. Size: *Equatorial view*: 25–33 μm.

5.45. Malvaceae

Abelmoscus moschatus: N3°33′33″; E115°33′05″ (Plate 11, figure 4).

Type: H, S. Morphology: *Grain*: polyporate (ca. 18–20). *Exine*: tectate, columellae short but distinct. Nexine indistinct. Exine thin with supratectal elements. *Pattern*: granulate with large supraechinae. Spines are lightly rounded. *Equatorial view*: circular. Size: *Equatorial view*: 125 μm. *Exine*: 2–2.4 μm. *Pore*: 8–11 μm. *Echinae*: 28 μm.

Sida rhombifolia: N3°45′27″; E115°26′35″ (Plate 11, figure 5).

Type: H. Morphology: *Grain*: polyporate (> 12 but < 20). *Exine*: tectate-perforate, columellae distinct. *Pattern*: tectum is densely perforate with supraechinae situated on top of verrucate protrusions. Smaller echinae are situated between the main echinae. The large supraechinae partially cover the pores. *Equatorial view*: circular. Size: *Exine*: 2–2.4 μm. *Equatorial view*: 75–95 μm. *Pore*: 5–7 μm. *Verrucae*: 2.5–4 × 3 μm. *Main echinae*: 4 μm. *Minor echinae*: < 1 μm.

5.46. Marantaceae

Phrynium maximum: N3°43′4″; E115°29′25″ (Plate 12, figure 2).

Type: H. Morphology: *Grain*: inaperturate. *Exine*: tectate. Exine thin. *Pattern*: granulate. *Equatorial view*: suboblate. Size: 24–32 μm.

5.47. Melastomataceae

Dissochaeta monticola: N3°33′39″; E115°33′24″ (Plate 12, figure 3).

Type: H, S. Morphology: *Grain*: heterocolporate (3–4-colporate and 3–4-colpate) with lalongate elliptic endoapertures. *Exine*: tectate, columellae indistinct. Nexine and sexine equal in width. Marginate towards the apertures. *Pattern*: scrabrate. *Polar view*: interhexagonal. *Equatorial view*: sub-prolate,-prolate spheroidal. Size: *Equatorial view*: 10–13 × 16–20 μm. *Pore*: 1 × 2–3 μm.

Medinella crassifolia: N3°43′55″; E115°29′18″ (Plate 12, figure 4).

Type: S, T. Uses: E (Christensen 2002). Morphology: *Grain*: heterocolporate (3–4-colporate and 3–4-colpate) with lalongate elliptic endoapertures. *Exine*: tectate, columellae indistinct. Nexine and sexine equal in width. Slightly marginate towards the apertures. *Pattern*: scrabrate. *Polar view*: interhexagonal. *Equatorial view*: sub-prolate-prolate spheroidal-spheroidal. Size: *Exine*: 1μm. *Equatorial view*: 9–14 × 13–15 μm. *Pore*: 2.4–3 μm.

Melastoma malabathricum: N3°44′09″; E115°28′42″ (Plate 12, figure 5).

Type: S. Uses: E, M (Christensen 2002). Morphology: *Grain*: heterocolporate (3–4-colporate and 3–4-colpate) with lalongate elliptic endoapertures. Exine marginate around apertures in that the sexine is longer than the nexine. *Exine*: tectate, columellae indistinct. Exine walls difficult to distinguish. *Pattern*: scrabrate. *Polar view*: interhexagonal. *Equatorial view*: sub-prolate-prolate spheroidal-spheroidal. Size: *Equatorial view*: 11–17 × 16–20 μm. *Pore*: 2 × 3 μm.

Pachycentria pulverulenta: N3°43′55″; E115°29′18″ (Plate 12, figure 6).

Type: S, L. Morphology: *Grain*: heterocolporate (3-colporate, 3-colpate) with lalongate elliptic endoapertures. *Exine*: tectate, columellae indistinct. Nexine and sexine equal in width. Exine marginate around apertures, in that the sexine is longer than the nexine. *Pattern*: scrabrate. *Polar view*: triangular *Equatorial view*: spheroidal-oblate spheroidal. Size: *Equatorial view*: 16–18 μm. *Pore*: 1.5 × 6 μm.

Pternandra tesselata: N3°34′17″; E115°33′19″ (Plate 12 figure 7).

Type: H, S. Uses: U (Christensen 2002). Morphology: *Grain*: heterocolporate (3-colporate and 3-colpate) with lalongate elliptic endoapertures. *Exine*: tectate, columellae indistinct. Nexine and sexine equal in width, although marginate towards the apertures. The sexine increases in thickness at the apertures. *Pattern*: microreticulate. *Polar view*: interhexagonal. *Equatorial view*: spheroidal. Size: *Tectum*: 1–1.5 μm. *Equatorial view*: 16 × 16–18 μm. *Pore*: 3–3.5 μm.

5.48. Menispermaceae

Pericampylus glaucus: N3°45′27″; E115°26′35″ (Plate 12, figure 8).

Type: L. Uses: R, M (Christensen 2002). Morphology: *Grain*: 3-colporate with lalongate elliptic-circular endoapertures. *Exine*: semi-tectate, columellae distinct. *Pattern*: reticulate-homobrochate. *Polar view*: circular. *Equatorial view*: spheroidal-subprolate. Size: *Exine*: 1 μm. *Equatorial view*: 10–13 × 12–14 μm. *Pore*: 2.5–3 μm.

5.49. Moraceae

Artocarpus heterophyllus: N3°33′39″; E115°33′24″ (Plate 12, figure 9).

Type: T. Uses: E (Anderson 1980; Christensen 2002). Morphology: *Grain*: 3-porate. Very small apertures, pores circular. *Exine*: tectate-perforate, columellae indistinct. *Pattern*: granulate. *Polar view*: circular. *Equatorial view*: spheroidal. Size: *Equatorial view*: 8–15 μm. *Pore*: < 1–1 μm.

5.50. Musaceae

Musa sp. N3°33′33″; E115°33′05″ (Plate 13, figure 2).

Type: T. Uses: E, M (Christensen 2002). Morphology: *Grain*: inaperturate. *Exine*: undetermined. This is probably due to deterioration of the grain. *Pattern*: granulate. *Equatorial view*: spheroidal. Size: *Exine*: 2–3.5 μm. *Equatorial view*: 57–87 μm.

5.51. Myrsinaceae

Ardisia pterocaulis N3°33′39″; E15°33′24″ (Plate 12, figure 10).

Type: S. Uses: M (Christensen 2002). Morphology: *Grain*: 3-colporate with lalongate elliptic endoapertures. *Exine*: semi-tectate, columellae distinct. A slight thickening of the nexine towards the apertures. *Pattern*: finely reticulate-homobrochate. *Polar view*: semi-angular. *Equatorial view*: spheroidal-prolate. Size: *Exine*: 1 μm. *Equatorial view*: 13–17 × 15–18 μm. *Pore*: 2–3 × 4–5 μm.

Embelia sp.: N3°43′17″; E115°29′25″ & N3°33′39″; E115°33′24″ (Plate 12, figure 11).

Type: S, T. Uses: E, M (Christensen 2002). Morphology: *Grain*: 3-colporate with lalongate elliptic endoapertures. *Exine*: tectate-perforate, columellae indistinct. Finely reticulate. *Polar view*: semi-angular-circular. *Equatorial view*: spheroidal-prolate. Size: *Equatorial view*: 15 × 18 μm.

5.52. *Myrtaceae*

Decaspermum fruticosum: N3°45′27″; E115°26′36″ (Plate 12, figure 12).

Type: S, T. Uses: E, U (Christensen 2002). Morphology: *Grain*: 3-parasyncolporate with lalongate endoapertures, pores circular. Grains are isopolar and radically symetrical. Apocolpia field not present. *Exine*: tectate, columellae indistinct. *Pattern*: granulate. *Polar view*: triangular. *Equatorial view*: peroblate. Size: *Equatorial view*: 12–15 × 21–24 μm. *Pore*: 1–1.5 μm.

Psidium guajava: N3°34′08″; E115°33′19″ (Plate 12, figure 13).

Type: T. Uses: E, M (Christensen 2002). Morphology: *Grain*: 3-parasyncolporate with lalongate endoapertures, pores circular. Grains are isopolar and radically symetrical. Apocolpia field not present. *Exine*: tectate, columellae indistinct. *Pattern*: granulate. *Polar view*: triangular. *Equatorial view*: oblate. Size: *Exine*: 1 μm. *Equatorial view*: 10–14 × 18–20 μm. *Pore*: 1–2 × 3–4 μm.

Syzygium fastigiatum: N3°43′57″; E115°29′41″ (Plate 12, figure 14).

Type: T. Uses: E, U (Christensen 2002). Morphology: *Grain*: 3-parasyncolporate with lalongate endoapertures, pores circular. Grains are isopolar and radically symetrical. Apocolpia field present. *Exine*: tectate, columellae indistinct. *Pattern*: scabrate. *Polar view*: triangular. *Equatorial view*: peroblate. Size: *Equatorial view*: 10 × 11–15 μm. *Pore*: 2–3 μm.

Syzigium subcrenatum: N3°44′17″; E115°29′44″ (Plate 12, figure 15).

Type: T. Morphology: *Grain*: 3-parasyncolporate with lalongate endoapertures, pores circular. Grains are isopolar and radically symetrical. Apocolpia field present. *Exine*: tectate, columellae indistinct. *Pattern*: scabrate. *Polar view*: triangular. *Equatorial view*: peroblate. Size: *Equatorial view*: 9–10 × 15–18 μm. *Pore*: 2–3 μm.

5.53. *Nepenthaceae*

Nepenthes stenophylla: N3°43′4″; E115°29′25″ (Plate 12, figure 16). Found along the verge of a road in Bario.

Type: H. Morphology: *Grain*: tetrad. *Exine*: intectate. *Pattern*: gemmate. Gemmae are well spaced. Size: *Tetrad*: 23–28 μm. *Individual grains*: 12–16.5 μm. Adam & Wilcock (1999) propose *Nepenthes* species are not taxonomically useful, as pollen shape, pollen unit, exine sculpturing and aperture type are all homogeneous.

5.54. *Ochnaceae*

Euthemis minor: N3°43′55″; E115°29′18″ (Plate 14, figure 1).

Type: S. Morphology: *Grain*: 3-colporate with lalongate elliptic endoapertures, pores tend to be elliptic-square. *Exine*: tectate, columellae indistinct. Grain appears to be both costate and marginate with a slight thickening of the nexine towards the apertures and a slight extension of the sexine. There is also a layer of ektectine over the apertures. *Pattern*: granulate. *Polar view*: semi-angular-triangular. *Equatorial view*: spheroidal. Size: *Exine*: 1 μm. *Equatorial view*: 20–26 μm. *Pore*: 4–5 × 4–7 μm.

5.55. *Oleaceae*

Chionanthus pluriflorus (Herbarium) (Plate 14, figure 2).

Type: T. Morphology: *Grain*: 3-colporate with lalongate elliptic-circular endoapertures. *Exine*: semitectate, columellae distinct. *Pattern*: finely reticulate. *Polar view*: circular. *Equatorial view*: oblate spheroidal. Size: *Equatorial view*: 10–16 × 15–17 μm. *Pore*: 1–1.5 μm.

Chionanthus sp.: N3°45′27″; E115°26′35″ (Plate 14, figure 3) Only two grains were identified. *Chionanthus* sp. has not been included in the pollen key.

Type: S, T. Morphology: *Grain*: apertures were very difficult to distinguish. 3-colpate, although perhaps colporate with very small indistinct endoapertures. More grains are needed for a more accurate determination. *Exine*: Tectate-imperforate, columellae are indistinct. *Pattern*: finely reticulate. *Polar view*: circular. *Equatorial view*: spheroidal-oblate. Size: *Equatorial view*: 9–11 μm.

5.56. *Onagraceae*

Ludwigia octovalvis: N°3.4527; E°115.2635 (Plate 13, figure 3).

Type: H. Morphology: *Grain*: tetrad 3-porate with pronounced labrum apertures. *Exine*: tectate, columellae indistinct. Nexine slightly smaller than the sexine. *Pattern*: psilate-granulate. Size: *Tetrad*: 85–90 μm. *Individual grain*: 45–90 μm. *Pore*: 5–11 μm.

5.57. *Orchidaceae*

Arundina graminifolia: N3°44′23″; E115°29′01″ (Plate 14, figure 6).

Type: H. Morphology: *Grain*: inaperturate polyad. *Exine*: tectate-perforate, columellae distinct, exine thin. *Pattern*: reticulate. *Polyad shape*: square. *Individual grain shape*: subspheroidal-rectangular. Size: *Exine*: 1 μm. *Equatorial view*: 28–33 × 35–54 μm. *Individual grain*: 17–21 × 24–28 μm.

Coelogyne sp.: N3°43′47″; E115°29′29″ (Plate 14, figure 7).

Type: H. Uses: R (Christensen 2002). Morphology: *Grain*: inaperturate polyad. *Exine*: tectate, columellae indistinct. *Pattern*: scabrate-granulate. *Polyad shape*: square-semiangular. *Individual grain shape*: subspheroidal-rectangular. *Exine*: 1 μm. *Equatorial view*: 20–38 × 31–52 μm. *Individual grain*: 11–22 × 15–22 μm.

Habenaria sp.: N3°33′39″; E115°33′24″ (Plate 13, figure 4).

Type: H. Morphology: *Grain*: inaperturate polyad. *Exine*: appears intectate with tightly packed, free-standing columellae, columellae are distinct. *Pattern*: micro-reticulate, columellae arranged in a reticulate pattern. *Polyad shape*: pear-bell-shaped with over 100 grains. *Individual grain shape*: subspheroidal-rectangular. *Exine*: 2 μm. *Equatorial view*: 112.5–150 μm. *Individual grain*: 10–17 × 15–23 μm.

Phaius sp.: N3°33′39″; E115°33′24″ (Plate 14, figure 8).

Type: H. Morphology: *Grain*: inaperturate polyad. *Exine*: tectate, columellae indistinct, exine walls cannot be separated but thick exine wall. *Pattern*: granulate. *Polyad shape*: pear-triangular. *Individual grain shape*: subspheroidal-rectangular. *Exine*: 1–3 μm. *Equatorial view*: 34–43 × 40–70 μm. *Individual grain*: 15–25 × 21–30 μm.

Pholidota imbricata: N3°44′09″; E115°28′42″ (Plate 14, figure 9).

Type: H, L. Morphology: *Grain*: inaperturate polyad. *Exine*: tectate, columellae indistinct, thick exine wall but sexine and nexine could not be separated. *Pattern*: scabrate. *Polyad shape*: square-semiangular. *Individual grain shape*: subspheroidal-rectangular. Size: *Tectum*: 1 μm. *Equatorial view*: 28–54 μm. *Individual grain*: 17–21 × 24–28 μm.

5.58. Passifloraceae

Passiflora sp.: N3°33′39″; E115°33′24″ (Plate 13, figure 5). Found at the edge of a disused rice field in Pa'Dalih.

Type: H. Uses: E (Christensen 2002). Morphology: *Grain*: parasyncolpate. *Exine*: intectate, columellae distinct. *Pattern*: lopho-reticulate (reticulum constructed of free standing columellae/retipilate). Colpi borders are built up of tightly packed columellae which are gemmate in appearance. *Polar view*: circular. *Equatorial view*: spheroidal. Size: 47–84 × 42–56 μm.

5.59. Piperaceae

Piper umbellatum: N3°45′27″; E115°26′35″ (Plate 14, figure 10).

Type: S. Uses: M (Christensen 2002). Morphology: *Grain*: 1–2 sulcate. Sulcate ends are straight. *Exine*: tectate, columellae indistinct, exine thin and walls inseparable. *Pattern*: scabrate. *Equatorial view*: subspheroidal. Size: *Tectum*: 0.6 μm. *Equatorial view*: 7–11 × 10–13 μm.

5.60. Poaceae

Isachne pulchella: N3°45′27″; E115°26′36″ (Plate 14, figure 11).

Type: H. Morphology: *Grain*: monoporate; aperture-aspis. *Exine*: tectate, columellae distinct. *Pattern*: psilate-scabrate. *Polar view*: circular. *Equatorial view*: spheroidal. Size: *Tectum*: 0.5 μm. *Equatorial view*: 25–27 μm. *Pore*: 2–2.5 μm.

5.61. Polygalaceae

Polygala paniculata: N3°45′27″; E115°26′35″ (Plate 14, figure 12).

Type: H. Morphology: *Grain*: polycolporate with 10–12 colpori; circular pores. *Exine*: tectate, columellae indistinct. *Pattern*: scabrate. *Polar view*: circular. *Equatorial view*: spheroidal-prolate. Size: *Tectum*: 2 μm. *Equatorial view*: 17–30.5 μm. *Pore*: 2.5–7 μm.

Salomonia cantoniensis: N3°34′08″; E115°33′19″ (Plate 13, figure 6).

Type: H, S. Uses: U (Christensen 2002). Morphology: *Grain*: polycolporate with 10–12 colpori; circular pores. *Exine*: tectate to tectate-perforate, columellae indistinct. *Pattern*: scabrate. *Polar view*: circular. *Equatorial view*: spheroidal-prolate. Size: *Tectum*: 2–3 μm. *Equatorial view*: 30–41 × 37–46 μm. *Pore*: 2–8 × 6–9 μm.

5.62. Polygonaceae

Persicaria minor: N3°33′33″; E115°33′05″ (Plate 13, figure 7).

Type: H. Morphology: *Grain*: polyporate. *Exine*: semitectate-intectate, columellae distinct. *Pattern*: the sexine is reticuloid. The muri are made up of tightly packed columellae, which often appear fused. Occasionally columellae can also be found on the lumina. *Equatorial view*: spheroidal. *Polar view*: circular. Size: *Equatorial view*: 37–48 μm. *Pore*: 4 μm.

Persicaria chinense: N3°33′39″; E115°33′24″ (Plate 13, figure 8).

Type: H. Morphology: *Grain*: 3-colpate. *Exine*: semitectate to intectate, columellae distinct. *Pattern*: the sexine is reticuloid with large lumina. The muri are made up of tightly packed columellae. Occasionally columellae can also be found on the lumina. The foot layer appears to be perforated-granulate. *Polar view*: circular. *Equatorial view*: spheroidal. Size: *Equatorial view*: 35–41 μm.

5.63. Rhamnaceae

Alphitonia excelsa: N3°34′08″; E115°33′19″ (Plate 15, figure 1).

Type: T. Uses: U (Christensen 2002). Morphology: *Grain*: 3-colporate. *Aperture*: angulaperturate with H-shaped and lalongate endoapertures. Endoapertures appear concave/invaginated. *Exine*: tectate, columellae indistinct. Costate around the endoapertures with a pronounced thickening of the nexine. *Pattern*: granulate. *Polar view*: subangular. *Equatorial view*: suboblate to almost rhomboidal in shape. Size: *Exine*: 1–1.5 μm. *Equatorial view*: 16–22 × 21–24 μm. *Pore*: 2.5 × 5 μm. This species is also described by Kodela (2006), although measurements appear slightly smaller in the equatorial axis.

5.64. Rhizophoraceae

Carallia sp.: N3°45′27″; E115°26′35″ (Plate 15, figure 2). Only two grains were identified. *Carallia* is not included in the pollen key.

Type: T. Uses: U (Christensen 2002). Morphology: *Grain*: 3-colporate with lalongate elliptic endoapertures. Endoapertures are restricted through the centre producing a bowtie formation. *Exine*: tectate-perforate. Sexine and nexine are tightly appressed at the middle of the interapertural area, gradually separating towards the germinals. *Pattern*: appears scabrate/finely reticulate, although this remains undetermined due to the limited number of grains. *Polar view*: circular-semi-angular. *Equatorial view*: subprolate-prolatespheroidal. Size: *Equatorial view*: 12–13.3 μm.

5.65. Rosaceae

Rubus moluccanus: N3°34′08″; E115°33′19″ (Plate 15, figure 3).

Type: S. Uses: E (Christensen 2002). Morphology: *Grain*: 3-colporate with square, and often bulging endoapertures. *Exine*: tectate-perforate with supratectal elements. Exine is thick. Both the nexine and sexine appear equal in thickness, although the sexine appears to increase slightly around the apertures. The nexine tends to be slightly shorter than the sexine around the apertures. Occasionally, however, grains appear fastigiate. A thin layer of ektectine covers the pores. *Pattern*: suprastriate. These sculpture elements lie on top of a perforated tectum and meander longitudinally in the mesocolpia region. *Polar view*: semi-angular. *Equatorial view*: spheroidal. Size: *Exine*: 2–3 μm. *Equatorial view*: 23–33 × 32–35 μm. *Pore*: 8–9 × 9–10 μm. This species is also reported by Kodela (2006), although Kodela reports that this grain can either be 3- or 4-colporate and that pores are circular to elliptical, often bulging and very variable in size.

Rubus rosifolia: N3°44′17″; E115°29′44″ (Plate 15, figure 4).

Type: S, T; Uses: R, E (Christensen 2002). Morphology: *Grain*: 3-colporate with square and often bulging endoapertures. *Exine*: tectate-perforate with supratectal elements. Columellae short but distinct. Sexine appears to thicken around the pores of some grains, although in others appears fastigiate. A layer of thin ektectine often covers the pores. *Pattern*: suprarugulate, on top of a perforated tectum. *Polar view*: semi-angular. *Equatorial view*: spheroidal. Size: *Tectum*: 1.5 μm. *Equatorial view*: 19–22 μm. *Pore*: 3–8 × 5–9 μm. This species is also reported by Kodela (2006).

5.66. Rubiaceae

Acranthera sp.: N3°33′39″; E115°33′24″ (Plate 15, figure 5).

Type: H. Morphology: *Grain*: 3-4 porate. *Aperture type*: Vestibulum. *Exine*: Tectate-perforate, columellae indistinct. Nexine and sexine equal in thickness. *Pattern*: Finely reticulate. *Polar view*: Circular-semi-angular. *Equatorial view*: Peroblate. Size: *Tectum*: 1 μm. *Equatorial view*: 12–17 × 20–22 μm.

Chassalia curviflora: N3°34′08″; E115°33′19″ (Plate 15, figure 6).

Type: S, T; Uses: M (Christensen 2002). Morphology; *Grain*: 3-4 colpate; *Aperture*: Short/medium colpi. Colpi do not extend completely to poles. *Exine*: Semi-tectate, columellae distinct. Sexine larger than nexine. No apparent change in the exine around the apertures. *Pattern*: Reticulate. *Polar view*: Circular-rectangular. *Equatorial view*: Oblate spheroidal. Size: *Tectum*: 2-3 μm. *Equatorial view*: 27–46 × 33–49 μm.

Exallage sp.: N3°45′27″; E115°26′35″ (Plate 15, figure 7).

Type: S, L; Uses: M (Christensen 2002). Morphology: *Grain*: 3 colporate. *Aperture*: Apertures are apolar. Pores are square within long rectangular-lalongate endoapertures. The endoapertures almost meet to form an equatorial belt. *Exine*: Semi-tectate, columellae distinct. A distinct thickening of the nexine around the endoapertures. *Pattern*: Finely reticulate-rugulate. *Polar view*: Circular. *Equatorial view*: Spheroidal. Size: *Tectum*: 2 μm. *Equatorial view*: 27–38 × 32–38 μm. *Endoaperture*: 4–5 × 17×24 μm.

Hedyotis sp.: N3°33′39″; E115°33′24″ (Plate 16, figure 1).

Type: S, T. Uses: M (Christensen 2002). Morphology: *Grain*: 3–4-colporate with lalongate elliptic endoapertures. 4-colporate grains tend to be apolar. *Exine*: semi-tectate, columellae distinct. Sexine slightly larger than the nexine and thickens at the apertures. *Pattern*: reticulate-heterobrochate. Lumina small. Lumina do not become smaller towards the colpi. *Polar view*: circular.

Equatorial view: spheroidal. Size: *Tectum*: 1–2 μm. *Equatorial view*: 25–30 μm. *Pore*: 3–5 × 10–18 μm.

Ixora otophora: N3°33′39″; E115°33′24″ (Plate 16, figure 2).

Type: S. Morphology: *Grain*: 3-colporate with lalongate elliptic endoapertures. Endoapertures meet to form and equatorial belt. Fastigium present in polar view. Thickening of the sexine around apertures. Nexine and sexine also separate. Operculum pores (surrounded by a thick annulus). *Exine*: tectate-perforate with supratectal elements. *Pattern*: supra-striatoreticulate on top of a scabrate-perforated tectum. *Polar view*: circular. *Equatorial view*: spheroidal-prolate spheroidal. Size: *Tectum*: 1 μm. *Equatorial view*: 17–25 μm. *Pore*: 3–3.5 μm.

Mussaenda hirsuta: N3°45′27″; E115°26′36″ (Plate 16, figure 3).

Type: S. Uses: M, U (Christensen 2002). Morphology: *Grain*: 3-colporate with circular pores. *Exine*: semi-tectate, columellae distinct. Sexine slightly larger than the nexine. *Pattern*: reticulate-homobrochate, lumina small. *Polar view*: circular. *Equatorial view*: spheroidal. Size: *Tectum*: 1–3 μm. *Equatorial view*: 26–32 × 27–37 μm. *Pore*: 5–6 × 7–9 μm.

Ophiorrhiza pallidula: N3°33′39″; E115°33′24″ (Plate 16, figure 4).

Type: H. Uses: U (Christensen 2002). Morphology: *Grain*: 3-colporate with circular pores. *Exine*: semi-tectate, columellae distinct, sexine and nexine of equal size, although nexine decreases slightly towards colpi. *Pattern*: finely reticulate-homobrochate. *Polar view*: subangular-triangular. *Equatorial view*: suboblate. Size: *Exine*: 2 μm. *Equatorial view*: 17–23 × 23–27 μm. *Pore*: 3–5 μm.

Pleiocarpidia borneensis (Herbarium) (Plate 16, figure 5).

Type: S, T. Morphology: *Grain*: 3-colporate with lanlongate elliptic endoapertures. Large pores. *Exine*: semi-tectate, columellae distinct. Nexine thins and seperates from the sexine around the apertures. *Pattern*: reticulate-homobrochate. *Polar view*: circular-semi-angular. *Equatorial view*: oblate spheroidal. Size: *Exine*: 1.5 μm. *Equatorial view*: 20–24 × 20–25 μm. *Pore*: 6–10 μm.

Pleiocarpidia sp.: N3°33′39″; E115°33′24″ (Plate 16, figure 6).

Type: S, T. Morphology: *Grain*: 3-colporate with lanlongate elliptic endoapertures. Large pores. *Exine*: tectate-perforate, columellae indistinct. Sexine and nexine equal in thickness, although sexine and nexine separate at the apertures and sexine slightly longer than the nexine. *Pattern*: finely reticulate. *Polar view*: circular-semi angular. *Equatorial view*: oblate spheroidal. Size: *Exine*: 1–2 μm. *Equatorial view*: 16–22 × 19.5–26 μm. *Pore*: 3.5–4 × 4.5–6 μm.

Psychotria robusta: N3°33′33″; E115°33′05″ (Plate 16, figure 7).

Type: S. Morphology: *Grain*: 3-colporate with lalongate elliptic endoapertures. Thickening of the nexine around colpi. *Exine*: semi-tectate, columellae distinct. *Pattern*: reticulate-heterobrochate. Lumina become smaller towards apertures. *Polar view*: circular. *Equatorial view*: suboblate-oblate spheroidal. Size: *Equatorial view*: 35–56 μm. *Pore*: 4–6 × 7–12 μm. *Furrow length*: 21–30 μm.

Spermacoce ocymoides: N3°44′17″; E115°29′44″ (Plate 16, figure 8).

Type: S, H. Morphology: *Grain*: 3–4-colporate with lalongate elliptic endoapertures, almost forming an equatorial belt. Thickening around apertures. *Exine*: tectate-perforate, columellae indistinct, sexine slightly thicker than the nexine. Nexine and sexine separate slightly at the apertures. *Pattern*: finely reticulate. *Polar view*: circular. *Equatorial view*: oblate spheroidal. Size: *Equatorial view*: 17–21 μm.

Tarenna sp.: N3°45′27″; E115°26′35″ (Plate 16, figure 9).

Type: S. Morphology: *Grain*: 3-colporate with lalongate elliptic-rectangular endoapertures. Fastigium present. Circular operculum pores. *Exine*: tectate-perforate, columellae short but visible. Sexine and nexine equal in width. *Pattern*: perforate-very finely reticulate. *Polar view*: circular. *Equatorial view*: oblate spheroidal. Size: *Tectum*: 1 μm. *Equatorial view*: 14–16 × 15–17 μm. *Pore*: 3–3.5 × 8–10 μm.

5.67. *Rutaceae*

Citrus sp.: N3°33′39″; E115°33′24″ (Plate 17, figure 1). Found at the edge of a disused rice field in Pa'Dalih.

Type: S, T. Uses: E (Christensen 2002). Morphology: *Grain*: 4-colporate (occasionally 3-colporate) with lalongate elliptic endoapertures. *Exine*: semi-tectate, columellae distinct. *Pattern*: reticulate; reticulum becomes smaller towards the colpi; sexine larger than nexine. *Polar view*: circular. *Equatorial view*: spheroidal-prolatespheroidal. Size: *Tectum*: 2–2.5 μm. *Equatorial view*: 23–27 × 23–27 μm. *Pore*: 2–2.5 × 4–5 μm.

Euodia malayana (Herbarium) (Plate 17, figure 3).

Type: T. Morphology: *Grain*: 3-colporate with lalongate elliptic-rectangular endoapertures. *Exine*: tectate-perforate, columellae indistinct. Sexine thicker than the nexine. *Pattern*: finely reticulate. *Polar view*: circular. *Equatorial view*: subprolate. Size: *Tectum*: 1.5 μm. *Equatorial view*: 16–18 × 20–22 μm. *Pore*: 1–2 × 4–7 μm.

Melicope incana: N3°45′27″; E115°26′35″& N3°34′08″; E115°33′19″ (Plate 17, figure 2).

Type: T. Uses: U (Christensen 2002). Morphology: *Grain*: 3-colporate with lalongate elliptic-rectangular endoapertures. Sexine is longer than the nexine at the apertures. *Exine*: tectate-perforate. *Pattern*: finely reticulate. *Polar view*: circular-semi angular. *Equatorial view*: prolate spheroidal-subprolate. Size: *Equatorial view*: 15.25–19.5 × 21–23.5 μm.

Melicope triphylla: N3°33′39″; E115°33′24″ (Plate 17, figure 4).

Type: S, T. Morphology: *Grain*: 3-colporate with lalongate elliptic endoapertures. *Exine*: Semi-tectate, columellae distinct and rounded. Nexine thin, sexine thick. *Pattern*: reticulate-heterobrochate *Polar view*: hexagonal. *Equatorial view*: oblate spheroidal-spheroidal. Size: *Equatorial view*: 16–19 × 17–20 μm. *Pore*: 1–2 × 4–6 μm.

5.68. Sapindaceae

Allophylus cobbe: N3°43′4″; E115°29′25″ (Plate 17, figure 5).

Type: S, T. Morphology: *Grain*: 3-porate; apertures are atrium. *Exine*: tectate, columellae indistinct, sexine smaller than the nexine in width. *Pattern*: granulate. *Polar view*: triangular. *Equatorial view*: peroblate-oblate. Size: *Tectum*: 1.5 μm. *Equatorial view*: 15–19 × 24–29 μm. *Pore*: 3.5–4 μm.

Guioa bijuga: N3°45′27″; E115°26′35″ (Plate 17, figure 6).

Type: S, T. Morphology: *Grain*: 3-parasyncolporate with circular pores. *Exine*: tectate, columellae indistinct, sexine and nexine indistinguishable. Sexine longer than nexine at the apertures. *Pattern*: granulate. *Polar view*: triangular. *Equatorial view*: peroblate-oblate. Size: *Tectum*: 1.17 μm. *Equatorial view*: 22.5–24 × 24.5–28 μm. *Polar view*: 12–12.5 μm.

5.69. Schizandraceae

Schizandra kadsura: N3°33′39″; E115°33′24″ (Plate 17, figure 7). Found in forest at Long Kelit, close to a perupun.

Type: L. Morphology: *Grain*: 6-colpoidate, three long colpi, which extend and are fused through the polar region; and three short colpi, arranged around the equator, alternating with the long colpi. *Exine*: semi-tectate, columellae distinct, sexine width larger than nexine width. *Pattern*: reticulate-homobrochate. *Polar view*: circular. *Equatorial view*: peroblate. *Equatorial view*: 12–17 × 22–25 μm.

5.70. Scrophulariaceae

Aeginetia indica: N3°33′39″; E115°33′24″ (Plate 17, figure 8).

Type: H. Morphology: *Grain*: 3-colpate. Colpi geniculate in appearance. *Exine*: tectate, columellae indistinct. *Pattern*: scabrate-finely granulate. *Polar view*: circular lobate. *Equatorial view*: suboblate-oblate-spheroidal-spheroidal. Size: *Equatorial view*: 20–22 × 21–25 μm.

Curanga felterrae: N3°45′27″; E115°26′35″ (Plate 17, figure 9).

Type: H. Morphology: *Grain*: 3–4-colpate with weakly defined colpi. *Exine*: semi-tectate to tectate-perforate, columellae distinct, sexine and nexine equal in width. *Pattern*: reticulate-homobrochate, lumina small. *Polar view*: circular. *Equatorial view*: spheroidal. Size: *Tectum*: 1 μm. *Equatorial view*: 16–24 μm.

Limnophila sp.: N3°45′27″; E115°26′35″ (Plate 18, figure 1).

Type: H. Morphology: *Grain*: 3-colporate, with lalongate bow tie endoapertures; endoapertures are restricted in the centre. *Exine*: tectate-perforate, columellae distinct. Sexine longer than the nexine at the apertures. *Pattern*: scabrate. *Polar view*: semi-angular-circular. *Equatorial view*: suboblate-oblatespheroidal. Size: *Tectum*: 1–1.5 μm. *Equatorial view*: 17–19 × 19–21 μm. *Pore*: 5–7 × 5–8 μm.

Lindernia ruelloides: N 3°34′08″; E 115°33′19″ & N 3°45′27″; 115°26′35″ (Plate 18, figure 2).

Type: H. Morphology: *Grain*: 3-colpate. Long, often non-linear colpi. *Exine*: semi-tectate, columellae distinct, sexine and nexine equal in width. *Pattern*: reticulate-heterobrochate. *Polar view*: circular. *Equatorial view*: subprolate-prolate. Size: *Tectum*: 1.3–2.4 μm. *Equatorial view*: 35.5–41 × 29–31 μm.

Scrophulariaceae sp.: N3°45′27″; E115°26′36″ (Plate 18, figure 3).

Type: H. Morphology: *Grain*: 3-colporate with lalongate elliptic-bow tie endoapertures (endoapertures restricted through the centre). *Exine*: tectate, columellae indistinct, sexine and nexine equal in width, although sexine longer than the nexine at the apertures. *Pattern*: scabrate. *Polar view*: semi-angular. *Equatorial view*: oblatespheroidal. Size: *Tectum*: 1.5 μm. *Equatorial view*: 18–20 × 20–22 μm. *Pore*: 5–6 μm.

5.71. Scyphostegiaceae

Scyphostegia borneensis: N3°33′33″; E115°33′05″ (Plate 18, figure 4).

Type: S, T. Uses: U (Christensen 2002). Morphology: *Grain*: 3-colporate with H-shaped endoapertures. *Exine*: tectate with supratectal element, columellae indistinct, sexine and nexine equal in width. *Pattern*: granulate with regularly spaced supragemmae. *Polar view*: circular. *Equatorial view*: subprolate. Size: *Exine*: 1–2 μm. *Equatorial view*: 18–21 × 20–21 μm. *Pore*: 6–8 × 8–9 μm.

5.72. *Smilacaceae*

Smilax leucophylla: N3°34′08″; E115°33′19″ (Plate 18, figure 5).

Type: S, L. Morphology: *Grain*: 1-sulcate (although some appear to have three sulci). *Exine*: intectate with free-standing well spaced columellae. *Pattern*: gemmate. *Equatorial view*: spheroidal-oblate. Size: *Exine*: 1 μm. *Equatorial view*: 12–19 μm.

5.73. *Solanaceae*

Solanum torvum: N3°43′4″; E15°29′25″ (Plate 18, figure 6). Found close to a rice field at the edge of the village in Pa'Dalih. A similar plant was also recorded growing in a ditch in Bario.

Type: S. Uses: E, M (Christensen 2002). Morphology: *Grain*: 3-colporate. Colpi are long, almost joining in the polar area. Endoapertures are also long lalongate elliptic, and form an equatorial belt. Fastigium present. *Exine*: tectate, columellae indistinct, sexine and nexine tightly appressed at the middle of the inter-apertural area, gradually separating towards the germinals. *Pattern*: granulate. *Polar view*: circular. *Equatorial view*: spheroidal-prolatespheroidal. Size: *Tectum*: 1–2 μm. *Equatorial view*: 22–24 μm. *Pore*: 14–15 × 5 μm.

5.74. *Sterculiaceae*

Melochia corchorifolia: N3°45′27″; E115°26′35″ (Plate 18, figure 7).

Type: S. Morphology: *Grain*: 3-colporate with short lalongate rectangular endoapertures. *Exine*: tectate-perforate, columellae distinct, sexine and nexine equal in width, separating towards the apertures. The nexine also increases in thickness towards the apertures. *Pattern*: microreticulate. *Polar view*: circular-semi-angular. *Equatorial view*: spheroidal. Size: *Tectum*: 1.5–2 μm. *Equatorial view*: varying in size, but average ca. 34–45 μm. *Pore*: 5–9 × 3–3.5 μm.

5.75. *Theaceae*

Gordonia borneensis (Herbarium) (Plate 20, figure 1).

Type: T. Morphology: *Grain*: 3-colporate. Large circular-square pores, broad colpi. Pores often bulging. Sexine is distinctly raised over apertures. *Exine*: tectate-perforate, columellae distinct. *Pattern*: perforate and rugulate tectum on top of a thick layer of columellae. The endexine is also visible. The nexine becomes thinner towards the apertures. *Polar view*: triangular. *Equatorial view*: oblatespheroidal. Size: *Exine*: 2.5–3 μm. *Equatorial view*: 41–45 × 44–57 μm. *Pore*: 11–14 × 11–16 μm.

Pyrenaria kunstleri (Herbarium) (Plate 18, figure 8).

Type: T. Morphology: *Grain*: 3-colporate. Large circular-square pores, broad colpi. Pores often bulging. *Exine*: tectate-perforate, columellae distinct. Nexine becomes thinner towards the colpi. *Pattern*: rugulate on top of a layer of columellae. *Polar view*: semi-angular. *Equatorial view*: oblate spheroidal-subprolate. Size: *Exine*: 1 μm. *Equatorial view*: 20–30 × 26–36 μm. *Pore*: 4–6 × 7–10 μm.

Schima noronhae (Herbarium) (Plate 19, figure 1).

Type: T. Uses: U (Christensen 2002). Morphology: *Grain*: 3-colporate with a pontoperculum (a type of operculum that is not completely isolated from the remainder of the sexine, but linked to it at the ends of the aperture). Large, square pores. *Exine*: semi-tectate, columellae distinct. Nexine becomes thinner towards the apertures. *Pattern*: reticulate-heterobrochate. Lumia large but become smaller towards the apertures and the apocolpia. *Polar view*: semi-angular. *Equatorial view*: suboblate-oblate. Size: *Exine*: 1.5 μm. *Equatorial view*: 32.5–35 × 40–45 μm. *Polar view*: 40–50 μm. *Pore*: 6–15 × 7–17 μm. *Lumina of the reticulum*: 0.6–1.7 μm.

Ternstroemia sp.: N3°43′57″; E115°41′3″ (Plate 19, figure 2).

Type: S, T. Morphology; *Grain*: 3-syncolpate. *Exine*: semi-tectate, columellae distinct. Nexine becomes thicker towards the apertures. *Pattern*: reticulate-heterobrochate. *Polar view*: circular-circular lobate. *Equatorial view*: suboblate. Size: *Equatorial view*: 17–26 × 25–30 μm.

5.76. *Thymelaeaceae*

Wikstroemia androsaemifolia (Herbarium) (Plate 19, figure 3).

Type: S. Uses: U (Christensen 2002). Morphology: *Grain*: polyporate. *Aperture*: small circular, > 10 pores. *Exine*: semi-tectate, columellae distinct. Nexine thin underneath a thick layer of columellae. *Pattern*: reticulate-heterobrochate. *Polar view*: circular. *Equatorial view*: spheroidal. Size: *Exine*: 2 μm. *Equatorial view*: 20–27 μm. *Pore*: 1.5 μm.

5.77. *Tiliaceae*

Grewia umbellata (Herbarium) (Plate 20, figure 2).

Type: T. Uses: E (Christensen 2002). Morphology: *Grain*: 3-colporate with lalongate elliptic-rectangular endoapertures. *Exine*: semi-tectate, columellae distinct. Nexine and sexine separate towards the apertures. *Pattern*: reticulate-perforate. Reticulum incomplete. *Polar view*: circular. *Equatorial view*: subprolate Size: *Tectum*: 2 μm. *Equatorial view*: 48–62 × 48–73 μm. *Pore*: 10–15 μm.

Microcos erythrocarpa (Herbarium) (Plate 19, figure 4).

Type: S, T. Morphology: *Grain*: 3-colporate with lalongate elliptic-rectangular endoapertures. *Exine*: semi-tectate with supratectal elements. Columellae indistinct. Nexine and sexine equal in width, but separate towards apertures. *Pattern*: suprareticulate. Lumina varies in size. Infratectum between the muri is perforated. *Polar view*: circular. *Equatorial view*: prolate. Size: *Tectum*: 2 μm. *Equatorial view*: 22–25 × 30–33 μm.

Triumfetta sp.: N3°34′08″; E115°33′19″ (Plate 19, figure 5).

Type: S. Morphology: *Grain*: 3-colporate with lalongate elliptic-rectangular endoapertures. *Exine*: semi-tectate, columellae distinct. Sexine thicker than nexine. *Pattern*: reticulate-heterobrochate. *Polar view*: circular. *Equatorial view*: perprolate. Size: *Tectum*: 2 μm. *Equatorial view*: 17–20 × 37–44 μm.

5.78. Ulmaceae

Trema tomentosa: N3°34′08″; E115°33′19″ (Plate 19, figure 6).

Type: T, S. Uses: U (Christensen 2002). Morphology: *Grain*: 2-porate. *Aperture type*: aspis. Circular pores with a thick annulus. *Exine*: tectate, columellae indistinct. Sexine and nexine tightly appressed. *Pattern*: verrucate and granulate. *Polar view*: circular. *Equatorial view*: spheroidal-oblate spheroidal. Size: *Equatorial view*: 15–18 μm. *Pore*: 2 μm.

5.79. Urticaceae

Debregeasia longifolia: N3°44′17″; E115°29′44″ (Plate 19, figure 7).

Type: S, T. Uses: E (Christensen 2002). Morphology: *Grain*: 3-porate. *Aperture*: aspis, although with only a slight thickening of the exine around the apertures. *Exine*: tectate, columellae indistinct. Sexine and nexine tightly appressed and indistinguishable. Exine is thin. *Pattern*: scabrate. *Polar view*: circular, *Equatorial view*: spheroidal. Size: *Equatorial view*: 12–15 μm. *Pore*: 1 μm. The pollen morphology of *Debregeasia longifolia* does not appear to be described elsewhere, although the genus can be found in the Australian Pollen and Spore Atlas (2006–2007).

5.80. Vitaceae

Vitex quinata: N3°34′08″; E115°33′19″ (Plate 19, figure 8).

Type: T. Morphology: *Grain*: 3-colpate-colporate. *Exine*: semi-tectate, columellae distinct. Colpi wide in the mesocolpia and triangular in the apocolpia. Sexine and nexine equal in width, although sexine decreases in thickness towards the colpi. *Pattern*: reticulate-homobrochate, lumina small. *Polar view*: semi-angular. *Equatorial view*: subprolate. Size: *Equatorial view*: 21–27 × 24–27 μm. Colpi width at widest section: 4.5–8.5 μm.

5.81. Xyridaceae

Xyris complanata: N3°44′17″; E115°29′44″ (Plate 20, figure 3). A herb found on very sandy open ground.

Type: H. Morphology: *Grain*: polyad, 1-sulcate on each grain. Sulci are straight. *Exine*: tectate-perforate, columellae distinct. *Pattern*: sculpture is both granulate and perforate. *Polyad shape*: long rectangular-ellipse. *Equatorial view*: individual grains are subspheroidal-rectangular in shape. Size: *Exine*: 4 μm. *Equatorial view*: 70–75 × 137–235 μm (length varies). *Individual grains*: 42–54 × 46–54 μm.

5.82. Zingiberaceae (preservation varies)

Alpinia nieuwenhuizii: N°34′08″; E115°33′19″ (Plate 20, figure 4).

Type: H. Uses: E (Christensen 2002). Morphology: *Grain*: inaperturate. *Exine*: tectate with supratectal elements. Nexine and sexine equal in width, although difficult to determine. *Equatorial view*: spheroidal-subspheroidal. *Pattern*: coarse granulate with gemmae situated on top of the tectum. Size: *Exine*: 7 μm. *Equatorial view*: 41–65 μm. *Gemmae*: 3.5 μm. Liang (1988) describes the genus *Alpinia* as non-aperaturate and spinate with longer spines than the genus *Globba*.

Etlingera brevilabrum: N3°33′33″; E115°33′05″ (Plate 20, figure 5).

Type: H. Uses: E, M (Christensen 2002). Morphology: *Grain*: inaperturate. *Exine*: difficult to determine. *Equatorial view*: spheroidal-subspheroidal. *Pattern*: coarse granulate (although this may be due to erosion of the exine). Size: *Exine*: 1–4 μm. *Equatorial view*: 64–92 μm. Liang (1988) describes the genus *Etlingera* as non-aperaturate and almost psilate.

Globba propinqua: N3°43′47″; E115°29′29″ (Plate 20, figure 6).

Type: H. Morphology: *Grain*: inaperturate. *Exine*: appears intectate, although this is difficult to determine. *Equatorial view*: spheroidal. *Pattern*: granulate with gemmae. Size: *Exine*: 1–2 μm. *Equatorial view*: 29–42 μm. Liang (1988) describes the genus *Globba* as non-aperaturate and short-spinate with shorter spines than the genus *Alpinia*.

Hornstedtia pininga: N3°45′27″; E115°26′35″ (Plate 20, figure 7).

Type: H. Uses: E (Christensen 2002). Morphology: *Grain*: inaperturate. *Exine*: undetermined. *Equatorial view*: spheroidal-subspheroidal. *Pattern*: granulate. Size: *Tectum*: 1 μm. *Equatorial view*: 75–99 μm. Liang

(1988) describes the genus *Hornstedtia* as non-aperturate and almost psilate.

Zingiber albiflorum: N3°34′08″; E115°33′19″ (Plate 20, figure 8).

Type: H. Morphology: *Grain*: inaperturate. *Equatorial view*: spheroidal-subspheroidal. *Exine*: tectate. *Pattern*: plated in an irregular reticulate pattern. There appears to be muri or a border around each plate, although no lumina. The tectum completely covers the whole surface of the pollen grain and each plate appears psilate. Size: *Tectum*: 1 μm. *Equatorial view*: 47–99 μm. Theilade et al. (1993) and Liang (1988) describe two types of morphology for *Zingiber*, either spheroidal or elliptical-prolate. Those that are elliptical-prolate tend to have a spiral-striate sculpturing and those that are circular are described as having a cerebroid/cerebelloid-areoate sculpture and are usually inaperaturate, although some species may be monosulcate. The species examined in this paper seems to be similar in that the grain is circular and does appear to be inaperaturate, but the sculpturing described by Theilade et al. (1993) and Liang (1988) is not quite cerebroid/cerebelloid, although possibly areolate.

Zingiberaceae sp.: N3°34′08″; E115°33′19″ (Plate 20, figure 9).

Type: H. Morphology: *Grain*: inaperturate. *Exine*: undetermined *Equatorial view*: spheroidal. *Pattern*: coarse granulate. Size: *Equatorial view*: 34–62 μm.

5.83. Spore morphological descriptions

5.83.1. Blechnaceae

Stenochlaena palustris: N3°43′4″; E115°29′18″ (Plate 4, figure 11).

Type: F. Uses: E (Christensen 2002). Morphology: *Spore laesura*: monolete. Laesura shape is straight, extending the length of the grain, almost to the apices. Grains are bilateral. *Pattern*: the sculptine is psilate with large and irregularly spaced gemmae. A perine is not visible. *Equatorial view*: bean-shaped-spheroidal. Size: *Equatorial view*: 16–36 × 36–47 μm. *Gemmae*: 1.5–3 μm.

5.83.2. Ophioglossaceae

Helmynthostachys zeylanica: N3°33′39″; E115°33′24″ (Plate 14, figure 4).

Type: F. Uses: E (Christensen 2002), M (Suja et al. 2004). Morphology: *Spore laesura*: trilete, non-curvaturate. Trilete mark extends to the apices. *Pattern*: the exine of the inter-radial and radial areas are verrucate-rugulate. A perine is not visible. *Shape*: circular-semi-angular in both equatorial and polar view. Size: *Exine*: 2 μm. *Equatorial view*: 24–34 μm.

Ophioglossum intermedium: N3°45′27″; E115°26′35″ (Plate 14, figure 5).

Type: F. Morphology: *Spore laesura*: trilete, non-curvaturate. Trilete mark extends to the apices. *Pattern*: the exine of the interradial and radial areas are psilate-granulate. A perine is not visible. *Shape*: circular-semi-angular in both equatorial and polar view. Size: *Exine*: 1–2 μm. *Equatorial view*: 35–46 μm.

6. Discussion

This paper has produced a pollen morphological account of 84 families, 164 genera and 201 species of plant, of which 176 specimens were collected from the Kelabit Highlands; however, with ca. 15,000 species of flowering plant and 3000 species of tree in Borneo (MacKinnon et al. 1998), this investigation covers only a mere fraction of the flowering plants found on the island, focussing primarily in and around the villages of Bario and Pa'Dalih, in the Kelabit Highlands. No pollen morphological investigations have previously been carried out in this region.

6.1. Importance to archaeological studies

The creation of modern pollen reference collections within the vicinity of archaeological excavations (particularly in tropical regions where reference collections are sparse but biodiversity rich) can significantly help in the identification of the fossil pollen record from those sites, by expanding the range of taxa that can be identified. This particular reference collection has already been of benefit during the 'Cultured Rainforest Project' in the reconstruction of the local vegetation both during and before human settlement in the region (Barker et al. 2008, 2009; Lloyd Smith et al. 2013; Jones et al. 2013a, 2013b, 2014). One important example of this is the modern pollen grain belonging to the sago palm, *Eugeissona utilis*, which helped identify the use/manipulation of *Eugeissona* ca. 3000 years ago (Jones et al. 2013a, 2013b). *Eugeissona utilis* has also been described by Thanikaimoni (1970), although the morphological descriptions are less detailed and tend to describe the genus, rather than the individual species; this is with the exception of size measurements and individual images. The images produced in Thanikaimoni (1970) are also different to those produced in this paper (e.g. in terms of clarity of images and ornamentation).

Many of the plants collected in this investigation have ethno-botanical uses (Christensen 2002). Understanding the composition of disturbance indicators and of plants with ethnobotanical value through modern pollen reference material could be extremely valuable for future archaeological work, particularly when trying to determine the history of early plant cultivation/manipulation in tropical rainforests.

6.2. *Importance to climatic studies*

The villages of Bario and Pa'Dalih lie between 950–1150 m, situated in lower montane forest. These areas may be sensitive to climatic fluctuations because of their close proximity to altitudinal boundaries (i.e. between lowland and upper montane forest), particularly the upper montane forest boundary on Mount Murud. Beaman (1999) describes an oak-laurel lower montane forest above 1775 m in the Kelabit Highlands, which changes into a lower-stature dwarfed mossy forest just below the summit ridge of Mount Murud at about 2000 m. Some of the plants recorded on Mount Murud include *Phyllocladus hypophyllus*, identified at 2300–2400 m, *Dacrycarpus imbuicatus* at 1500 m, *Dacrydium beccarii* at 1200 m, *Dacrydium gibbsiae* at 2100–2400 m, *Dacrydium xanthandrum* at 2300–2400 m and *Podocarpus neriifolius* at 2300–2400 m (Beaman 1999). These species do not appear in the botanical collections from Bario, at 1150 m, recorded by Latiff et al. (1999), and neither were they recorded at Bario or Pa'Dalih during this investigation, at 950–1150 m. Forest composition between lowland and lower montane forest has similarly been considered by Van Steenis (1964). Van Steenis (1964) describes the lower montane taxa belonging to Araliaceae, Celastraceae, Elaeocarpaceae, Ericaceae, *Ilex*, Myrsinaceae, Myrtaceae, Symplocaceae, Polygalaceae and Theaceae as scarcer in the lowlands. These lower montane species are also well represented by Latiff et al. (1999) and, indeed, most of the lower montane taxa mentioned by Van Steenis (1964) have also been recorded in this investigation with the exception of the families Magnoliaceae, Celastraceae and Symplocaceae. To interpret possible climate fluctuations in the pollen record, such as whether altitudinal belts have shifted or whether precipitation rates may have changed, a good understanding of the local vegetation composition is essential. The collection of over 200 plant specimens during this investigation has contributed to the understanding of the local plant composition, which in turn has been used to publish a 50,000-year environmental and climatic record (see Jones et al. 2014) from Bario and Pa'Dalih.

6.3. *Importance to botanical studies*

The collection of modern pollen grains, particularly in tropical regions, can be of particular value to botanical studies not only because of the potential to discover new species but also the potential to document taxa from areas not previously documented. Furthermore, this study helps to strengthen the botanical collections already collected from the Kelabit Highlands. Some of the authors who describe previous collections from the Kelabit Higlands include Beaman (1999), Latiff et al. (1999), Christensen (2002) and Pearce (2006). Beaman et al. (1999), for example, describe orchids; 181 taxa in total, of which only three of the genera and none of the species are represented in this paper. Pearce (2006) considers mainly the area in and around Pulong Tau National Park, in which 116 families, 227 genera and over 570 species were recorded. These specimens include some taxa located close to Bario, of which a few specimens are also represented in this paper (e.g. *Rungia* PTNP1 and *Begonia* sp). Beaman (1999) considers primarily the summit flora on Mount Murud (258 specimens). Only 24 families, 19 genera and one species, recorded by Beaman (1999), are represented in this paper. Latiff et al. (1999) collected 68 families, 143 genera and 197 specimens from Bario, of which 48 families, ca. 48 genera and ca. 18 species are recorded in this paper (24 families, 29 genera and 17 species more than Beaman 1999). This is likely associated with both the higher altitude of Beaman's collection site and because the collection site of Latiff et al. (1999) is based in Bario, which is also one of the areas sampled in this investigation. It is interesting to note that out of the 176 species recorded from the Kelabit Highlands during this investigation, only 18 species are the same as those recorded by Latiff et al. (1999). Christensen (2002), on the other hand, collected 1144 species of plants from Nanga Sumpa and Pa'Dalih, and 92 species recorded by Christensen (2002) have also been recorded in this collection.

6.4. *Importance to modern pollen studies*

No pollen analysis has ever been carried out in the Kelabit Highlands; therefore, this study is important in the discovery and documentation of new pollen morphologies, as well as in providing additional or supporting information on morphologies that have already been examined elsewhere. Where other pollen morphological accounts are available elsewhere, detail may vary and morphological accounts may differ. Kodela (2006), for example, describes the pollen apertures of *Trema tomentosa* as small but with slightly protruding pores, and the sculpturing as appearing granulate. This investigation is quite similar in its description of *Trema tomentosa*, although it in addition describes the pores as 2 μm, circular with a thick annulus, whilst the sculpturing is reported as both verrucate and granulate. Large & Mabberley (1995) describe *Vitex quinata* as having a perforate-fenestrate ornamentation and note that the genus is generally considered to be stenopalynous. In this investigation, *Vitex quinata* is described as having a reticulate-homobrochate ornamentation with small lumina. Morphological representation of *Annona muricata* can be found in Liu & Xu (2012), who describe the sculpture of *Annona muricata* as psilate and foveolate. The *Annona muricata* examined in this paper, however, contains not only a psilate and foveolate infratectum but also a clavate supra-tectum, which is not described by Liu and Xu (2012). Pollen images of *Annona muricata* from Colorado Island have also been published by Moreno & Roubik (2007). Further examples of pollen grains, where pollen morphological descriptions are absent or limited elsewhere, include many of the species examined from the Orchidaceae and Cucurbitaceae family, all of the species examined in the Araceae family and the species *Leuconotis anceps*, *Daemonorops fissa*, *Eugeissona utilis*, *Burmannia disticha*, *Clethra longispicata*, *Chloranthus erectus*, *Cratoxylum glaucum*, *Cratoxylum sumatranum*, *Bauhinia finlaysoniana*, *Fordia splendidissima*, *Pithecellobium clypearia*, *Dichroa febrifuga*, *Curculigo latifolia*, *Ophiopogon caulescens*, *Lepeostegeres centiflorus*, *Scurrula parasitica*, *Phrynium maximum*, *Medinella crassifolia*, *Pachycentria pulverulenta*, *Pternandra tesselata*, *Artocarpus heterophyllus*, *Embelia* sp. and *Musa* sp. The pollen morphology of Zingiberaceae is another example. The family is still poorly understood and several species remain palynologically unknown (Theilade et al. 1993). The main reason for this is that the pollen wall consists of a thin exine; this means the grains are susceptible to erosion and rarely preserve well in sediments. According to Liang (1988), the thin exine also means the pollen grains are almost non-resistant to acetolysis. Authors who have published morphological descriptions on Zingiberaceae species include Theilade et al. (1993) and Liang (1988). In contrast to the Zingiberaceae family, the Acanthaceae family preserve much better in sediments due to a thicker exine, and are resistant to acetolysis. The Acanthaceae is a large family of ca. 3450 species (Ghosh & Karmakar 2012) and morphological descriptions have been published by a number of authors including Carine & Scotland (1998) and Ghosh & Karmakar (2012). Ghosh & Karmakar (2012) report pollen morphologies from the genera *Hemigraphis*, *Peristrophe* and *Rungia* as well as the species *Justicia gendarussa* described in this investigation. Carine & Scotland (1998) have produced a detailed morphological account of 66 species of *Strobilanthes* from southern India and Sri Lanka. Pollen illustrations and descriptions from some of the species listed in this investigation can also be found on the Australian Pollen and Spore website (APSA 2006–2007). The pollen morphologies described in this paper support the publications of Carine & Scotland (1998) and Ghosh & Karmakar (2012). Another example is Xyridaceae. Campbell (2012) describes Xyridaceae as a subtropical family of about five genera predominantly found in South America that exhibit two pollen morphologies. She characterizes *Xyris* species by medium to large, elliptic, sulcate pollen grains. This is also true for the Sarawak species of *Xyris* identified in this paper. No other publication could be found representing the pollen morphology of *Xyris*.

7. Conclusion

Originally designed to aid fossil pollen identification, as part of the ‘Cultured Rainforest Project’, this investigation provides a detailed morphological account of pollen grains and spores, extracted from 176 species of plants, collected from the Kelabit Highlands of Sarawak, and from 25 plant specimens, stored at SAR. Pollen analysis is useful for climatic, environmental, archaeological and modern investigations; however, there are ca. 15,000 species of flowering plants and 3000 species of trees in Borneo, let alone in the rest of tropical southeast Asia, but reference collections are still sparse for this part of the world. This is the first pollen morphological study for the central highlands of Borneo, which covers only a small proportion of the diverse range of flora found within Borneo. As well as providing new knowledge on pollen morphologies and plant composition and supporting previously published material from other regions, this investigation also demonstrates that there is still a clear need for further morphological investigations to provide a more comprehensive reference collection for both the lowlands and highlands of Borneo.

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