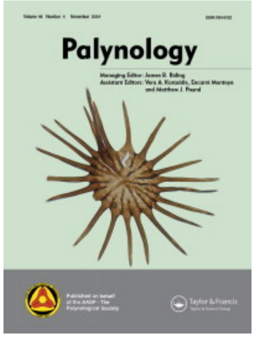

Palynology

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/tpal20

A global modern pollen and spore dataset

Matthew J. Pound & Jennifer M. K. O'Keefe

To cite this article: Matthew J. Pound & Jennifer M. K. O'Keefe (20 Dec 2024): A global modern pollen and spore dataset, Palynology, DOI: 10.1080/01916122.2024.2431282

To link to this article: https://doi.org/10.1080/01916122.2024.2431282

PALYNOLOGY
https://doi.org/10.1080/01916122.2024.2431282

DATA NOTE

OPEN ACCESS Check for updates

A global modern pollen and spore dataset

Matthew J. Pound[a] and Jennifer M. K. O'Keefe[b]

[a]Department of Geography and Environmental Sciences, Northumbria University, Newcastle upon Tyne, UK; [b]Department of Engineering Sciences, Morehead State University, Morehead, KY, USA

ABSTRACT
Here we present a new global compilation of modern pollen and spore data for use in testing and evaluating palaeoclimate reconstruction methods. The resulting dataset contains 21,503 pollen assemblages from all continents excluding Antarctica. All pollen assemblages have geographical coordinates listed, and the majority have an elevation measurement. Taxonomic nomenclature has been standardised.

KEYWORDS
Contemporary; surface; world; terrestrial; ecosystems

1. Introduction

Many Cenozoic plant-based palaeoclimate reconstructions use nearest living relative techniques (Wang et al. 2021; McCoy et al. 2024). These assume that the fossil taxon had similar climatic requirements to its living relative(s). The climatic requirements of the nearest living relative are then used to reconstruct the palaeoclimate of the time interval being investigated (Kershaw 1997; Fauquette et al. 1998; Kühl et al. 2002; Utescher et al. 2014; Chevalier 2022). As part of ongoing research into the global climate of the Middle Miocene geological time interval, it became necessary to evaluate pollen-based palaeoclimate reconstruction techniques with modern data. We present the global modern pollen and spore dataset (here after called GALORE: GlobAL mOdeRn pollEn) developed for this purpose. This dataset compiles data from previously published databases: the African Pollen Database (Ivory et al. 2020), the modern pollen dataset of China (Chen et al. 2021), the Eurasian Pollen Database (Chevalier et al. 2019; Davis et al. 2020), Latin American pollen database (Flantua et al. 2015), LegacyPollen 1.0 (Herzschuh et al. 2022), Neotoma (Williams et al. 2018), and the North American Modern Pollen Database (Whitmore et al. 2005). Additional regional, country, region, and site-specific studies have been added to these, when they are not currently incorporated in these databases, with the aim of increasing geographic coverage. This dataset does not aim to reproduce or replace these existing databases; instead, it is a product built by extracting specific data samples from these other databases.

2. Materials and methods

Modern pollen and spore assemblage data were collated from existing databases, datasets and individual publications. Data collation initially focussed on existing databases. Literature searches, using Web of Science and Google Scholar, were performed for any country that was not included after this initial collation (using both the English and the official-language name for missing countries). Searches concluded at the end of 2023. Geographical data were recorded as a site name that is consistent with that given by the original authors, digital latitude and longitude, and elevation. When publications did not provide any of these details, country, latitude and longitude were determined from published location maps and Google Earth. When elevation was absent, this was listed as n/a. Elevation has also been derived from the WorldClim 2.1 elevation 30 s dataset as an additional internally consistent format (Fick and Hijmans 2017). Contextual data include environmental information on the site, sample type, duration of sampling (for pollen traps only) and how the pollen assemblage was recorded.

Pollen and spore assemblages in GALORE were standardised by removing uncertain identifications, indeterminate records and non-plant taxa. Uncertain identifications were any taxa noted as cf. (*confer*) or aff. (*species affinis*), any assigned to more than one family, any assigned a morphological name, or any assigned to a rank above family level. Following this filtering of uncertain identifications, all taxa were checked in the Global Biodiversity Information Facility during March 2024 (GBIF 2024) and updated to their current taxonomic name. The GBIF has a taxonomy backbone that draws on 105 different sources to automatically check names and enables this central database to collate from multiple resources (GBIF Secretariat 2023).

Fossil pollen is rarely identified to a modern species level. As such, all species-level identifications were aggregated into

CONTACT Matthew J. Pound matthew.pound@northumbria.ac.uk Department of Geography and Environmental Sciences, Northumbria University, Newcastle upon Tyne, UK

Published online 20 Dec 2024

their generic level. Poaceae genera were collated at the family level, as these pollen are almost never identified to the genus level in Cenozoic palynology (e.g. Guimarães et al. 2015; Hui et al. 2018; Mander et al. 2023). Many other pollen grains are commonly identified at the family level, but examples exist in the literature for identification to genus and thus those were left for individual users to determine how to treat them. Sub-families were also collated into their respective families. The resulting dataset contains only genus and family names to mimic the data commonly used for palaeoclimatic reconstructions (Wang et al. 2021; Pilie et al. 2023; McCoy et al. 2024).

3. Dataset description and limitations

GALORE comprises three items: geographical and contextual data; pollen assemblages; and a reference list. Within the geographical and contextual data is a unique locality–pollen assemblage identifying number that links to the pollen assemblage table. Geographical information includes site name, country, digital coordinates and elevation of the site. Where available, a description of the environment has been reproduced. Sample type provides the source of the pollen; and, where this is a pollen trap, 'time interval' provides the length of collection in months. Data type presents the format in which the pollen assemblage was recorded: presence–absence, counts, percentages, or unknown. Finally, source citations are provided to enable traceability of the data. Pollen assemblages are presented in rows, with each pollen taxon listed alphabetically in columns. This table can be related to the first by the ID number and site name. Finally, a full list of references is provided.

GALORE synthesises previously published modern pollen data. The data it presents reflects that published by the authors cited for each locality. There were potential sources of uncertainty in both the geographical and pollen assemblage data. Within the geographical data, determining a precise latitude and longitude from a location map and Google Earth means that some locations have lower geospatial resolution than sites where authors provide this information. The elevation recorded in publications does not always agree with the elevation from the WorldClim 2.1 dataset (the largest difference is 3182 m). These differences could stem from either uncertainty in the original publications or topographical features not visible in the 30 s WorldClim 2.1 dataset. Despite this, 16,176 records have elevation differences of <100 m between that recorded from the original publications and that derived from the WorldClim 2.1 dataset.

As much of this data can be considered historical (the oldest record was published in 1954), the environmental data may not be accurate to present-day conditions at the sampling site. Pollen assemblage data that was recorded as presence–absence was intended to be a less-biased recording method than attempting to accurately measure from published pollen diagrams (when no other data presentation was published). Whilst this brings in its own biasing – all pollen appear to be present equally in presence–absence data – this is clearly identified in the dataset and therefore a user can filter these out. Presence–absence data is useful, as several palaeoclimate reconstruction methodologies use presence–absence data in their procedures (Utescher et al. 2014; McCoy et al. 2024).

In generating this dataset, it became obvious that a clear geographical bias exists between the northern and southern hemispheres and particular geographical regions, despite the data having sufficient geographical/elevation spread to incorporate all major vegetated climate zones on Earth (Figure 1). However, there are clear opportunities to build upon this dataset, either by generating new data, or by making historical and archive data readily available to the wider community. It would also be beneficial to the community for this data to be registered in Neotoma (Williams et al. 2018), or a readily available region-specific database. Although the GALORE dataset was created for a specific purpose, it likely has more uses beyond testing palaeoclimate reconstruction techniques, and prospective users are encouraged to reach out to the corresponding author to discuss whether the dataset is appropriate for their needs.

4. Data sources

The pollen and spore data in GALORE was collated from: Abreu et al. (2003), Adekanmbi and Ogundipe (2010), Agwu (1986, 2001), Al-Eisawi and Dajani (1988), Amaral et al. (2013), Amaral (2023), Anshari et al. (2004), Barboni and Bonnefille (2001), Barboni et al. (2019), Barrow (1978), Basumatary et al. (2017), Behling et al. (2000), Bell and Fletcher (2016), Bengo (2020, 2023), Bengo et al. (2020), Beuning (1997, 2023), Bishop et al. (2003), Blaus et al. (2020, 2023), Bonnefille and Riollet (1988), Botha et al. (1992), Bourel (2023), Boyd (1994), Buchet (1982, 2023a, 2023b), Burry et al. (2005), Bush (2000), Bush and Rivera (1998), Bush et al. (2001, 2015, 2021), Caratini et al. (1988), Carrión et al. (2000), Chabangborn et al. (2020), Charalampopoulos et al. (2021), Chen et al. (2021), Cheng et al. (2020), Chevalier et al. (2019), Collao-Alvarado et al. (2015), Cooremans (1989), Correa-Metrio et al. (2011, 2013), Davis et al. (2020), Deng et al. (2006), Djamali et al. (2020), Ebenezer and Christopher (2019), Edorh (1986, 2023a, 2023b, 2023c), Edorh and Afidegnon (2009), El Ghazali (2023), El Ghazali and Moore (1998), Elenga (1992, 2023a, 2023b), Elenga et al. (2000), Elliot (1999), El-Moslimany (1983), Fiacconi (2017), Fiacconi and Hunt (2017), Flantua et al. (2015), Fontana (2005), Frazer et al. (2020), Fredoux (1978, 2023), Fukumoto et al. (2015), Gaillard et al. (2021), Geng et al. (2022), Ghosh et al. (2017), Gil Romera et al. (2006, 2007), Goldberg et al. (1988), Green et al. (2002), Guarín et al. (2015), Gucel et al. (2013), Hamilton (1972, 2023), Hedberg (1954, 2023), Henga-Botsikabobe (2023), Henga-Botsikabobe et al. (2020), Herzschuh et al. (2022), Hope and Pask (1998), Hope et al. (2019), Horisk et al. (2023), Horrocks and Ogden (1994), Ivory and Russell (2016), Ivory et al. (2020), Jan et al. (2016), Jolly (2023), Jolly et al. (1996), Kiared et al. (2017), Laseski (1983, 2023a, 2023b), Latorre and Perez (1997), Leal and Bilbao (2011), Leal et al. (2013), Lebamba (2009, 2023a, 2023b), Lebamba et al. (2009), Ledru (2002), Lézine (1981, 1987,

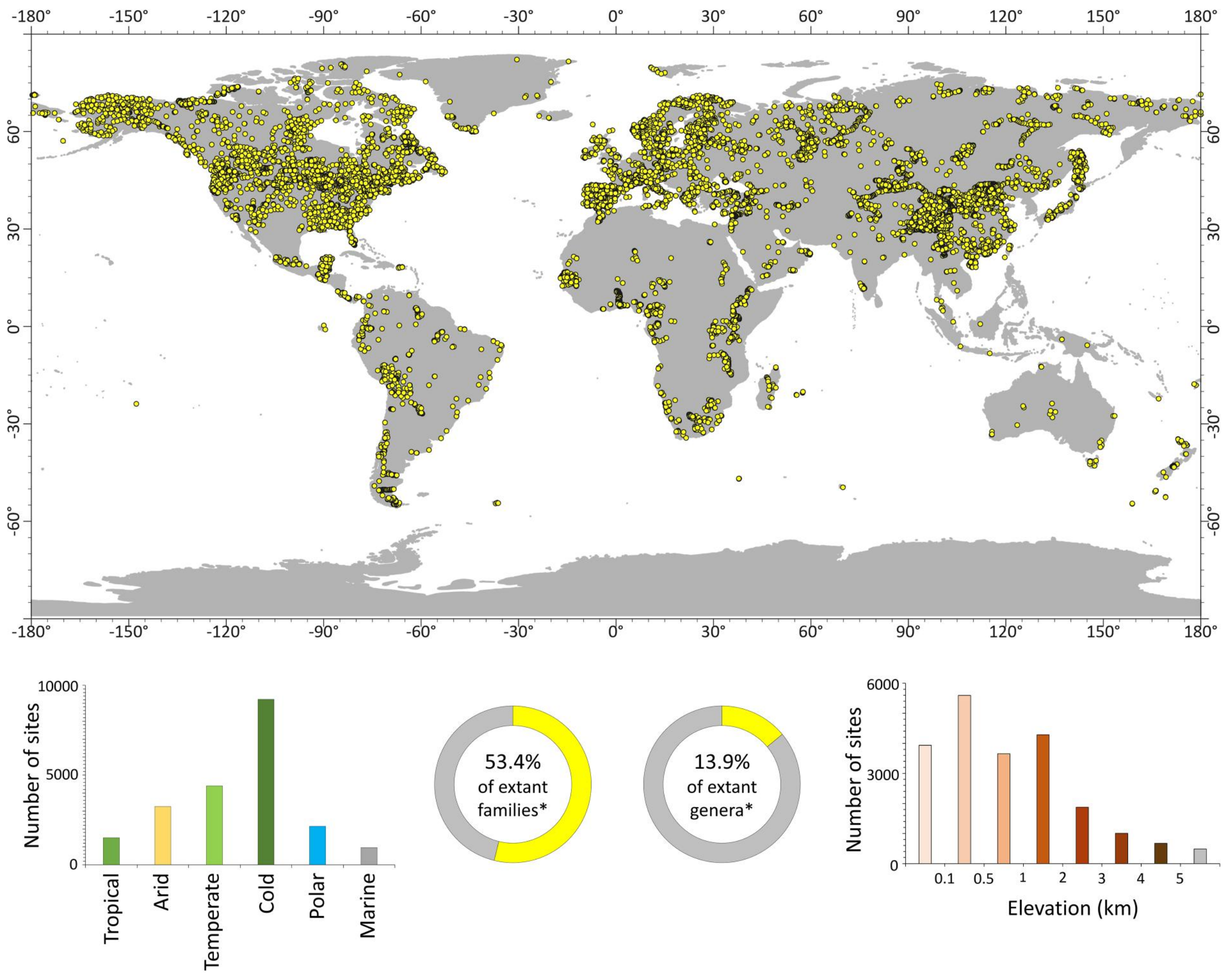

Figure 1. The GALORE dataset showing geographical distribution and, below, numbers of sites in different climate zones (Beck et al. 2018), numbers of extant families and genera (Christenhusz and Byng 2016; Brinda and Atwood 2024) recorded in GALORE and numbers of sites binned by elevation (excluding the 482 sites without elevation data).

2023a, 2023b, 2023c, 2023d, 2023e, 2023f, 2023g, 2023h, 2023i, 2023j, 2023k), Lézine and Edorh (1991), Lézine and Hooghiemstra (1990), Lézine et al. (1998, 2010), Lopez (2023), Lopez et al. (2017), Lu et al. (2010, 2020), Maldonado et al. (2005), Maley (1981, 2023a, 2023b, 2023c) Maley and Livingstone (1983), Mancini (1993), Marais et al. (2015); Masciadri et al. (2013), McGlone and Meurk (2000), McGlone and Moar (1997), Medeanic (2004), Mittre and Sharma (1977), Mohammed (1992, 2023a, 2023b), Mohammed et al. (2004), Nguyen et al. (2022), Njokuocha (2006), Olatoyan et al. (2023), Ortega Rosas et al. (2008, 2020), Ortuño et al. (2011), Palacios (2011), Pandey and Minckley (2019), Pearson (1997), Penny (2001), Penny et al. (2006), Pereira et al. (2018), Perveen et al. (2007, 2014), Pinar et al. (1999), Pocknall (1982), Prasad and Quamar (2023), Punwong et al. (2024), Quamar and Stivrins (2021), Quamar et al. (2018), Randall (1990), Reese and Liu (2005), Reis et al. (2023), Reynaud (2023), Riedel et al. (2015), Ritchie (1986, 2023), Rodríguez-de la Cruz et al. (2010), Rucina (2000, 2023), Saad (2023), Saad and Sami (1967), Saeidi Ghavi Andam et al. (2021), Salzmann (1999), Schüler et al. (2014), Scott (1976, 1982, 1985, 1987, 1988, 1989, 1995, 1996, 1999), Scott and Bonnefille (1986), Scott and Bousman (1990), Scott and Brink (1992), Scott and Cooremans (1990, 1992), Scott and Woodborne (2007), Scott et al. (1992, 2003, 2004), Selkirk et al. (1982, 1988), Semeniuk et al. (2000, 2006), Singh et al. (1974), Stevenson et al. (2007), Straka (1991), Sugden (1989, 2023), Tng et al. (2010), Tossou (2002, 2023), Urrego et al. (2011), Valencia et al. (2010), Van Zinderen Bakker (1984); Van Zinderen Bakker and Müller (1987), Verlhac et al. (2018), Vincens (1982, 1987, 2023a, 2023b, 2023c, 2023d, 2023e), Vincens et al. (2000, 2006a, 2006b), Weng et al. (2004), Whitmore et al. (2005), Williams et al. (2018), Ybert (1977, 2023a, 2023b), Young and Schofield (1973a, 1973b), and Yulianto et al. (2005).

Acknowledgements

The authors thank the four peer-reviewers for their helpful comments that have greatly improved this manuscript.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

The authors wish to acknowledge funding awarded to the 'Fungi in a Warmer World' (FiaWW) project, jointly from NSF/Geo (award no. 2015813) and NERC (award no. NE/V01501X/1).

ORCID

Matthew J. Pound http://orcid.org/0000-0001-8029-9548
Jennifer M. K. O'Keefe http://orcid.org/0000-0003-1793-593X

Data availability statement

Data is available from Zenodo (https://zenodo.org/doi/10.5281/zenodo.11125269) and the National Geoscience Data Centre (submission ID 21D8A562BB2C1740E0630B37940A6E9E).

References

Abreu I, Ribeiro H, Cunha M. 2003. An aeropalynological study of the Porto region (Portugal). Aerobiologia. 19(3/4):235–241.

Adekanmbi OH, Ogundipe OT. 2010. Aeropalynological studies of the University of Lagos campus, Nigeria. Notulae Scientia Biologicae. 2(4):34–39.

Agwu COC. 1986. History of climate and vegetation of east central Nigeria as deduced from pollen analysis: preliminary investigations. Bulletin de liaison de l'Association Sénégalaise pour l'Etude du Quaternaire Africain. 76:5–8.

Agwu COC. 2001. A study of Niger Delta environment through air-borne palynomorphs, Port Harcourt, Nigeria. Palaeoecology of Africa. 27:191–205.

Al-Eisawi D, Dajani B. 1988. Airborne pollen of Jordan. Grana. 27(3):219–227.

Amaral PGC. 2023. African Pollen Database: Chad_Amaral_Surface_2013_trans fossil pollen dataset. doi: 10.14768/APD.zhab-s798

Amaral PGC, Vincens A, Guiot J, Buchet G, Deschamps P, Doumnang JC, Sylvestre F. 2013. Palynological evidence for gradual vegetation and climate changes during the African Humid Period termination at 13 N from a Mega-Lake Chad sedimentary sequence. Climate of the Past. 9(1):223–241.

Anshari G, Kershaw PA, Van Der Kaars S, Jacobsen G. 2004. Environmental change and peatland forest dynamics in the Lake Sentarum area, West Kalimantan, Indonesia. Journal of Quaternary Science. 19(7):637–655.

Barboni D, Ashley GM, Bourel B, Arráiz H, Mazur JC. 2019. Springs, palm groves, and the record of early hominins in Africa. Review of Palaeobotany and Palynology. 266:23–41.

Barboni D, Bonnefille R. 2001. Precipitation signal in pollen rain from tropical forests, South India. Review of Palaeobotany and Palynology. 114(3-4):239–258.

Barrow CJ. 1978. Postglacial pollen diagrams from South Georgia (sub-Antarctic) and West Falkland Island (South Atlantic). Journal of Biogeography. 5(3):251–274.

Basumatary SK, Gogoi B, Prasad V. 2017. Characteristic modern pollen assemblages in relation to vegetation types in the East Khasi Hills, northeast India. Palynology. 41(2):162–170.

Beck HE, Zimmermann NE, McVicar TR, Vergopolan N, Berg A, Wood EF. 2018. Present and future Köppen-Geiger climate classification maps at 1-km resolution. Scientific Data. 5(1):180214.

Behling H, Arz HW, Pätzold J, Wefer G. 2000. Late Quaternary vegetational and climate dynamics in northeastern Brazil, inferences from marine core GeoB 3104-1. Quaternary Science Reviews. 19(10):981–994.

Bell BA, Fletcher WJ. 2016. Modern surface pollen assemblages from the Middle and High Atlas, Morocco: insights into pollen representation and transport. Grana. 55(4):286–301.

Bengo MD. 2020. Etude palynologique et statistique de quelques échantillons fluviatiles actuels du bassin de la Sanaga. Mémoire de DEA de Paléontologie, Université de Montpellier II; p. 32.

Bengo MD. 2023. African Pollen Database: Cameroon_Bengo_1992_trans fossil pollen dataset. doi: 10.14768/APD.x772-ae71

Bengo MD, Elenga H, Maley J, Giresse P. 2020. Evidence of pollen transport by the Sanaga River on the Cameroon shelf. Comptes Rendus Géoscience. 352(1):59–72.

Beuning KRM. 1997. Late-glacial and Holocene vegetation, climate and hydrology of lakes Albert and Victoria, East Africa [unpublished PhD thesis]. University of Minnesota; p. 183.

Beuning KRM. 2023. African Pollen Database: Uganda_Beuning_1997_trans fossil pollen dataset. doi: 10.14768/APD.hvdg-vb49

Bishop P, Penny D, Stark M, Scott M. 2003. A 3.5 ka record of paleoenvironments and human occupation at Angkor Borei, Mekong Delta, southern Cambodia. Geoarchaeology. 18(3):359–393.

Blaus A, McMichael CNH, Raczka MF, Herrick C, Palace M, Witteveen NH, Nascimento MN, Bush MB. 2023. Amazonian pollen assemblages reflect biogeographic gradients and forest cover. Journal of Biogeography. 50(11):1926–1938.

Blaus A, Reitalu T, Massante JC, Hiiesalu I, Gerhold P, Veski S. 2020. Modern pollen–plant diversity relationships inform palaeoecological reconstructions of functional and phylogenetic diversity in calcareous fens [Dataset]. Dryad. doi: 10.5061/dryad.wstqjq2hh

Bonnefille R, Riollet G. 1988. Palynologie des sédiments Holocènes de sites archéologiques du Quatar. In: Inizan M-L, editor. Préhistoire à Quatar. Vol. 2. Paris: Recherche sur les civilisations; p. 137–145.

Botha GA, Scott L, Vogel JC, Von Brunn V. 1992. Palaeosols and palaeoenvironments during the Late Pleistocene Hypothermal in northern Natal. South African Journal of Science. 88:508–508.

Bourel B. 2023. African Pollen Database: Ethiopia_Tanzania_Barboni_trans fossil pollen dataset. doi: 10.14768/APD.h2tc-bz27

Boyd WE. 1994. Quaternary pollen analysis in the arid zone of Australia: further results from Dalhousie Springs, Central Australia. Australian Geographical Studies. 32(2):274–280.

Brinda JC, Atwood JJ. 2024. The Bryophyte Nomenclator. 2024 Feb 29. https://www.bryonames.org/.

Buchet G. 1982. Transport des pollens dans les fleuves Omo et Awash (Ethiopie): étude de vases actuelles. Mémoire de l'Ecole pratique des Hautes Etudes, Institut de Montpellier; p. 171.

Buchet G. 2023a. African Pollen Database: Ethiopia_Buchet_Omo_1982_trans fossil pollen dataset. doi: 10.14768/APD.qxx3-a804

Buchet G. 2023b. African Pollen Database: Ethiopia_Buchet_Awash_1982_trans fossil pollen dataset. doi: 10.14768/APD.j1p8-0371

Burry LS, D'Antoni HL, Frangi JL. 2005. Polen y vegetación en la Patagonia extraandina argentina a 45° S. Anales del Jardín Botánico de Madrid. 62:143–152.

Bush MB. 2000. Deriving response matrices from Central American modern pollen rain. Quaternary Research. 54(1):132–143.

Bush MB, Alfonso-Reynolds AM, Urrego DH, Valencia BG, Correa-Metrio YA, Zimmermann M, Silman MR. 2015. Fire and climate: contrasting pressures on tropical Andean timberline species. Journal of Biogeography. 42(5):938–950.

Bush MB, Correa-Metrio A, van Woesik R, Collins A, Hanselman J, Martinez P, McMichael CN. 2021. Modern pollen assemblages of the Neotropics. Journal of Biogeography. 48(1):231–241.

Bush MB, Moreno E, de Oliveira PE, Asanza E, Colinvaux PA. 2001. The influence of biogeographic and ecological heterogeneity on Amazonian pollen spectra. Journal of Tropical Ecology. 17(5):729–743.

Bush MB, Rivera R. 1998. Pollen dispersal and representation in a neotropical rain forest. Global Ecology and Biogeography Letters. 7(5):379–392.

Caratini C, Tissot C, Frédoux A. 1988. Caractérisation des aérosols désertiquesa Niamey (Niger) par leur contenu pollinique. Institut Français de Pondichéry, Travaux de la Section Scientifique et Technique. 25:251–268.

Carrión J, Scott L, Huffman T, Dreyer C. 2000. Pollen analysis of Iron Age cow dung in Southern Africa. Vegetation History and Archaeobotany. 9(4):239–249.

Chabangborn A, Punwong P, Phountong K, Nudnara W, Yoojam N, Sainakum A, Won-In K, Sompongchaiyakul P. 2020. Environmental changes on the west coast of the Gulf of Thailand during the 8.2 ka event. Quaternary International. 536:103–113.

Charalampopoulos A, Damialis A, Lazarina M, Halley JM, Vokou D. 2021. Spatiotemporal assessment of airborne pollen in the urban environment: the pollenscape of Thessaloniki as a case study. Atmospheric Environment. 247:118185.

Chen H-Y, Xu D-Y, Liao M-N, Li K, Ni J, Cao X-Y, Cheng B, Hao X-D, Kong Z-C, Li S-F, et al. 2021. A modern pollen dataset of China. Chinese Journal of Plant Ecology. 45(7):799–808.

Cheng Z, Weng C, Foong SY, Dai L. 2020. A study on modern pollen rain and pollen morphology in the tropical western Malay Peninsula and its implications for paleoenvironmental reconstructions in the Sunda region. Review of Palaeobotany and Palynology. 279:104236.

Chevalier M. 2022. crestr: an R package to perform probabilistic climate reconstructions from palaeoecological datasets. Climate of the Past. 18(4):821–844.

Chevalier M, Davis BAS, Sommer PS, Zanon M, Carter VA, Phelps LN, Mauri A, Finsinger W. 2019. Eurasian Modern Pollen Database (former European Modern Pollen Database). PANGAEA. doi: 10.1594/PANGAEA.909130

Christenhusz MJ, Byng JW. 2016. The number of known plants species in the world and its annual increase. Phytotaxa. 261(3):201–217.

Collao-Alvarado K, Maldonado A, González L, Sandoval A, De Porras ME, Zamora A, Arancio G. 2015. Estudio de la relación polen-vegetación actual en el Norte de Chile, en el transecto Pozo Almonte-Salar de Huasco (20°15′S/69°06′O). Gayana Botánica. 72(1):125–136.

Cooremans B. 1989. Pollen production in central South Africa. Pollen et Spores. 31:61–78.

Correa-Metrio A, Bush M, Lozano-García S, Sosa-Nájera S. 2013. Millennial-scale temperature change velocity in the continental northern Neotropics. PLoS One. 8(12):e81958.

Correa-Metrio A, Bush MB, Pérez L, Schwalb A, Cabrera KR. 2011. Pollen distribution along climatic and biogeographic gradients in northern Central America. The Holocene. 21(4):681–692.

Davis BAS, Chevalier M, Sommer P, Carter VA, Finsinger W, Mauri A, Phelps LN, Zanon M, Abegglen R, Åkesson CM, et al. 2020. The Eurasian Modern Pollen Database (EMPD), version 2. Earth System Science Data. 12(4):2423–2445.

Deng Y, Horrocks M, Ogden J, Anderson S. 2006. Modern pollen–vegetation relationships along transects on the Whangapoua Estuary, Great Barrier Island, northern New Zealand. Journal of Biogeography. 33(4): 592–608.

Djamali M, Mashkour M, Akhani H, Belkacem D, Gambin B, Leydet M, Samadi N, Tengberg M, Gandouin E. 2020. Pollen analysis of present-day striped hyena (*Hyaena hyaena*) scats from central Iran: implications for dryland paleoecology and animal paleoethology. Review of Palaeobotany and Palynology. 281:104277.

Ebenezer IO, Christopher EB. 2019. The applications of pollen analysis in environmental monitoring in Akoko north-east local government area of Ondo State, Nigeria. GSC Biological and Pharmaceutical Sciences. 8(1):064–077.

Edorh TM. 1986. Végétation et pluie pollinique actuelles au Togo [unpublished thesis]. Université Aix-Marseille III; p. 146.

Edorh TM. 2023a. African Pollen Database: Togo_Edorh_1986_trans fossil pollen dataset. doi: 10.14768/APD.a3jq-k570

Edorh TM. 2023b. African Pollen Database: Togo_Edorh_unpublish_trans fossil pollen dataset. doi: 10.14768/APD.3zzx-s633

Edorh TM. 2023c. African Pollen Database: Nigeria_Edorh_unpublish_trans fossil pollen dataset. doi: 10.14768/APD.jyb2-3b03

Edorh TM, Afidegnon D. 2009. Représentation pollinique de la végétation actuelle des zones humides du sud-est du Togo. Annales des Sciences Agronomiques. 10(1):51–70.

El Ghazali GE. 2023. African Pollen Database: Sudan_ElGhazali_1998_trans fossil pollen dataset. doi: 10.14768/APD.tjet-wm31

El Ghazali GE, Moore PD. 1998. Modern lowland pollen spectra and contemporary vegetation in the eastern Sahel Vegetation Zone, Sudan. Review of Palaeobotany and Palynology. 99(3-4):235–246.

Elenga H. 1992. Végétation et climat du Congo depuis 24 000 ans B.P. Analyse palynologique de séquences sédimentaires du pays Bateke et du littoral [Thèse]. Université Aix-Marseille III; p. 238.

Elenga H. 2023a. African Pollen Database: Congo_Elenga_1992_trans fossil pollen dataset. doi: 10.14768/APD.ynj4-mw63

Elenga H. 2023b. African Pollen Database: Congo_Elenga_2000_trans fossil pollen dataset. doi: 10.14768/APD.preg-na87

Elenga H, de Namur C, Vincens A, Roux M, Schwartz D. 2000. Use of plots to define pollen–vegetation relationships in densely forested ecosystems of tropical Africa. Review of Palaeobotany and Palynology, 1-3 112:79–96.

Elliot MB. 1999. Modern pollen-vegetation relationships in Northland, New Zealand. New Zealand Journal of Botany. 37(1):131–148.

El-Moslimany AP. 1983. History of climate and vegetation in the Eastern Mediterranean and the Middle East from the Pleniglacial to the mid-Holocene [PhD thesis]. University of Washington.

Fauquette S, Guiot J, Suc J-P. 1998. A method for climatic reconstruction of the Mediterranean Pliocene using pollen data. Palaeogeography, Palaeoclimatology, Palaeoecology. 144(1-2):183–201.

Fiacconi M. 2017. Cave pollen taphonomy in Kurdish Iraq [unpublished PhD thesis]. Liverpool John Moores University; p. 198.

Fiacconi M, Hunt CO. 2017. Palynology of surface sediments from caves in the Zagros Mountains (Kurdish Iraq): patterns and processes. Review of Palaeobotany and Palynology. 239:66–76.

Fick SE, Hijmans RJ. 2017. WorldClim 2: new 1km spatial resolution climate surfaces for global land areas. International Journal of Climatology. 37(12):4302–4315.

Flantua SGA, Hooghiemstra H, Grimm EC, Behling H, Bush MB, González-Arango C, Gosling WD, Ledru M-P, Lozano-García S, Maldonado A, et al. 2015. Updated site compilation of the Latin American pollen database. Review of Palaeobotany and Palynology. 223:104–115.

Fontana SL. 2005. Coastal dune vegetation and pollen representation in south Buenos Aires Province, Argentina. Journal of Biogeography. 32(4):719–735.

Frazer H, Prieto AR, Carbonella JC. 2020. Modern pollen source and spatial distribution from surface lake sediments in the southwestern Pampa grasslands, Argentina: implications to interpret Holocene pollen records. Review of Palaeobotany and Palynology. 277:104207.

Fredoux A. 1978. Pollens et spores d'espèces actuelles et quaternaires de région périlagunaires de Côte d'Ivoire [unpublished thesis]. Université de Montpellier; p. 106.

Fredoux A. 2023. African Pollen Database: Ivory_Coast_Fredoux_1978_trans fossil pollen dataset. doi: 10.14768/APD.z0d0-2891

Fukumoto Y, Li X, Yasuda Y, Okamura M, Yamada K, Kashima K. 2015. The Holocene environmental changes in southern Indonesia reconstructed from highland caldera lake sediment in Bali Island. Quaternary International. 374:15–33.

Gaillard MJ, Githumbi E, Achoundong G, Lézine AM, Hély C, Lebamba J, Marquer L, Mazier F, Li F, Sugita S. 2021. The challenge of pollen-based quantitative reconstruction of Holocene plant cover in tropical regions: a pilot study in Cameroon. In: Runge J, Gosling W, Lézine, A-M, Scott L, editors. Quaternary vegetation dynamics. London: CRC Press; p. 183–206.

GBIF. 2024. GBIF Home Page. [accessed 2024 Mar 29]. https://www.gbif.org.

GBIF Secretariat. 2023. GBIF Backbone Taxonomy. Checklist dataset; doi: 10.15468/39omei [accessed 2024 Nov 13].

Geng R, Andreev A, Kruse S, Heim B, van Geffen F, Pestryakova L, Zakharov E, Troeva E, Shevtsova I, Li F, et al. 2022. Modern pollen assemblages from lake sediments and soil in East Siberia and relative pollen productivity estimates for major taxa. Frontiers in Ecology and Evolution. 10:837857.

Ghosh R, Bruch AA, Portmann F, Bera S, Paruya DK, Morthekai P, Ali SN. 2017. A modern pollen–climate dataset from the Darjeeling area, eastern Himalaya: assessing its potential for past climate reconstruction. Quaternary Science Reviews. 174:63–79.

Gil Romera G, Scott L, Marais E, Brook GA. 2006. Middle to late Holocene moisture changes in the desert of northwest Namibia, derived from fossil hyrax dung pollen. The Holocene. 16(8):1073–1084.

Gil Romera G, Scott L, Marais E, Brook GA. 2007. Late Holocene environmental change in the northwestern Namib Desert margin: new fossil pollen evidence from hyrax middens. Palaeogeography, Palaeoclimatology, Palaeoecology. 249(1-2):1–17.
Goldberg C, Buch H, Moseholm L, Weeke ER. 1988. Airborne pollen records in Denmark, 1977–1986. Grana. 27(3):209–217.
Green BJ, Dettmann ME, Rutherford S, Simpson RW. 2002. Airborne pollen of Brisbane, Australia: a five-year record, 1994-1999. Grana. 41(4): 242–250.
Guarín FA, Abril MAQ, Alvarez A, Fonnegra R. 2015. Atmospheric pollen and spore content in the urban area of the city of Medellin, Colombia. Hoehnea. 42(1):9–19.
Gucel S, Guvensen A, Ozturk M, Celik A. 2013. Analysis of airborne pollen fall in Nicosia (Cyprus). Environmental Monitoring and Assessment. 185(1):157–169.
Guimarães JTF, Nogueira ACR, Júnior J, Soares JL, Alves R, Kern AK. 2015. Palynology of the Middle Miocene – Pliocene Novo Remanso Formation, Central Amazonia, Brazil. Ameghiniana. 52(1):107–134.
Hamilton AC. 1972. The interpretation of pollen diagrams from highland Uganda. Palaeoecology of Africa. 7:45–150.
Hamilton AC. 2023. African Pollen Database: Uganda_Hamilton_1972_trans fossil pollen dataset. doi: 10.14768/APD.sk1x-wp74
Hedberg O. 1954. A pollen-analytical reconnaissance in Tropical East Africa. Oikos. 5(2):137–166.
Hedberg O. 2023. African Pollen Database: Kenya_Hedberg_1954_trans fossil pollen dataset. doi: 10.14768/APD.s1mb-ka02
Henga-Botsikabobe K, Ngomanda A, Oslisly R, Favier C, Muller SD, Bremond L. 2020. Modern pollen–vegetation relationships within tropical marshes of Lopé National Park (Central Gabon). Review of Palaeobotany and Palynology. 275:104168.
Henga-Botsikabobe K. 2023. African Pollen Database: Gabon_Henga_2016_trans fossil pollen dataset. doi: 10.14768/APD.4c5c-ek32
Herzschuh U, Li C, Böhmer T, Postl AK, Heim B, Andreev AA, Cao X, Wieczorek M, Ni J. 2022. LegacyPollen 1.0: a taxonomically harmonized global late Quaternary pollen dataset of 2831 records with standardized chronologies. Earth System Science Data. 14(7):3213–3227.
Hope G, Pask J. 1998. Tropical vegetational change in the late Pleistocene of New Caledonia. Palaeogeography, Palaeoclimatology, Palaeoecology. 142(1-2):1–21.
Hope G, van der Kaars S, Finn J, Zay Moe K. 2019. Holocene environmental change at Inle Lake, Shan State, Myanmar, and its implications for the regional development of agriculture. Palaeogeography, Palaeoclimatology, Palaeoecology. 523:18–29.
Horisk KE, Ivory SJ, McCorriston J, McHale M, Al Mehri A, Anderson A, Anderson RS, Al Kathiri AA. 2023. Vegetation dynamics in Dhofar, Oman, from the Late Holocene to present inferred from rock hyrax middens. Quaternary Research. 116:12–29.
Horrocks M, Ogden J. 1994. Modern pollen spectra and vegetation of Mt Hauhungatahi, central North Island, New Zealand. Journal of Biogeography. 21(6):637–649.
Hui Z, Li X, Ma Z, Xiao L, Zhang J, Chang J. 2018. Miocene pollen assemblages from the Zeku Basin, northeastern Tibetan Plateau, and their palaeoecological and palaeoaltimetric implications. Palaeogeography, Palaeoclimatology, Palaeoecology. 511:419–432.
Ivory SJ, Lézine AM, Grimm E, Williams J. 2020. Relaunching the African pollen database: abrupt change in climate and ecosystems. Past Global Changes Magazine. 28:26.
Ivory SJ, Russell J. 2016. Climate, herbivory, and fire controls on tropical African forest for the last 60ka. Quaternary Science Reviews. 148:101–114.
Jan F, Schüler L, Behling H. 2016. Vegetation and pollen along a 200-km transect in Khyber Pakhtunkhwa Province, northwestern Pakistan. Palynology. 40(3):322–342.
Jolly D. 2023. African Pollen Database: Gabon_Jolly_1996_trans fossil pollen dataset. doi: 10.14768/APD.f905-xe76
Jolly D, Bonnefille R, Burcq S, Roux M. 1996. Représentation pollinique de la forêt dense humide du Gabon, tests statistiques. Comptes rendus de l'Académie des sciences. Série 2. Sciences de la terre et des planètes. 322:63–70.
Kershaw AP. 1997. A bioclimatic analysis of early to middle Miocene Brown Coal Floras, Latrobe Valley, South-eastern Australia. Australian Journal of Botany. 45(3):373–387.
Kiared G, Bessedik M, Riding JB. 2017. The aeropalynology of Es-Sénia airport, Oran, northwest Algeria. Palynology. 41(1):121–131.
Kühl N, Gebhardt C, Litt T, Hense A. 2002. Probability density functions as botanical-climatological transfer functions for climate reconstruction. Quaternary Research. 58(3):381–392.
Laseski RA. 1983. Modern pollen data and Holocene climate change in Eastern Africa [unpublished thesis]. Brown University; p. 269.
Laseski RA. 2023a. African Pollen Database: Kenya_Laseski_1983_trans fossil pollen dataset. doi: 10.14768/APD.820v-hm58
Laseski RA. 2023b. African Pollen Database: Uganda_Laseski_1983_trans fossil pollen dataset. doi: 10.14768/APD.0ct0-b036
Latorre F, Perez CF. 1997. One year of airborne pollen sampling in Mar del Plata (Argentina). Grana. 36(1):49–53.
Leal AV, Bilbao BA. 2011. Vegetation changes during the late Holocene in morichal of the Orinoco Llanos, Venezuela. Acta Botanica Venezuelica. 34:237–256.
Leal AV, Bilbao BA, Berrio JC. 2013. A contribution to pollen rain characterization in forest-savanna mosaics of the Venezuelan Guayana and its use in vegetation reconstructions from sedimentary records. American Journal of Plant Sciences. 04(07):33–52.
Lebamba J. 2009. Relation pollen-végétation-climat actuels en Afrique centrale. Une approche numérique appliquée à la séquence Quaternaire du lac Barombi Mbo, Cameroun [Thèse]. Université Montrpellier 2; p. 253.
Lebamba J. 2023a. African Pollen Database: Gabon_Lebamba_2009S_trans fossil pollen dataset. doi: 10.14768/APD.q341-6v64
Lebamba J. 2023b. African Pollen Database: Cameroon_Lebamba_2009S_trans fossil pollen dataset. doi: 10.14768/APD.yyn3-wr51
Lebamba J, Ngomanda A, Vincens A, Jolly D, Favier C, Elenga H, Bentaleb I. 2009. Central African biomes and forest succession stages derived from modern pollen data and plant functional types. Climate of the Past. 5(3):403–429.
Ledru MP. 2002. Late Quaternary history and evolution of the cerrados as revealed by palynological records. In: Oliveira PS, Marquis RJ, editor. The Cerrados of Brazil: ecology and natural history of a Neotropical savanna. New York City: Columbia University Press; p. 33–50.
Lézine AM. 1981. Le Lac Abiyata (Ethiopie) – Palynologie et paléoclimatologie du Quaternaire récent [unpublished thesis]. Université de Bordeaux I; p. 125.
Lézine AM. 1987. Paléoenvironnements végétaux d'Afrique nord-tropicale depuis 12 000 B.P., analyse oillinique de séries sédimentaires continentales (Sénégal, Mauritanie) [Thèse]. Université Aix-Marseille II; p. 180.
Lézine AM. 2023a. African Pollen Database: Mali_Lezine_1990_trans fossil pollen dataset. doi: 10.14768/APD.0c4m-s569
Lézine AM. 2023b. African Pollen Database: Mauritania_Lezine_1990_trans fossil pollen dataset. doi: 10.14768/APD.87re-0406
Lézine AM. 2023c. African Pollen Database: Mauritania_Soulet_2005_trans fossil pollen dataset. doi: 10.14768/APD.6j2m-c182
Lézine AM. 2023d. African Pollen Database: Angola_Soulet_2005_trans fossil pollen dataset. doi: 10.14768/APD.cg8w-sr96
Lézine AM. 2023e. African Pollen Database: Algeria_Soulet_2005_trans fossil pollen dataset. doi: 10.14768/APD.cdsj-xd09
Lézine AM. 2023f. African Pollen Database: Algeria_Hoggar_Lezine fossil pollen dataset. doi: 10.14768/APD.kmfg-2b76
Lézine AM. 2023g. African Pollen Database: Cameroon_Lezine_RPP fossil pollen dataset. doi: 10.14768/APD.yah9-pb32
Lézine AM. 2023h. African Pollen Database: Cameroon_Verlhac_2018_trans fossil pollen dataset. doi: 10.14768/APD.he47-r121
Lézine AM. 2023i. African Pollen Database: Ethiopia_Lezine_1981_trans fossil pollen dataset. doi: 10.14768/APD.k3ax-n580
Lézine AM. 2023j. African Pollen Database: Oman_Lezine_S_trans fossil pollen dataset. doi: 10.14768/APD.mnq9-bf75
Lézine AM. 2023k. African Pollen Database: Yemen_Lezine_1998_trans fossil pollen dataset. doi: 10.14768/APD.rg1n-6c68
Lézine AM, Edorh TM. 1991. Modern pollen deposition in West African Sudanian environments. Review of Palaeobotany and Palynology. 67(1-2):41–58.

Lézine AM, Hooghiemstra H. 1990. Land-sea comparisons during the last glacial-interglacial transition: pollen records from West Tropical Africa. Palaeogeography, Palaeoclimatology, Palaeoecology. 79(3-4):313–331.
Lézine A-M, Robert C, Cleuziou S, Inizan M-L, Braemer F, Saliège J-F, Sylvestre F, Tiercelin J-J, Crassard R, Méry S, et al. 2010. Climate change and human occupation in the Southern Arabian lowlands during the last deglaciation and the Holocene. Global and Planetary Change. 72(4):412–428.
Lézine A-M, Saliège J-F, Robert C, Wertz F, Inizan M-L. 1998. Holocene lakes from Ramlat as-Sab'atayn (Yemen) illustrate the impact of monsoon activity in southern Arabia. Quaternary Research. 50(3):290–299.
Lopez TF. 2023. African Pollen Database: Benin_Tossous_TOTAL 2015_2017_trans fossil pollen dataset. doi: 10.14768/APD.eytd-e312
Lopez TF, Monique TG, Adéline ZR, Akpov A, Koffi A. 2017. Caractérisation Du Contenu Pollinique De L'atmosphère De La Commune d'Abomey-Calavi De 2015 À 2017. European Scientific Journal, ESJ. 13(30):417–440.
Lu KQ, Qin F, Li Y, Xie G, Li JF, Cui YM, Ferguson DK, Yao YF, Wang GH, Wang YF. 2020. A new approach to interpret vegetation and ecosystem changes through time by establishing a correlation between surface pollen and vegetation types in the eastern central Asian desert. Palaeogeography, Palaeoclimatology, Palaeoecology. 551:109762.
Lu X, Herrmann M, Mosbrugger V, Yao T, Zhu L. 2010. Airborne pollen in the Nam Co Basin and its implication for palaeoenvironmental reconstruction. Review of Palaeobotany and Palynology. 163(1-2):104–112.
Maldonado A, Betancourt JL, Latorre C, Villagran C. 2005. Pollen analyses from a 50 000-yr rodent midden series in the southern Atacama Desert (25° 30′ S). Journal of Quaternary Science. 20(5):493–507.
Maley J. 1981. Etudes palynologiques dans le bassin du Tchad et paléoclimatologie de l'Afrique Nord-Tropicale de 30.000 ans à l'époque actuelle. Travaux et Documents. 129:586.
Maley J. 2023a. African Pollen Database: Chad_Maley_80VL_trans fossil pollen dataset. doi: 10.14768/APD.qe0p-ey30
Maley J. 2023b. African Pollen Database: Chad_Maley_80S_trans fossil pollen dataset. doi: 10.14768/APD.c6bx-w448
Maley J. 2023c. African Pollen Database: Ghana_Maley_1983_trans fossil pollen dataset. doi: 10.14768/APD.9gga-7570
Maley J, Livingstone DA. 1983. Extension d'un élément montagnard dans le sud du Ghana (Afrique de l'Ouest) au Pléostocène supérieur et à l'Holocène inférieur: premières données polliniques. Comptes Rendus de l'Académie des Sciences, Paris – Série II. 296:1287–1292.
Mancini MV. 1993. Recent pollen spectra from forest and steppe of South Argentina: a comparison with vegetation and climate data. Review of Palaeobotany and Palynology. 77(1-2):129–142.
Mander L, Jaramillo C, Oboh-Ikuenobe F. 2023. Descriptive systematics of Upper Palaeocene–Lower Eocene pollen and spores from the northern Niger Delta, south-eastern Nigeria. Palynology. 47(3):2200525.
Marais E, Scott L, Gil-Romera G, Carrión JS. 2015. The potential of palynology in fossil bat-dung from Arnhem Cave, Namibia. Transactions of the Royal Society of South Africa. 70(2):109–115.
Masciadri S, Stutz S, García-Rodríguez F. 2013. Modern pollen–vegetation relationship of plant communities in the Uruguayan Atlantic coast. Brazilian Journal of Botany. 36(1):31–44.
McCoy J, Gibson ME, Hocking EP, O'Keefe JM, Riding JB, Roberts R, Campbell S, Abbott GD, Pound MJ. 2024. Temperate to tropical palaeoclimates on the northwest margin of Europe during the middle Cenozoic. Palaeontologia Electronica. 27:1–66.
McGlone MS, Meurk CD. 2000. Modern pollen rain, subantarctic Campbell Island, New Zealand. New Zealand Journal of Ecology. 24: 181–194.
McGlone MS, Moar NT. 1997. Pollen-vegetation relationships on the subantarctic Auckland Islands, New Zealand. Review of Palaeobotany and Palynology. 96(3-4):317–338.
Medeanic S. 2004. The distribution of palynomorphs in the superficial sediments on the margin of the Patos lagoon estuary, RS, Brazil, as compared with the actual vegetation. Iheringia, Série Botânica. 59: 183–200.
Mittre V, Sharma C.1977. Pollen analytical studies at the Nal Lake (Nalsarovar), Gujarat. Journal of Palaeosciences. 26(1–3):95–104.
Mohammed MU. 1992. Paléoenvironnement et paléoclimatologie des dern iers millénaires en Ethiopie. Contribution palynologique [Thèse de doctorat]. University of Aix-Marseille III; p. 221.
Mohammed MU. 2023a. African Pollen Database: Ethiopia_Mohammed_1992_trans fossil pollen dataset. doi: 10.14768/APD.22s7-af61
Mohammed MU. 2023b. African Pollen Database: Ethiopie_Mohammed_1997_trans fossil pollen dataset. doi: 10.14768/APD.p2h0-6d12
Mohammed MU, Kaniewski D, Renault-Miskovsky J. 2004. Etude palynologique du site de Fejej FJ-1. In: de Lumley H, Beyene Y, editors. Les sites préhistoriques de la région de Fejej, Sud-Omo, Ethiopie, dans leur contexte stratigraphique et paléontologique. Paris: Association pour la Diffusion de la Pensée Française, Editions Recherche sur les Civilisations; p. 173–202.
Nguyen CTT, Moss P, Wasson RJ, Stewart P, Ziegler AD. 2022. Environmental change since the Last Glacial Maximum: palaeo-evidence from the Nee Soon Freshwater Swamp Forest, Singapore. Journal of Quaternary Science. 37(4):707–719.
Njokuocha RC. 2006. Airborne pollen grains in Nsukka, Nigeria. Grana. 45(1):73–80.
Olatoyan JO, Neumann FH, Orijemie EA, Sievers C, Evans M, Hattingh T, Schoeman MH. 2023. Modern pollen-and phytolith-vegetation relationships at a wetland in northeastern South Africa. South African Journal of Botany. 161:780–796.
Ortega Rosas CI, Calderón-Ezquerro MDC, Gutiérrez-Ruacho OG. 2020. Fungal spores and pollen are correlated with meteorological variables: effects in human health at Hermosillo, Sonora, Mexico. International Journal of Environmental Health Research. 30(6):677–695.
Ortega Rosas CI, Peñalba MC, Guiot J. 2008. Holocene altitudinal shifts in vegetation belts and environmental changes in the Sierra Madre Occidental, Northwestern Mexico, based on modern and fossil pollen data. Review of Palaeobotany and Palynology. 151(1-2):1–20.
Ortuño T, Ledru MP, Cheddadi R, Kuentz A, Favier C, Beck S. 2011. Modern pollen rain, vegetation and climate in Bolivian ecoregions. Review of Palaeobotany and Palynology. 165(1-2):61–74.
Palacios LP. 2011. Cambios en la vegetación y en el clima en áreas estuarinas del norte del caribe Colombiano [doctoral dissertation, master thesis]. Bogotá (Colombia): Universidad Nacional de Colombia.
Pandey S, Minckley TA. 2019. Modern pollen–vegetation studies from the Sajnekhali Island Wildlife Sanctuary, Sundarbans, Eastern India. Palynology. 43(2):213–222.
Pearson S. 1997. Stick-nest rat middens as a source of palaeo-environmental data in central Australia [unpublished PhD thesis]. Sydney: UNSW; p. 314.
Penny D. 2001. A 40,000 year palynological record from north-east Thailand; implications for biogeography and palaeo-environmental reconstruction. Palaeogeography, Palaeoclimatology, Palaeoecology. 171(3-4):97–128.
Penny D, Pottier C, Fletcher R, Barbetti M, Fink D, Hua Q. 2006. Vegetation and land-use at Angkor, Cambodia: a dated pollen sequence from the Bakong temple moat. Antiquity. 80(309):599–614.
Pereira EDLÁ, Torres GR, Lupo LC, Kulemeyer JJ. 2018. Pollen assemblages of surface sediments from the North of the Argentine Chaco region. Revista de Biología Tropical. 66:1754–1768.
Perveen A, Qaiser M, Sad-Ul-Islam M. 2007. Airborne pollen survey of Karachi and adjacent areas in relation to allergy. World Applied Sciences Journal. 2:289–298.
Perveen A, Zeb S, Khan M, Qaiser M. 2014. Seasonal fluctuations of airborne pollen grains count and its correlation with climatic factors from Khairpur, Sindh, Pakistan. Pakistan Journal of Botany. 46:299–306.
Pilie M, Gibson ME, Romero IC, Nuñez Otaño NB, Pound MJ, O'Keefe JMK, Warny S. 2023. Miocene Climatic Optimum fungal record and plant-based CREST climatic reconstruction from southern McMurdo Sound, Antarctica. Journal of Micropalaeontology. 42(2):291–307.
Pinar NM, Şakiyan N, İnceoğlu Ö, Kaplan A. 1999. A one-year aeropalynological study at Ankara, Turkey. Aerobiologia. 15(4):307–310.
Pocknall DT. 1982. Modern pollen spectra from mountain localities, South Island, New Zealand. New Zealand Journal of Botany. 20(4): 361–371.

Prasad N, Quamar MF. 2023. Modern pollen–vegetation relationship from the Mahasamund District (Chhattisgarh), central India: implications for palaeoecological reconstruction. Grana. 62(5-6):317–330.
Punwong P, Englong A, Marchant R, Jirapinyakul A, Suttiwong A, Chirawatkul P, Chotikarn P, Pumijumnong N, Yuttithum M, Maprasop P, et al. 2024. A multi-proxy reconstruction of the late Holocene vegetation dynamics in Krabi mangroves, Thailand Andaman Sea. Quaternary Science Advances. 13:100133.
Quamar MF, Ali SN, Pandita SK, Singh Y. 2018. Modern pollen assemblages from Reasi (Jammu and Kashmir), India: a tool for interpreting fossil pollen records. Grana. 57(5):364–376.
Quamar MF, Stivrins N. 2021. Modern pollen and non-pollen palynomorphs along an altitudinal transect in Jammu and Kashmir (Western Himalaya), India. Palynology. 45(4):669–684.
Randall PM. 1990. A study of modern pollen deposition, Southern Alps, South Island, New Zealand. Review of Palaeobotany and Palynology. 64(1-4):263–272.
Reese CA, Liu KB. 2005. A modern pollen rain study from the central Andes region of South America. Journal of Biogeography. 32(4):709–718.
Reis LS, Guimarães JTF, Yao Q, de Sá CYG, De Oliveira PE. 2023. Modern pollen spectra from bat guano deposits in southeastern Amazonia. Review of Palaeobotany and Palynology. 318:104983.
Reynaud I. 1991. Introduction à l'étude des relations Homme-Milieu naturel dans les forêts du Cameroun. Etude palynologique des sédiments du lac Ossa au cours des derniers siècles. Mémoire de DEA, Université Montpellier II. https://doi.org/10.14768/APD.6zaj-2x25#
Reynaud I. 2023. African Pollen Database: Cameroun_Reynaud_VL_trans fossil pollen dataset. doi: 10.14768/APD.6zaj-2x25#
Riedel N, Stebich M, Anoop A, Basavaiah N, Menzel P, Prasad S, Sachse D, Sarkar S, Wiesner M. 2015. Modern pollen vegetation relationships in a dry deciduous monsoon forest: a case study from Lonar Crater Lake, central India. Quaternary International. 371:268–279.
Ritchie JC. 1986. Modern pollen spectra from Dakhleh Oasis, Western Egyptian Desert. Grana. 25(3):177–182.
Ritchie JC. 2023. African Pollen Database: Egypt_Ritchie_1987_trans fossil pollen dataset. doi: 10.14768/APD.tp0q-v621
Rodríguez-de la Cruz D, Sánchez-Reyes E, Dávila-González I, Lorente-Toledano F, Sánchez-Sánchez J. 2010. Airborne pollen calendar of Salamanca, Spain, 2000–2007. Allergologia et Immunopathologia. 38(6):307–312.
Rucina SM. 2000. Pollen vegetation relationships in the Aberdare Mountains, Kenya [Msc thesis]. Aberystwyth: University of Wales; p. 108.
Rucina SM. 2023. African Pollen Database: Kenya_Rucina_2000_trans fossil pollen dataset. doi: 10.14768/APD.h95p-6q76
Saad SI. 2023. African Pollen Database: Egypt_Saad_1967_trans fossil pollen dataset. doi: 10.14768/APD.5k4g-8813
Saad SI, Sami S. 1967. Studies of pollen and spores content of Nile Delta deposits (Berenbal region). Pollen et Spores. 9:467–503.
Saeidi Ghavi Andam S, Djamali M, Nelle O, Naderi Beni A, Haghighifard M, Brisset E, Poschlod P. 2021. Vegetation history of the Maharlou Lake basin (SW Iran) with special reference to the Achaemenid period (550–330 BC). Vegetation History and Archaeobotany. 30(5):595–610.
Salzmann U. 1999. Zur holozänen vegetations- und klimaentwicklung der westafrikanischen savannen Paläoökologische untersuchungen in der Sahel- und Sudanzone NO-Nigerias [PhD thesis]. Frankfurt (Germany): University of Wuerzburg; p. 144.
Schüler L, Hemp A, Behling H. 2014. Relationship between vegetation and modern pollen-rain along an elevational gradient on Kilimanjaro, Tanzania. The Holocene. 24(6):702–713.
Scott L. 1976. Preliminary palynological results from the Alexandersfontein Basin near Kimberley. Annals of the South African Museum. 71:73–189.
Scott L. 1982. A Late Quaternary pollen record from the Transvaal bushveld, South Africa. Quaternary Research. 17(3):339–370.
Scott L. 1985. Palynological indications of the Quaternary vegetation history of Marion Island (sub-Antarctic). Journal of Biogeography. 12(5): 413–431.
Scott L. 1987. Pollen analysis of hyena coprolites and sediments from Equus Cave, Taung, Southern Kalahari (S. Africa). Quaternary Research. 28(1):144–156.
Scott L. 1988. Holocene environmental change at western Orange Free State pans, South Africa, inferred from pollen analysis. Palaeoecology of Africa. 19:109–118.
Scott L. 1989. Late Quaternary vegetation history and climatic change in the eastern Orange Free State, South Africa. South African Journal of Botany. 55(1):107–116.
Scott L. 1995. Pollen evidence for vegetational and climate change during the Neogene and Quaternary in Southern Africa. In: Vrba E, Denton G, Partridge TC, Burckle LH, editors. Paleoclimate and evolution with emphasis on human origins. New Haven (CT): Yale University Press; p. 65–76.
Scott L. 1996. Palynology of hyrax middens: 2000 years of palaeo-environmental history in Namibia. Quaternary International. 33:73–79.
Scott L. 1999. Palynological analysis of the Pretoria Saltpan (Tswaing Crater) sediments and vegetation history in the Bushveld savanna biome, South Africa. In: Partridge TC, editor. Tswaing – investigations into the origin, age and palaeoenvironments of the Pretoria Saltpan. Pretoria (South Africa): Council for Geosciences; p. 143–166.
Scott L, Bonnefille R. 1986. A search for pollen from the hominid deposits of Kromdraai, Sterkfontein and Swartkrans: some problems and preliminary results. South African Journal of Science. 82:380–382.
Scott L, Bousman CB. 1990. Palynological analysis of hyrax middens from southern Africa. Palaeogeography, Palaeoclimatology, Palaeoecology. 76(3-4):367–379.
Scott L, Brink JS. 1992. Quaternary palaeoenvironments of pans in central South Africa: palynological and palaeontological evidence. South African Geographer. 19:22–34.
Scott L, Cooremans B. 1990. Late Quaternary pollen from a hot spring in the upper Orange River Basin, South Africa. South African Journal of Science. 86:154–156.
Scott L, Cooremans B. 1992. Pollen in recent *Procavia* (hyrax), *Petromus* (dassie rat) and bird dung in South Africa. Journal of Biogeography. 19(2):205–215.
Scott L, Cooremans B, Maud RR. 1992. Preliminary palynological evaluation of the Port Durnford Formation at Port Durnford, Natal coast, South Africa. South African Journal of Sciences. 88:470–474.
Scott L, Fernandez-Jalvo Y, Carrion JS, Brink JS. 2003. Preservation and interpretation of pollen in hyena corprolites: taphonomical observations from Spain and Southern Africa. Palaeontologia Africana. 39:83–91.
Scott L, Marais E, Brook GA. 2004. Fossil hyrax dung and evidence of Late Pleistocene and Holocene vegetation types in the Namib Desert. Journal of Quaternary Science. 19(8):829–832.
Scott L, Woodborne S. 2007. Pollen analysis and dating of Late Quaternary faecal deposits (hyraceum) in the Cederberg, Western Cape, South Africa. Review of Palaeobotany and Palynology. 144(3-4): 123–134.
Selkirk DR, Selkirk PM, Bergstrom DM, Adamson DA. 1988. Ridge top peats and palaeolake deposits on Macquarie Island. Papers and Proceedings of The Royal Society of Tasmania. 122(1):83–90.
Selkirk DR, Selkirk PM, Griffin K. 1982. Palynological evidence for Holocene environmental change and uplift on Wireless Hill, Macquarie Island. Proceedings of the Linnean Society of New South Wales. 107:1–17.
Semeniuk C, Milne L, Ladd P, Semeniuk V. 2006. Pollen in the surface sediments of wetlands in the Becher Point area, southwestern Australia: a baseline for use in interpreting Holocene sequences. Journal of the Royal Society of Western Australia. 89:27–43.
Semeniuk V, Milne LA, Waterhouse H. 2000. Contemporary and subrecent pollen record for the Leschenault Inlet estuary: towards a palynological baseline. Journal of the Royal Society of Western Australia. 83:335.
Singh G, Joshi RD, Chopra SK, Singh AB. 1974. Late Quaternary history of vegetation and climate of the Rajasthan Desert, India. Philosophical Transactions of the Royal Society of London. B, Biological Sciences. 267:467–501.

Stevenson J, Haberle SG, Johnston FH, Bowman DM. 2007. Seasonal distribution of pollen in the atmosphere of Darwin, tropical Australia: preliminary results. Grana. 46(1):34–42.
Straka H. 1991. Palynologia Madagassica et Mascarenica. 2nd partie. Echantillons de surface. Akademie der Wissenschaften und der Litteratur. Stuttgart (Germany): Mainz, Franz Steiner Verlag; p. 43.
Sugden JM. 1989. Late Quaternary Palaeoecology of the central and marginal uplands of the Karoo, South Africa [unpublished PhD thesis]. Cape Town (South Africa): University of Cape Town.
Sugden JM. 2023. African Pollen Database: SouthAfrica_Sugden_1989_trans fossil pollen dataset. doi: 10.14768/APD.4d9k-fd85
Tng DYP, Hopf F, Haberle SG, Bowman DMJS. 2010. Seasonal pollen distribution in the atmosphere of Hobart, Tasmania: preliminary observations and congruence with flowering phenology. Australian Journal of Botany. 58(6):440–452.
Tossou MG. 2002. Recherche palynologique sur la végétation Holocène du Sud-Bénin (Afrique de l'Ouest) [Thèse]. Togo: Université de Lome; p. 133.
Tossou MG. 2023. African Pollen Database: Benin_Tossou_2002_trans fossil pollen dataset. doi: 10.14768/APD.t5vs-jm52
Urrego DH, Silman MR, Correa-Metrio A, Bush MB. 2011. Pollen–vegetation relationships along steep climatic gradients in western Amazonia. Journal of Vegetation Science. 22(5):795–806.
Utescher T, Bruch AA, Erdei B, François L, Ivanov D, Jacques FMB, Kern AK, Liu YS, Mosbrugger V, Spicer RA. 2014. The coexistence approach – theoretical background and practical considerations of using plant fossils for climate quantification. Palaeogeography, Palaeoclimatology, Palaeoecology. 410:58–73.
Valencia BG, Urrego DH, Silman MR, Bush MB. 2010. From ice age to modern: a record of landscape change in an Andean cloud forest. Journal of Biogeography. 37(9):1637–1647.
Van Zinderen Bakker EM. 1984. Palynological evidence for late Cenozoic arid conditions along the Namibia coast from Holes 532 and 530A, Leg 75, Deep Sea Drilling Project. Initial Reports of the Deep Sea Drilling Project. 75:763–768.
Van Zinderen Bakker EM, Müller M. 1987. Pollen studies in the Namib desert. Pollen et Spores. 29:185–206.
Verlhac L, Izumi K, Lézine AM, Lemonnier K, Buchet G, Achoundong G, Tchiengué B. 2018. Altitudinal distribution of pollen, plants and biomes in the Cameroon highlands. Review of Palaeobotany and Palynology. 259:21–28.
Vincens A. 1982. Palynologie des environnements actuels et Plio-Pléistocène à l'Est du Lac Turkana (Kenya) [Unpublished thesis]. Université Aix-Marseille II; p. 244.
Vincens A. 1987. Recent pollen sedimentation in Lake Natron, Tanzania: a model for the interpretation of fossil spectra in arid region. Sédimentation pollinique actuelle dans le lac Natron, Tanzanie: un modèle pour l'interprétation de spectres fossiles en région aride. Sciences Géologiques. Bulletin. 40(1):155–165.
Vincens A. 2023a. African Pollen Database: Kenya_Vincens_2006_trans fossil pollen dataset. doi: 10.14768/APD.1k5d-pe40
Vincens A. 2023b. African Pollen Database: Kenya_Vincens_1982_trans fossil pollen dataset. doi: 10.14768/APD.ved9-eh88
Vincens A. 2023c. African Pollen Database: Tanzania_Vincens_2006_trans fossil pollen dataset. doi: 10.14768/APD.1kbe-k532
Vincens A. 2023d. African Pollen Database: Tanzania_Vincens_1987_NATVL_trans fossil pollen dataset. doi: 10.14768/APD.6egx-4b93
Vincens A. 2023e. African Pollen Database: Cameroon_Vincens_2000_trans fossil pollen dataset. doi: 10.14768/APD.gqbd-4309
Vincens A, Bremond L, Brewer S, Buchet G, Dussouillez P. 2006a. Modern pollen-based biome reconstructions in East Africa expanded to southern Tanzania. Review of Palaeobotany and Palynology. 140(3-4):187–212.
Vincens A, Dubois MA, Guillet B, Achoundong G, Buchet G, Beyala VKK, De Namur C, Riera B. 2000. Pollen-rain–vegetation relationships along a forest–savanna transect in southeastern Cameroon. Review of Palaeobotany and Palynology. 110(3-4):191–208.
Vincens A, Tiercelin JJ, Buchet G. 2006b. New Oligocene–early Miocene microflora from the southwestern Turkana Basin: palaeoenvironmental implications in the northern Kenya Rift. Palaeogeography, Palaeoclimatology, Palaeoecology. 239(3-4):470–486.
Wang Q, Li Y, Ferguson DK, Mo W-B, Yang N. 2021. An equable subtropical climate throughout China in the Miocene based on palaeofloral evidence. Earth-Science Reviews. 218:103649.
Weng C, Bush MB, Silman MR. 2004. An analysis of modern pollen rain on an elevational gradient in southern Peru. Journal of Tropical Ecology. 20(01):113–124.
Whitmore J, Gajewski K, Sawada M, Williams JW, Shuman B, Bartlein PJ, Minckley T, Viau AE, Webb IT, Shafer S, et al. 2005. Modern pollen data from North American and Greenland for multi-scale paleoenvironmental applications. Quaternary Science Reviews. 24(16-17):1828–1848.
Williams JW, Grimm EC, Blois JL, Charles DF, Davis EB, Goring SJ, Graham RW, Smith AJ, Anderson M, Arroyo-Cabrales J, et al. 2018. The Neotoma Paleoecology Database, a multiproxy, international, community-curated data resource. Quaternary Research. 89(1):156–177.
Ybert J-P. 1977. Les pollens atmosphériques en Côte d'Ivoire et au Tchad. Unpublished report. p. 20.
Ybert J-P. 2023a. African Pollen Database: Ivory_Coast_Ybert_TOTAL YEAR_1977_trans fossil pollen dataset. doi: 10.14768/APD.k88h-3368
Ybert J-P. 2023b. African Pollen Database: Chad_Ybert_TOTAL YEAR_1977_trans fossil pollen dataset. doi: 10.14768/APD.b4hn-n927
Young SB, Schofield EK. 1973a. Palynological evidence for the late glacial occurrence of Pringlea and Lyallia on Kerguelen Islands. Rhodora. 75: 239–247.
Young SB, Schofield EK. 1973b. Pollen evidence for Late Quaternary climate changes on Kerguelen Islands. Nature. 245(5424):311–312.
Yulianto E, Tsuji H, Sukapti WS, Tanaka N. 2005. A Holocene pollen and charcoal record from a tropical lowland swamp in Rawa Danau, West Java, Indonesia. Tropics. 14(3):271–281.