

Supplementary Data 2. List of fossils used in the dating analyses and the corresponding references.

- 1. Acrogymnospermae** (crown min age 290Ma)- Mapes, G. & Rothwell, G. W.
Permineralized ovulate cones of *Lebachia* from late Palaeozoic limestones of Kansas. *Palaeontology* 27, 69–94 (1984).
Mapes, G. & Rothwell G. W. Structure and relationship of primitive conifers. *N. Jb. Geol. Paläont.* 183, 269–287 (1991).
- 2. Magnoliales** (stem min age 108.8Ma)- Crane, P. R., Friis, E. M. & Pedersen, K. R.
Palaeobotanical evidence on the early radiation of magnoliid angiosperms. *Plant Syst. Evol.* 8, 51–72 (1994).
- 3. Pandanales** (crown min age 65)- Jarzen, D. M. The terrestrial palynoflora from the Cretaceous-Tertiary transition, Alabama, U.S.A. *Pollen and Spores* 20, 535–553 (1978).
Muller, J. Fossil pollen records of extant angiosperms. *Bot. Rev.* 47, 1–142 (1981).
- 4. Arecales** (crown min age 65) - Pan, A. D., Jacobs, B. F., Dransfield, J. & Baker, W. J. The fossil history of palms (Arecaceae) in Africa and new records from the Late Oligocene (28–27 Mya) of north - western Ethiopia. *Bot. J. Linn. Soc.* 151, 69–81 (2006).
- 5. Eudicotyledonae** (crown min age 125Ma)- Hughes, N. F. & McDougall, A. B. Barremian-Aptian angiosperm pollen records from southern England. *Rev. Palaeobot. Palynol.* 65, 145–151 (1990).
Doyle, J. A. Revised palynological correlations of the lower Potomac group (USA) and the cocobeach sequence of Gabon (Barremian-Aptian). *Cretaceous Res.* 13, 337–349 (1992).
Brenner G. J. in *Flowering Plant Origin, Evolution, and Phylogeny* (Taylor, D. W. & Hickey, L. J.) 91–115 (Chapman & Hall, New York, 1996)
Friis, E. M., Pedersen, K. R. & Crane, P. R. Cretaceous angiosperm flowers: Innovation and evolution in plant reproduction. *Palaeogeogr., Palaeoclimatol., Palaeoecol.* 232, 251–293 (2006).
- 6. Proteales** (crown min age 108.8Ma)- Crane, P. R. & Herendeen, P. S. Cretaceous floras containing angiosperm flowers and fruits from eastern North America. *Rev. Palaeobot. Palynol.* 90, 319–337 (1996).

7. **Buxales** (stem min age 112Ma)- Anderson, C. L., Bremer, K. & Friis, E. M. Dating phylogenetically basal eudicots using rbcL sequences and multiple fossil reference points. *Am. J. Bot.* 92, 1737–1748 (2005).
8. **Gunnerales** (crown min age 88.2Ma)- Muller, J. Fossil pollen records of extant angiosperms. *Bot. Rev.* 47, 1–142 (1981).
9. **Caryophyllales** (crown min age 83.5Ma) - Collinson, M. E., Boulter, M. C. & Holmes, P. L. in *The Fossil Record 2* (Benton, M. J.) 809–841 (Chapman and Hall, London, 1993).
10. **Cornales** (crown min age 86.3Ma) - Takahashi M, Crane PR, Manchester SR. 2002. *Hironoia fusiformis* gen. et sp. nov.; a cornalean fruit from the Kamikitaba locality (Upper Cretaceous, Lower Coniacian) in northeastern Japan. *Journal of Plant Research* 115: 463–473.
11. **Ericales** (crown min age 91.2Ma) - Nixon, K. C. & Crepet, W. L. Late Cretaceous fossil flowers of ericalean affinity. *Am. J. Bot.* 80, 616–623 (1993).
12. **Saxifragales** (crown min age 89.3Ma) - Hermsen, E. J. et al. *Divisestylus* gen. nov. (aff. *Iteaceae*), a fossil saxifrage from the Late Cretaceous of New Jersey, USA. *Am. J. Bot.* 90, 1373–1388 (2003).
13. **Myrtales** (crown min age 88.2Ma) - Takahashi, M., Crane, P. R. & Ando, H. *Esgueiria futabensis* sp. nov., a new angiosperm flower from the Upper Cretaceous (lower Coniacian) of northeastern Honshu, Japan. *Paleontol. Res.* 3, 81–87 (1999).
14. **Sapindales** (crown min age 65Ma) - Knobloch, E. D. & Mai, D. H. Monograph of the fruits and seeds in the Cretaceous of Central Europe. *Rozprawy Ústředního Ústavu Geologického* 47, 1–219 (1986).
15. **Fabales** (crown min age 59.9Ma) - Herendeen, P. S. & Crane, P. R. in *Advances in Legume systematics, part 4. The fossil record.* (Herendeen, P. S. & Dilcher, D. L.) 57–68 (Royal Botanic Gardens, Kew, 1992).
16. **Fagales** (stem min age 96Ma) - Friis, E. M., Pedersen, K. R. & Schönenberger, J. Normapolles plants: a prominent component of the Cretaceous rosid diversification. *Plant Syst. Evol.* 260, 107–140 (2006).

- 17. Austrobaileyales** (crown min age 113Ma) - Upchurch GR. 1984. Cuticular Anatomy of Angiosperm Leaves from the Lower Cretaceous Potomac Group. I. Zone I Leaves. *American Journal of Botany* 71: 192–202.
- 18. Cabombaceae** (Nymphaeales) (stem min age 100.5Ma) - Taylor DW, Brenner GJ, Basha SH. 2008. *Scutifolium jordanicum* gen. et sp. nov. (Cabombaceae), an aquatic fossil plant from the Lower Cretaceous of Jordan, and the relationships of related leaf fossils to living genera. *American Journal of Botany* 95: 340–352.
- 19. Ceratophyllum** (Ceratophyllaceae, Ceratophyllales) (stem min age 127.2Ma) - Gomez B, Daviero-Gomez V, Coiffard C, Martín-Closas C, Dilcher DL. 2015. *Montsechia*, an ancient aquatic angiosperm. *Proceedings of the National Academy of Sciences* 112: 10985–10988.
- 20. Hedyosmum** (Chloranthaceae, Chloranthales) (stem min age 123Ma) - Friis EM, Pedersen KR, Crane PR. 1994. Angiosperm floral structures from the Early Cretaceous of Portugal (PK Endress and EM Friis, Eds.). *Pl. Syst. Evol. Suppl.* 8: 31–49.
- 21. Winteraceae** (Canellales) (stem min age 125Ma) - Doyle JA, Hotton CL, Ward J V. 1990. Early Cretaceous tetrads, zonosulculate pollen, and Winteraceae. I. Taxonomy, morphology, and ultrastructure. *American Journal of Botany* 77: 1544–1557.
- 22. Calycanthoideae** (Calycanthaceae, Laurales) (crown min age 86.3Ma) - Crepet WL, Nixon KC, Gandolfo MA. 2005. An extinct calycanthoid taxon, *Jerseyanthus calycanthoides*, from the Late Cretaceous of New Jersey. *American Journal of Botany* 92: 1475–1485.
- 23. Hernandiaceae** (Laurales) (crown min age 41.2Ma) - Manchester SR, O’Leary EL. 2010. Phylogenetic distribution and identification of fin-winged fruits. *Botanical Review* 76: 1–82.
- 24. Magnoliaceae** (Magnoliales) (stem min age 96.5Ma) - Dilcher DL, Crane PR. 1984. *Archaeanthus*: An Early Angiosperm From the Cenomanian of the Western Interior of North America. *Annals of the Missouri Botanical Garden* 71: 351–383.
- 25. Hydrocharitaceae** (Alismatales) (crown min age 55.9Ma) - Bone D. 1986. The stratigraphy of the Reading Beds (Palaeocene), at Felpham, West Sussex. *Tertiary Research* 8: 17–32.

- 26. Posidoniaceae** (Alismatales) (stem min age 66Ma) - van der Ham RWJM, van Konijnenburg-van Cittert JHA, Indehberge L. 2007. Seagrass foliage from the Maastrichtian type area (Maastrichtian, Danian, NE Belgium, SE Netherlands). *Review of Palaeobotany and Palynology* 144: 301–321.
- 27. Asteliaceae** (Asparagales) (crown min age 23.2Ma) - Maciunas E, Conran JG, Bannister JM, Paull R, Lee DE. 2011. Miocene *Astelia* (Asparagales: Asteliaceae) macrofossils from southern New Zealand. *Australian Systematic Botany* 24: 19–31.
- 28. Alstroemeriaceae** (Liliales) (crown min age 23.2Ma) - Conran JG, Bannister JM, Mildenhall DC, Lee DE, Chacón J, Renner SS. 2014. Leaf fossils of *Luzuriaga* and a monocot flower with in situ pollen of *Liliacidites contortus* Mildenh. & Bannister sp. nov. (Alstroemeriaceae) from the Early Miocene. *American Journal of Botany* 101: 141–155.
- 29. Ripogonaceae** (Liliales) (stem min age 51Ma) - Conran JG, Carpenter RJ, Jordan GJ. 2009. Early Eocene *Ripogonum* (Liliales: Ripogonaceae) leaf macrofossils from southern Australia. *Australian Systematic Botany* 22: 219–228.
- 30. Cyclanthaceae** (Pandanales) (crown min age 47Ma) - Smith SY, Collinson ME, Rudall PJ. 2008. Fossil *Cyclanthus* (Cyclanthaceae, Pandanales) from the eocene of Germany and England. *American Journal of Botany* 95: 688–699.
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- 32. Bromeliaceae** (Poales) (crown min age 41.2Ma) - Graham A. 1985. Studies in Neotropical Paleobotany. IV. The Eocene Communities of Panama. *Annals of the Missouri Botanical Garden* 72: 504–534.
- 33. Cyperaceae** (Poales) (crown min age 47Ma) - Smith SY, Collinson ME, Simpson DA, Rudall PJ, Marone F, Stampanoni M. 2009. Elucidating the affinities and habitat of ancient, widespread Cyperaceae: *Volkeria messelensis* gen. et sp. nov., a fossil mapanioid sedge from the Eocene of Europe. *American Journal of Botany* 96: 1506–1518.
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Oligocene sediments of coastal central Queensland, Australia. Review of Palaeobotany and Palynology 110: 141–173.

35. **Typhaceae** (Poales) (crown min age 51.66Ma) - Grande L. 1984. Paleontology of the Green River Formation, with a review of the fish fauna, second edition. Geological Survey of Wyoming Bulletin 63: 1–333.
36. **Zingiberaceae** (Zingiberales) (stem min age 66Ma) - Knowlton F. 1917. Fossil floras of the Vermejo and Raton formations of Colorado and New Mexico. U.S. Geological Survey Professional Paper 101: 223–435.
37. **Buxaceae** (Buxales) (stem min age 100.5Ma) - Drinnan AN, Crane PR, Friis EM, Pedersen KR. 1991. Angiosperm flowers and tricolpate pollen of buxaceous affinity from the Potomac Group (Mid-Cretaceous) of Eastern North America. American Journal of Botany 78: 153–176.
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39. **Proteaceae** (Proteales) (crown min age 72.1Ma) - Carpenter RJ, Macphail MK, Jordan GJ, Hill RS. 2015. Fossil evidence for open, proteaceae-dominated heathlands and fire in the late cretaceous of Australia. American Journal of Botany 102: 2092–2107.
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42. **Haloragaceae** (Saxifragales) (stem min age 72.1Ma) - Hernandez-Castillo GR, Cevallos-Ferriz SRS. 1999. Reproductive and vegetative organs with affinities to Haloragaceae from the Upper Cretaceous Huepac Chert Locality of Sonora, Mexico. American Journal of Botany 86: 1717.
43. **Hamamelidaceae** (Saxifragales) (crown min age 83.6Ma) - Magallón-Puebla S, Herendeen PS, Endress PK. 1996. Allonia decandra: Floral remains of the tribe

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44. **Iteaceae** (Saxifragales) (crown min age 48Ma) - Wolfe JA, Wehr WC. 1987. Middle Eocene dicotyledonous plants from Republic, northeastern Washington. *United States Geological Survey Bulletin* 1597: 1–25.
45. **Staphyleaceae** (Crossosomatales) (crown min age 56Ma) - Knowlton F. 1917. Fossil floras of the Vermejo and Raton formations of Colorado and New Mexico. *U.S. Geological Survey Professional Paper* 101: 223–435.
46. **Francoaceae** (Geraniales) (crown min age 15.97Ma) - Palazzesi L, Gottschling M, Barreda V, Weigend M. 2012. First Miocene fossils of Vivianiaceae shed new light on phylogeny, divergence times, and historical biogeography of Geraniales. *Biological Journal of the Linnean Society* 107: 67–85.
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49. **Melastomataceae** (Myrtales) (stem min age 56Ma) - Brown RW 1962. Paleocene flora of the Rocky Mountains and Great Plains. *Geological Survey Professional Paper* 375: 1-119.
50. **Vitaceae** (Vitales) (crown min age 61.6Ma) - Manchester SR, Kapgate DK, Wen J. 2013. Oldest fruits of the grape family (Vitaceae) from the Late Cretaceous Deccan Cherts of India. *American Journal of Botany* 100: 1849–1859.
51. **Akaniaceae** (Brassicales) (crown min age 61.6Ma) - Iglesias A, Wilf P, Johnson KR, Zamuner AB, Cúneo NR, Matheos SD, Singer BS. 2007. A Paleocene lowland macroflora from Patagonia reveals significantly greater richness than North American analogs. *Geology* 35: 947–950.

- 52. Tapisciaceae** (Huerteales) (crown min age 41.2Ma) - Manchester SR. 1988. Fruits and seeds of *Tapiscia* (Staphylaceae) from the Middle Eocene of Oregon U.S.A. *Tertiary Research* 9: 59-66.
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- 54. Malvaceae** (Malvales) (stem min age 72.1Ma) - Estrada-Ruiz E, Martínez-Cabrera HI, Cevallos-Ferriz SRS. 2007. Fossil woods from the late Campanian-early Maastrichtian Olmos Formation, Coahuila, Mexico. *Review of Palaeobotany and Palynology* 145: 123-133.
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- 56. Simaroubaceae** (Sapindales) (crown min age 41.2Ma) - Collinson ME, Manchester SR, Wilde V. 2012. Fossil fruits and seeds of the Middle Eocene Messel biota, Germany. *Abh. Senckenberg Ges. Naturforsch.* 570: 1-251.
- 57. Celastraceae** (Celastrales) (crown min age 37.8Ma) - Hollick A. 1936. The Tertiary floras of Alaska. U.S. Geological Survey Professional Paper 182: 1-185.
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- 59. Anisophylleaceae** (Cucurbitales) (crown min age 11.63Ma) - Anderson JAR, Muller J. 1975. Palynological study of a holocene peat and a miocene coal deposit from NW Borneo. *Review of Palaeobotany and Palynology* 19: 291-351.
- 60. Cucurbitaceae** (Cucurbitales) (stem min age 47.8Ma) - Chandler MEJ. 1961. The Lower Tertiary floras of southern England. I. Paleocene Floras. London Clay Flora (Supplement). Text and Atlas. London: British Museum (Natural History).
- 61. Polygalaceae** (Fabales) (crown min age 56Ma) - Pigg KB, DeVore ML, Wojciechowski MF. 2008. *Paleosecuridaca curtisii* gen. et sp. nov., *Securidaca*-Like Samaras (Polygalaceae) from the Late Paleocene of North Dakota and Their Significance to

the Divergence of Families within the Fabales. *International Journal of Plant Sciences* 169: 1304–1313.

62. **Surianaceae** (Fabales) (crown min age 48.5Ma) - Kruse H. 1954. Some Eocene dicotyledonous Woods from Eden Valley, Wyoming. *Ohio Journal of Science* 54: 243–268.
63. **Fagaceae** (Fagales) (crown min age 37.8Ma) - Crepet WL, Daghljan CP. 1980. Castaneoid inflorescences from the Middle Eocene of Tennessee and the diagnostic value of pollen (at the subfamily level) in Fagaceae. *American Journal of Botany* 67: 739–757.
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66. **Chrysobalanaceae** (Malpighiales) (crown min age 48.5Ma) - Brown RW. 1929. Additions to the flora of the Green River formation. U.S. Geological Survey Professional Paper 154: 279–292.
67. **Clusiaceae** (Malpighiales) (stem min age 86.3Ma) - Crepet WL, Nixon KC. 1998. Fossil Clusiaceae from the Late Cretaceous (Turonian) of New Jersey and implications regarding the history of bee pollination. *American Journal of Botany* 85: 1122–1133.
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- 71. Cunoniaceae** (Oxalidales) (crown min age 56Ma) - Hill RS. 1991. Leaves of Eucryphia (Eucryphiaceae) from Tertiary Sediments in South-eastern Australia. *Australian Systematic Botany* 4: 481-497.
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- 74. Moraceae** (Rosales) (crown min age 47.8Ma) - Chandler MEJ. 1963. The Lower Tertiary floras of Southern England. III. Flora of the Bournemouth Beds; the Boscombe, and the Highcliff Sands. London: British Museum (Natural History).
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- 76. Polygonaceae** (Caryophyllales) (stem min age 66Ma) - Manchester SR, O’Leary EL. 2010. Phylogenetic distribution and identification of fin-winged fruits. *Botanical Review* 76: 1–82.
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- 80. Actinidiaceae** (Ericales) (crown min age 83.6Ma) - Keller JA, Herendeen PS, Crane PR. 1996. Fossil flowers and fruits of the Actinidiaceae from the Campanian (Late Cretaceous) of Georgia. *American Journal of Botany* 83: 528–541.
- 81. Vaccinioideae** (Ericaceae, Ericales) (crown min age 66Ma) - Knobloch E, Mai DH. 1986. Monographie der Früchte und Samen in der Kreide von Mitteleuropa. *Rozprawy ústředního ústavu geologického*. Praha 47: 1-219.
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- 87. Symplocaceae** (Ericales) (crown min age 47.8Ma) - Tiffney B H. 1999. Fossil fruit and seed flora from the Early Eocene Fisher/Sullivan Site. Pages 139–159 in RE Weems & GJ Grimsley (eds.), *Early Eocene vertebrates and plants from the Fisher/Sullivan Site (Nanjemoy Formation) Stafford County, Virginia*. Virginia Division of Mineral Resources Publication.
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- 90. Aquifoliaceae** (Aquifoliales) (stem min age 61.6Ma) - Mai DH. 1970. Subtropische Elemente im europäischen Tertiär I. Die Gattungen *Gironniera*, *Sarcococca*, *Illicium*, *Evodia*, *Ilex*, *Mastixia*, *Alangium*, *Symplocos* und *Rehderodendron*. *Paläontologische Abhandlungen Abt. B* 3: 441–503, pls. 58–69.
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- 93. Ehretiaceae** (Boraginales) (crown min age 47.8Ma) - Chandler MEJ. 1961. The Lower Tertiary floras of southern England. I. Paleocene Floras. *London Clay Flora (Supplement)*. Text and Atlas. London: British Museum (Natural History).
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