Alcheringa: An Australasian Journal of Palaeontology
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/talc20

First fossil pollen record of the Northern Hemisphere species Aglaoreidia cyclops Erdtman, 1960 in Australia

Carlos A. Sánchez Botero , Francisca E. Oboh-ikuenobe & Mike Macphail
Published online: 16 May 2013.

To cite this article: Carlos A. Sánchez Botero , Francisca E. Oboh-ikuenobe & Mike Macphail (2013): First fossil pollen record of the Northern Hemisphere species Aglaoreidia cyclops Erdtman, 1960 in Australia, Alcheringa: An Australasian Journal of Palaeontology, DOI:10.1080/03115518.2013.785336

To link to this article: http://dx.doi.org/10.1080/03115518.2013.785336

First fossil pollen record of the Northern Hemisphere species *Aglaoreidia cyclops* Erdtman, 1960 in Australia

CARLOS A. SÁNCHEZ BOTERO, FRANCISCA E. OBOH-IKUENOBE and MIKE MACPHAIL

Sánchez Botero, C.A., Oboh-Ikuenobe, F.E. & Macphail, M.K., 2013. First fossil pollen record of the Northern Hemisphere species *Aglaoreidia cyclops* Erdtman, 1960 in Australia. *Alcheringa 37*, 1–5. ISSN 0311-5518.

Aglaoreidia cyclops Erdtman, 1960 is a fossil pollen species associated with upper Eocene to lower Oligocene freshwater deposits in Europe and North America. Specimens preserved in upper Eocene lignites near Norseman, Western Australia, are the first record of this Northern Hemisphere species both in Australia and the Southern Hemisphere. This new report widens the biogeographic distribution originally considered for this species. The stratigraphical and environmental characteristics of *A. cyclops* also make it an excellent stratigraphic indicator of upper Eocene freshwater deposits in Western Australia.

Carlos A. Sánchez Botero [casmwc@mail.mst.edu], Francisca E. Oboh-Ikuenobe [ikuenobe@mst.edu] Department of Geological Sciences and Engineering, Missouri University of Science and Technology, 129 McNutt Hall, Rolla, MO 65409, USA; Mike Macphail [mike.macphail@anu.edu.au] Department of Archaeology and Natural History, College of Asia and the Pacific, Australian National University Canberra, ACT 0200, Australia. *Received 12.10.2012; revised 6.3.2013; accepted 7.3.2013.*

Keywords: *Aglaoreidia cyclops*, Werillup Formation, Western Australia, late Eocene, Southern Hemisphere.

THE FOSSIL genus *Aglaoreidia* Erdtman, 1960 was erected to accommodate spherical to bilaterally symmetrical fossil pollen grains characterized by a single pore and heterobrochate reticulate exine. General agreement exists that the genus represents an extinct clade of aquatic herbs although suggested nearest living relatives (NLRs) of individual species range from the freshwater bur-reed (Sparganiaceae) and pondweed (Potamogetonaceae) families to the marine sea-grass (Ruppiaceae) family (Collinson 1982, Gandolfo *et al.* 2009). The type species *Aglaoreidia cyclops* Erdtman, 1960 was described from specimens preserved in the upper Eocene Lower Headon Beds, southern England, and a second, closely related species, *Aglaoreidia pristina* was described by Fowler (1971) from correlative Eocene sediments in Hampshire and the Isle of Wight. *Aglaoreidia cyclops* is typically associated with freshwater palaeoenvironments (Collinson 1982, Gandolfo *et al.* 2009) whilst *A. pristina* occurs in marine and brackish strata. Both species are found in upper Eocene and/or Oligocene deposits across northwest and central Europe, Turkey and North America and, therefore, were considered to be endemic to the Northern Hemisphere (see Erdtman 1960, Krutzsch 1963, Fowler 1971, Machin 1971, Frederiksen 1980, Ollivier-Pierre 1980, Akkiraz *et al.* 2006, Ramírez-Arriaga *et al.* 2006). The only confirmed representative of the fossil genus in Australia is *Aglaoreidia qualumis*, described by Stover & Partridge (1973) from specimens recorded in upper Eocene to lower Oligocene strata in the onshore Gippsland Basin, southeastern Australia.

Here we describe specimens of *Aglaoreidia cyclops* preserved in upper Eocene lignitic facies within a succession of lower to upper Eocene carbonaceous sands, silts and clays (Werillup Formation) infilling the Cowan palaeodrainage system (see Clarke 1993, 1994, Clarke *et al.* 1996, 2003) near Norseman, Western Australia (Fig. 1). These specimens are the first known record of the morphospecies both in Australia and the Southern Hemisphere. Like Northern Hemisphere populations of *Aglaoreidia cyclops*, the parent plants appear to have grown in a freshwater environment and potentially are useful in dating and correlating upper Eocene sequences elsewhere in southwestern Australia. How the morphospecies came to be established in Australia is unclear but is likely to have involved trans-oceanic dispersal.

Material and age control

Specimens of *Aglaoreidia cyclops* (ranging from 1% to 20% of total palynomorph counts) were recovered from LA2-09 borehole (32°11′33.5″S, 121°45′30″E), drilled in 2009 on the eastern shoreline of Lake Aerodrome, Norseman in Western Australia. This borehole was one of ten drilled in and near playa lakes in Western Australia as part of a multidisciplinary project studying the evolution of these salt lakes. The late Eocene (Middle *Nothofagidites asperus* Zone) age of the

http://dx.doi.org/10.1080/03115518.2013.785336

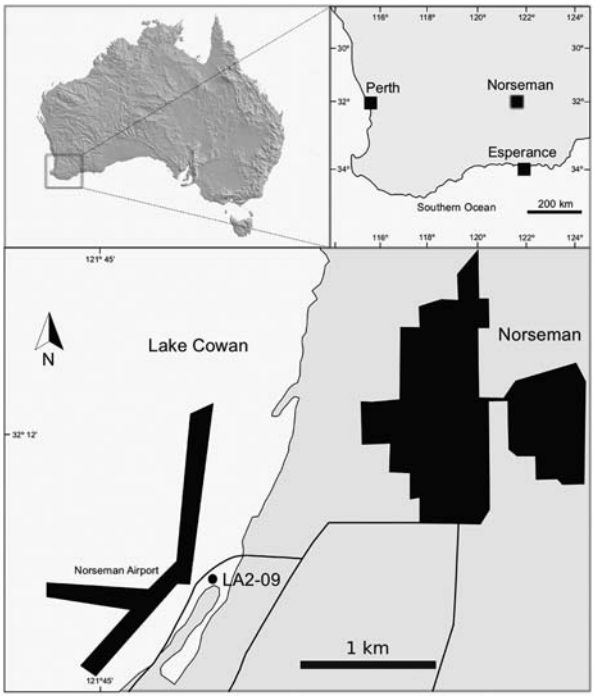

Fig. 1. Location of the LA2-09 borehole near Norseman municipality, Western Australia.

lignitic sequence is based on the association of *Sparganiaceaepollenites barungensis*, *Dryadopollis reteequetrus* (Fig. 2I) and *Reevesiapollis reticulatus* (Fig. 2H), with *Proteacidites crassus* and *Santalumidites cainozoicus*, species that first and last appear in this zone, respectively (compare Stover & Partridge 1982, Milne 1988, Macphail 1999, Partridge 1999, 2006). High relative abundances of the freshwater algal cyst *Botryococcus braunii* and *Nothofagidites* pollen (Fig. 2G; nearest living equivalent *Nothofagus*) and absence of marine algae (dinoflagellates) imply that the lignites accumulated in a freshwater swamp surrounded by temperate rainforest growing under relatively uniform wet climates. Apart from trace occurrences of *Tricolpites trioblatus* (NLR *Wilsonia*: see Martin 2000), there is no evidence for a saline influence at the site.

Systematic palynology

Aglaoreidia Erdtman, 1960 emend. Fowler, 1971

Type species. Aglaoreidia cyclops Erdtman, 1960 (Fig. 2A–E)

Repository. Illustrated specimens of *Aglaoreidia cyclops* and other selected palynomorphs (Fig. 2) are located in strew mounts MST-1133-S1, MST-1136-S1, MST-1159-S1, MST-1164-S1 and MST-1167-S1, stored in the Paleontology Laboratory at Missouri University of Science and Technology, USA.

Locality. 45–60 m depth, LA2-09 borehole in Lake Aerodrome, Western Australia.

Description. Monad, bilaterally symmetrical, amb elliptical to sub-circular in polar view; monoporate, pore circular to elliptical, 3.5 µm and 9 µm in diameter, annulate, annulus formed by thickening of the nexine; exine, *ca* 1 µm thick, increasing to 2–2.5 µm around the pore, tectate, columellate, reticulate, heterobrochate, muri supported by single columellae, lumina polygonal to sub-circular, *ca* 4 µm diameter on the proximal surface surrounding the pore and decreasing to *ca* 1 µm towards the ends of the grain and across distal surface opposite the pore; 32–48 µm length of the longest axis (50 specimens measured).

Comparison. *Aglaoreidia pristina* Fowler, 1971 differs from *A. cyclops* in that the largest lumina are located on the distal surface of the grain; *Aglaoreidia qualumis* Stover & Partridge, 1973 (Fig. 2F) is smaller, has a spherical grain shape, and has homobrochate lumina and a circular pore.

Remarks. Although referring *Aglaoreidia* to a monocotyledonous group of unknown affinity, Erdtman (1960) compared the fossil genus to Amaryllidaceae and Liliaceae pollen. Machin (1971) noted similarities with pollen of Ruppiaceae and Potamogetonaceae, and suggested a relationship with the parent plant of the fossil fruit *Limnocarpus*. Collinson (1982) reinforced this suggestion by proposing a strong relationship with various genera of Potamogetonaceae based on the fossil assemblages in which the species occurs. Harley (2006) compared *Aglaoreidia* with the pollen grain of the palm *Borassodendron machadonis*, suggesting that they shared a similar morphology, despite differences in size. It is worth noting that, although there is a rich Eocene–Oligocene macrofossil record in southwestern Australia, no macrofossils of any of these plant groups have been reported from the region (see Hill & Merrifield 1993, Carpenter & Pole 1995, McLoughlin & Hill 1996).

Discussion

The well-preserved fossil pollen recovered from LA2-09 (Fig. 2A–E) very closely resembles specimens of *Aglaoreidia cyclops* described and illustrated by Erdtman (1960, pl. 1, figs b, c) and Fowler (1971, pl. 1, figs 3, 4), particularly in the large annulate pore and a decrease in the size of the lumina away from the pore and on the distal surface of the grain. We discount the possibility that the grains are Northern Hemisphere contaminants, introduced either during drilling or processing of the samples in the Global Geolab Laboratory. Reasons include: (1) contamination of the lignite by drilling mud is highly unlikely; the boreholes were drilled using the rotosonic technique (Boart Longyear's semisonic drill Rig 1415) that does not utilize fluids during the drilling process; (2) specimens of *Aglaoreidia cyclops* (up to 20% in some samples) are

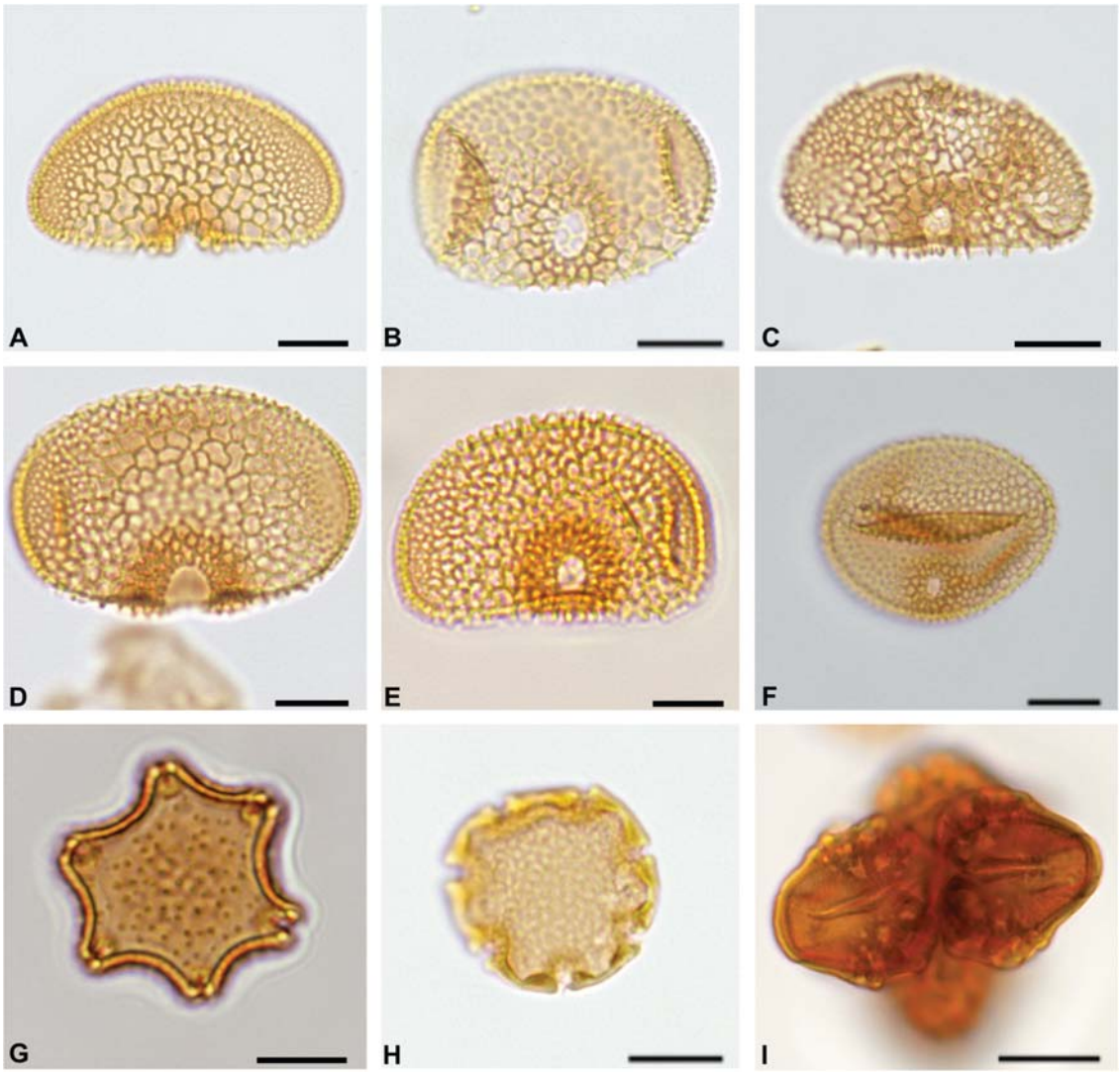

Fig. 2. Selected palynomorphs from the upper Eocene Werillup Formation. Specimen names followed by strew mount number and England Finder coordinates. **A**, *Aglaoreidia cyclops* Erdtman, 1960 (MST-1136-S1; V44/1). **B**, *Aglaoreidia cyclops* Erdtman, 1960 (MST-1136-S1; K35/4). **C**, *Aglaoreidia cyclops* Erdtman, 1960 (MST-1136-S1; R36/1). **D**, *Aglaoreidia cyclops* Erdtman, 1960 (MST-1164-S1; K34). **E**, *Aglaoreidia cyclops* Erdtman, 1960 (MST-1133-S1; R43/2). **F**, *Aglaoreidia qualumis* Stover & Partridge, 1973 (MST-1134-S1; M43). **G**, *Nothofagidites falcatus* (Cookson) Hekel, 1972 (MST-1133-S1; Q44/4). **H**, *Reevesiapollis reticulatus* (Cooper) Krutzsch, 1970 (MST-1159-S1; R28). **I**, *Dryadopollis retequetrus* (Stover & Partridge) Pocknall & Mildenhall, 1984 (MST-1167-S1; T21). Scale bar = 10 μm.

restricted to lignitic facies within the Werillup Formation and do not occur in samples of sediments overlying this formation; (3) a duplicate set of samples from the Werillup Formation processed as a control at Missouri University of Science and Technology produced identical results to those from the first laboratory; and (4) no other palynomorphs restricted to the Northern Hemisphere were recovered.

How *Aglaoreidia cyclops* reached Australia is unknown, since there are no confirmed records between central Europe/North America and Australia. For example, Indian monoporate fossil pollen specimens identified as *Aglaoreidia* by Singh & Sarkar (1994, pl. 1, fig. 10) are spherical, characterized by a uniformly fine reticulum, while the poor quality of the illustrations means that the affinity of *Aglaoreidia* sp. cf. *A. cyclops* from the Paleocene–lower Eocene Jiachala Formation in Tibet (Li *et al.* 2005, fig. 4.18) can not be confirmed. The Australian *Aglaoreidia qualumis* has been considered a junior synonym of *Sparganiaceaepollenites barungensis* Harris, 1972 by Mildenhall & Crosbie (1979) and suggested to be a fossil member of the Sparganiaceae or Typhaceae. *Aglaoreidia*-type pollen preserved in Paleocene sediments at Koingnaas in South Africa has been compared to *Aglaoreidia qualumis* (De Villiers & Cadman 2001), whilst specimens described by Jaramillo & Dilcher (2001) as *Aglaoreidia*? *foveolata* from Paleocene sediments in northern South America are foveolate, not reticulate. *Aglaoreidia cyclops* has not been recorded in South America (Gandolfo *et al.* 2009, V. Barreda, pers. comm. 2012) and has not been reported in any previous palynological studies in southwestern Australia (Balme & Churchill 1959, Hos 1975, Bint 1981, Stover & Partridge 1982, Milne 1988).

Nevertheless, the palaeo-distribution in the Northern Hemisphere indicates that trans-oceanic dispersal of *Aglaoreidia cyclops* occurred during the late Eocene. Therefore, the chance of long-distance dispersal across the equator, perhaps by migrating birds, is one possible explanation. What is certain is that freshwater habitats along the southwest margin of Australia in the late Eocene would have allowed hydrophytes such as *Aglaoreidia cyclops* to become established in the shorter term (see Macphail *et al.* 1994, Macphail 2007).

Acknowledgements

We would like to thank Drs Kathy Benison, Brenda Beitler Bowen and Stacy Story for their roles during drilling and sampling of the cores; the Geological Survey of Western Australia for use of their facilities at the Joe Lord Core Library in Kalgoorlie; Dr Carlos Jaramillo for his help with pollen identification; Dr Alan Partridge for his comments on an earlier version of this paper; and Dr Viviana Barreda for her suggestions and comments. The study was funded by a National Science Foundation grant (EAR-0719838) to Francisca Oboh-Ikuenobe.

References

Akkiraz, M.S., Akgün, F., Örcen, S., Bruch, A.A. & Mosbrugger, V., 2006. Stratigraphic and palaeoenvironmental significance of Bartonian–Priabonian (middle–late Eocene) microfossils from the Bascesme Formation, Denizli Province, Western Anatolia. *Turkish Journal of Earth Sciences 15*, 155–180.

Balme, B.E. & Churchill, D.M., 1959. Tertiary sediments at Coolgardie, Western Australia. *Journal of the Royal Society of Western Australia 42*, 37–43.

Bint, A.N., 1981. An early Pliocene pollen assemblage from Lake Tay, south-western Australia, and its phytogeographic implications. *Australian Journal of Botany 29*, 277–291.

Carpenter, R.J. & Pole, M.S., 1995. Eocene plant fossils from the Lefroy and Cowan palaeodrainages, Western Australia. *Australian Systematic Botany 8*, 1107–1154.

Clarke, J.D.A., 1993. Stratigraphy of Lefroy and Cowan Palaeodrainages, Western Australia. *Journal of the Royal Society of Western Australia 76*, 15–22.

Clarke, J.D.A., 1994. Evolution of the Lefroy and Cowan Palaeodrainages, Western Australia. *Australian Journal of Earth Sciences 41*, 55–68.

Clarke, J.D.A., Bone, Y. & James, N.P., 1996. Cool-water carbonates in an Eocene palaeoestuary, Norseman Formation, Western Australia. *Sedimentary Geology 101*, 213–226.

Clarke, J.D.A., Gammon, P.R., Hou, B. & Gallagher, S.J., 2003. Middle to Upper Eocene stratigraphic nomenclature and deposition in the Eucla Basin. *Australian Journal of Earth Sciences 50*, 231–248.

Collinson, M.E., 1982. A reassessment of fossil Potamogetonaceae fruits with description of new material from Saudi Arabia. *Tertiary Research 4*, 83–104.

De Villiers, S.E. & Cadman, A., 2001. An analysis of the palynomorphs obtained from Tertiary sediments at Koingnaas, Namaqualand, South Africa. *Journal of African Earth Sciences 33*, 17–47.

Erdtman, G., 1960. On the three new genera from the Lower Headon Beds, Berkshire. *Botaniska Notiser 113*, 46–48.

Fowler, K., 1971. A new species of *Aglaoreidia* Erdtman from the Eocene of Southern England. *Pollen et Spores 13*, 135–147.

Frederiksen, N.O., 1980. Sporomorphs from the Jackson Group (Upper Eocene) and adjacent strata of Mississipi and western Alabama. *US Geological Survey Professional Paper 1084*, 75.

Gandolfo, M.A., Zamaloa, M.C., Cúneo, N.R. & Archangelsky, A., 2009. Potamogetonaceae fossil fruits from the Tertiary of Patagonia, Argentina. *International Journal of Plant Sciences 170*, 419–428.

Harley, M.M., 2006. A summary of fossil records for Arecaceae. *Botanical Journal of the Linnean Society 151*, 39–67.

Harris, W.K., 1972. New form species of pollen from southern Australian early Tertiary sediments. *Transactions of the Royal Society of Australia 96*, 53–65.

Hekel, H., 1972. Pollen and spore assemblages from Queensland Tertiary sediments. *Geological Survey of Queensland Publication 355*, 1–34.

Hill, R.S. & Merrifield, H.E., 1993. An Early Tertiary macroflora from West Dale, south-western Australia. *Alcheringa 17*, 285–326.

Hos, D., 1975. Preliminary investigation of the palynology of the upper Eocene Werillup Formation, Western Australia. *Journal of the Royal Society of Western Australia 58*, 1–14.

Jaramillo, C. & Dilcher, D., 2001. Middle Paleogene palynology of central Colombia, South America: a study of pollen and spores from tropical latitudes. *Palaeontographica B 258*, 87–213.

Krutzsch, W., 1963. Zur regionalen und stratigraphen Verbreitung von *Aglaoreidia cyclops* Erdtman 1960. *Grana Palynologica 4*, 121–129.

Krutzsch, W., 1970. *Reevesiapollis*, ein neues Pollengenus der Sterculiaceen aus dem mitteleuropaischen Tertiar. *Feddes repertorium 81*, 371–384.

Li, G., Wan, X., Liu, W., Lian, D. & Hyesu, Y., 2005. Discovery of Paleogene marine stratum along the southern side of Yarlung-Zangbo suture zone and its implications in tectonics. *Science in China Series D-Earth Sciences 48*, 647–661.

Machin, J., 1971. Plant microfossils from Tertiary deposits of the Isle of Wight. *New Phytologist 70*, 851–872.

Macphail, M.K., 1999. Palynostratigraphy of the Murray Basin, inland southeastern Australia. *Palynology 23*, 197–240.

Macphail, M.K., 2007. *Australian Palaeoclimates: Cretaceous to Tertiary: A review of palaeobotanical and related evidence to the year 2000*. CRC-LEME Open File Report 151 (Special Volume ISBN 1 921039 75 2).

Macphail, M.K., Alley, N.F., Truswell, E.M. & Sluiter, I.R.K., 1994. Early Tertiary vegetation: evidence from spores and pollen. In *History of the Australian Vegetation: Cretaceous to Recent*. Hill, R.S., ed., Cambridge University Press, Cambridge, 189–261.

Martin, H.A., 2000. Re-assignment of the affinities of the fossil pollen type *Tricolpites trioblatus* Mildenhall and Pocknall to *Wilsonia* (Convolvulaceae) and a reassessment of the ecological interpretations. *Review of Palaeobotany and Palynology 111*, 237–251.

McLoughlin, S. & Hill, R.S., 1996. The succession of Western Australian Phanerozoic floras. In *Gondwanan Heritage: Past, Present and Future of the Western Australian Biota* (Proceedings of the Conference on Systematics, Evolution and Conservation of the Western Australian Biota, Perth, 1993). Hopper, S.D., Chappill, J.A., Harvey, M.S. & George, A.S., eds, Surrey Beatty, Sydney, 61–80.

Mildenhall, D.C. & Crosbie, Y.M., 1979. Some porate pollen from the upper Tertiary of New Zealand. *New Zealand Journal of Geology and Geophysics 22*, 499–508.

Milne, L., 1988. Palynology of a late Eocene lignitic sequence from the western margin of the Eucla Basin, Western Australia. *Memoirs of the Association of Australasian Palaeontologists 5*, 285–310.

Ollivier-Pierre, M.F., 1980. Étude palynologique (spores et pollens) de gisements Paléogènes due Massif Armoricain. Stratigraphie et Paléogéographie. *Mémoire de la Société géologique et minéralogique de Bretagne 25*, 1–239.

Partridge, A.D., 1999. *Late Cretaceous to Tertiary Geological Evolution of the Gippsland Basin.* PhD thesis, Latrobe University, Bundoora, Victoria, 439 pp. (unpublished)

PARTRIDGE, A.D., 2006. Late Cretaceous–Cenozoic palynology zonations Gippsland Basin. In *Australian Mesozoic and Cenozoic Palynology Zonations—Updated to the 2004 Geologic Time Scale*. MONTEIL, E., coord., Geoscience Australia Record 2006/23, 7.

POCKNALL, D.T. & MILDENHALL, D.C., 1984. Late Oligocene–early Miocene spores and pollen from Southland, New Zealand. *New Zealand Geological Survey Paleontological Bulletin 51*, 1–66.

RAMÍREZ-ARRIAGA, E., PRÁMPARO, M.B., MARTÍNEZ-HERNÁNDEZ, E. & VALIENTE-BAUNET, A., 2006. Palynology of the Paleogene Cuayuca Formation (stratotype sections), southern Mexico: chronostratigraphical and palaeoecological implications. *Review of Paleobotany and Palynology 141*, 259–275.

SINGH, H.P. & SARKAR, S., 1994. Palynostratigraphy of the Kasauli Formation (Lower Miocene), Himachal Pradesh, India. *Geophytology 24*, 49–54.

STOVER, L.E. & PARTRIDGE, A.D., 1973. Tertiary and Late Cretaceous spores and pollen from the Gippsland Basin, Southeastern Australia. *Proceedings of the Royal Society of Victoria 85*, 237–286.

STOVER, L.E. & PARTRIDGE, A.D., 1982. Eocene spore-pollen from the Werillup Formation, Western Australia. *Palynology 6*, 69–95.