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Living fossils in the Indo-Pacific Warm Pool: A refuge for thermophilic dinoflagellates during glaciations

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SUPPLEMENTAL FIGURES

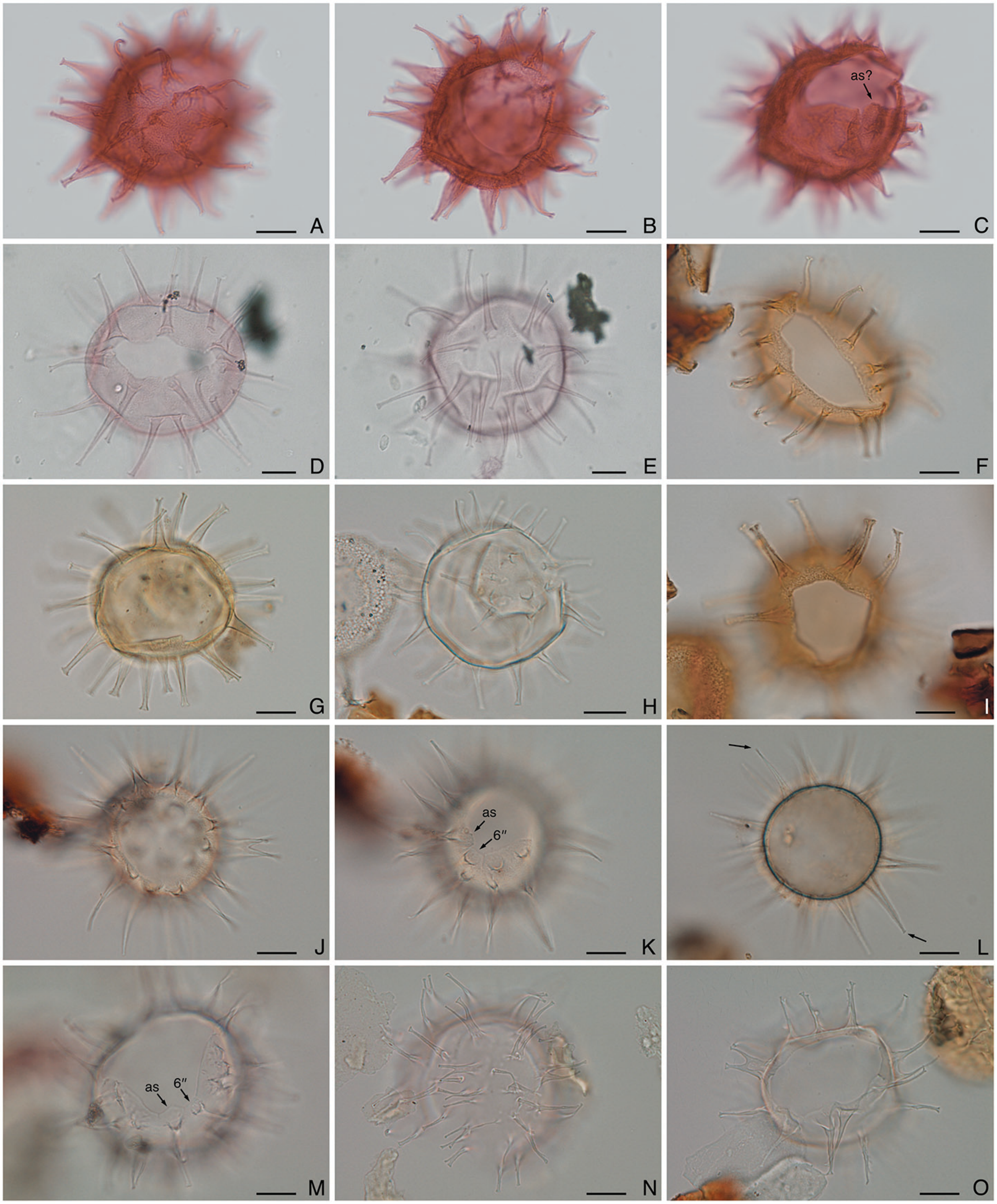
ABBREVIATIONS USED

1′–4′ = apical plates. 1″–6″ = precingular plates. c1–c6 = cingular plates. 1‴–6‴ = postcingular plates. 1⁗ = antapical plate. ap = apical pore. as = anterior sulcal plate. ams = anterior median sulcal plate. ras = right accessory plate. rs = right sulcal plate. ls = left sulcal plate. ps = posterior sulcal plate. 1p = posterior intercalary plate.

TAXONOMIC NAMES CITED

- *Dapsilidinium pastielsii* (Davey and Williams, 1966) Bujak et al., 1980
- *Dapsilidinium pseudocolligerum* (Stover, 1977) Bujak et al., 1980 [Here treated as a junior synonym of *Dapsilidinium pastielsii*]
- Genus *Diphyes* Cookson, 1965
- Genus *Hystrichokolpoma* Klumpp, 1953

Figure DR1 (overleaf). Fossil cysts of *Dapsilidinium pastielsii*. (A–C) Holotype from the lower Eocene of southern England (sample Sh.4, taken 80 feet below the contact of the London Clay with the overlying Bagshot Sands; Williams and Downie, 1966, fig. 7). (A) High focus on antapical surface. (B) Mid-focus showing processes. (C) Low focus on apical archeopyle. (D, E) Holotype of *D. pseudocolligerum* from the middle Oligocene of the continental shelf off South Carolina (Stover, 1977), treated here as a morphological variant of *D. pastielsii*. (D) High focus on apical surface showing archeopyle. (E) Low focus on antapical surface. (F) Specimen from the upper Eocene of Virginia (Edwards et al., 2009). (G) Specimen from the lower Rupelian of Belgium (De Coninck, 1999), (H) Specimen from the lower Oligocene of Florida (Brewster-Wingard et al., 1997). (I) Specimen from the lower Oligocene of Virginia (Edwards et al., 2009) showing archeopyle. (J–L) Specimens from the Serravalian of the Porcupine Basin (Louwye et al., 2008), where (J, K) are upper and lower foci of the same specimen. (M–N) Specimens from



the lower Pleistocene of the Bahamas (Head and Westphal, 1999). See Table DR2 for details. Note (C, K, N) the characteristic geniculate margin of the anterior sulcal (as) plate and rectilinear margin of plate 6″, and (L) the presence of extremely tapered processes. All scale bars = 10 µm.

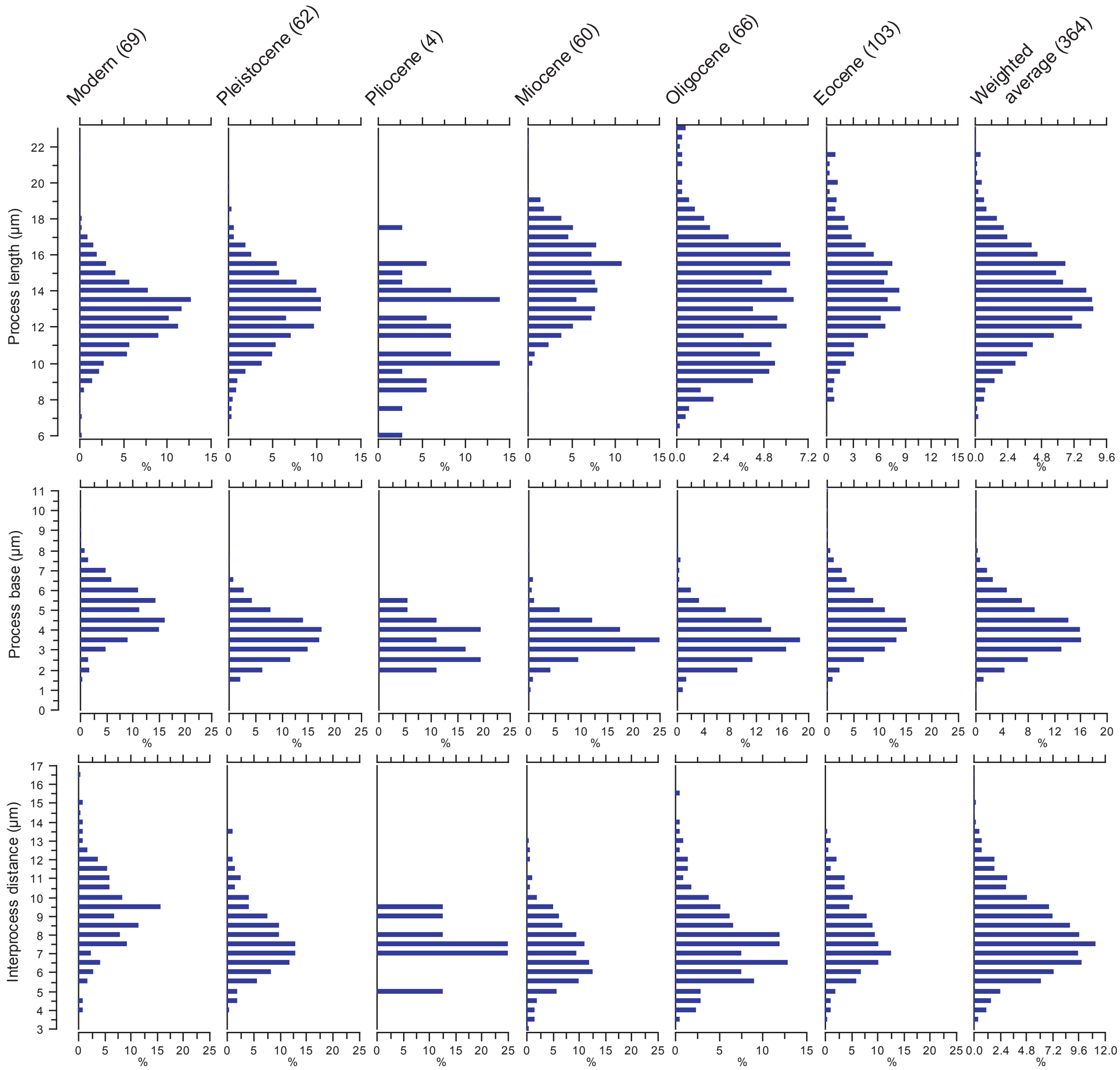


Figure DR2. Size-frequency curves for process length (µm), process base (µm), and distance between processes (µm) for modern, Pleistocene, Pliocene, Miocene, Oligocene, and Eocene specimens of *Dapsilidinium pastielsii*. The curves on the far right are weighted averages calculated from all the data.

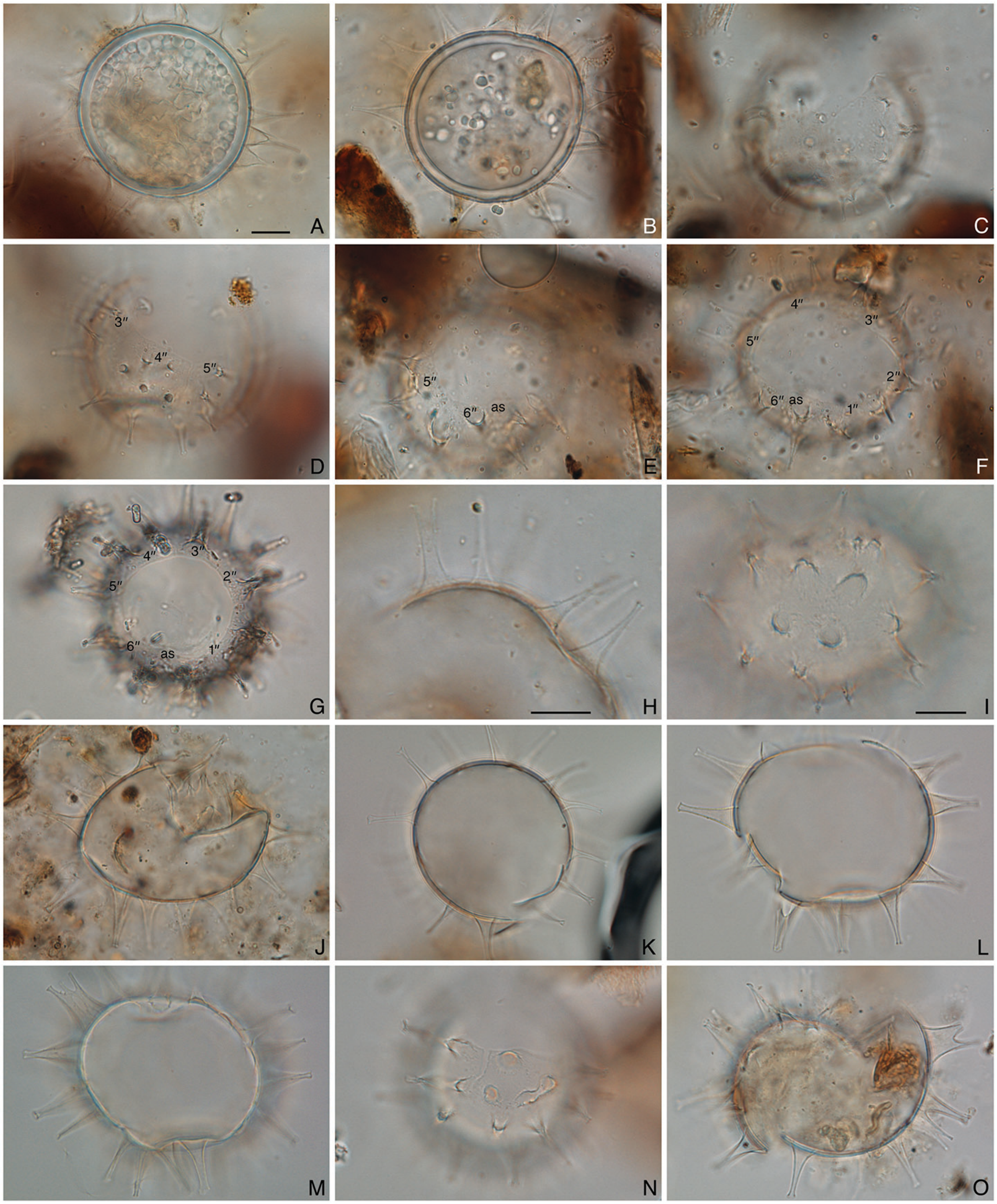


Figure DR3. Modern cysts of *Dapsilidinium pastielsii.* (A–I) Cysts used in germination experiments from Station 1, Shioya Bay, Okinawa, Japan. (A, B) Cysts with cell contents, (B) showing ovoidal shape. (C–F) Specimen photographed in different orientations to show details of the archeopyle. (G) Different specimen with pronounced archeopyle from Shioya Bay. (H)

Process structure of another specimen showing presence of surface granules. (I) Presence of elongate claustra on process bases. (J) Specimen from Ambon. (K–N) Specimens from Masinloc. (O) Specimen from Palau. All scale bars = 10 µm, where scale bar for A applies to all others except H, I.

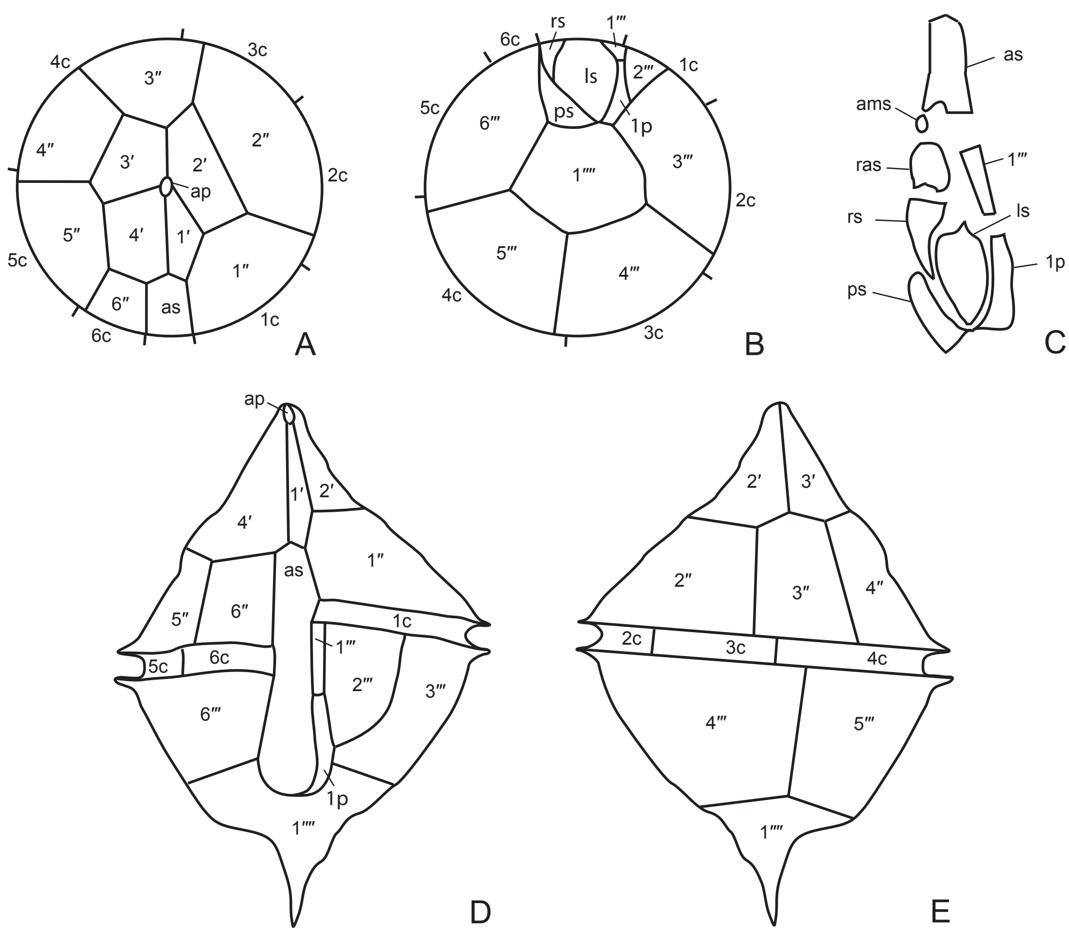


Figure DR4. Schematic tabulation of the motile stage of *Dapsilidinium pastielsii*. (A) Apical view. (B) Antapical view. (C) Sulcal plates. (D) Ventral view (sulcal plates not drawn). (E) Dorsal view. Note contact between 4′ and the anterior sulcal (as) plate, an unusual topology for cribroperidinioideans but shared with the genera *Diphyes* and *Hystrichokolpoma*.

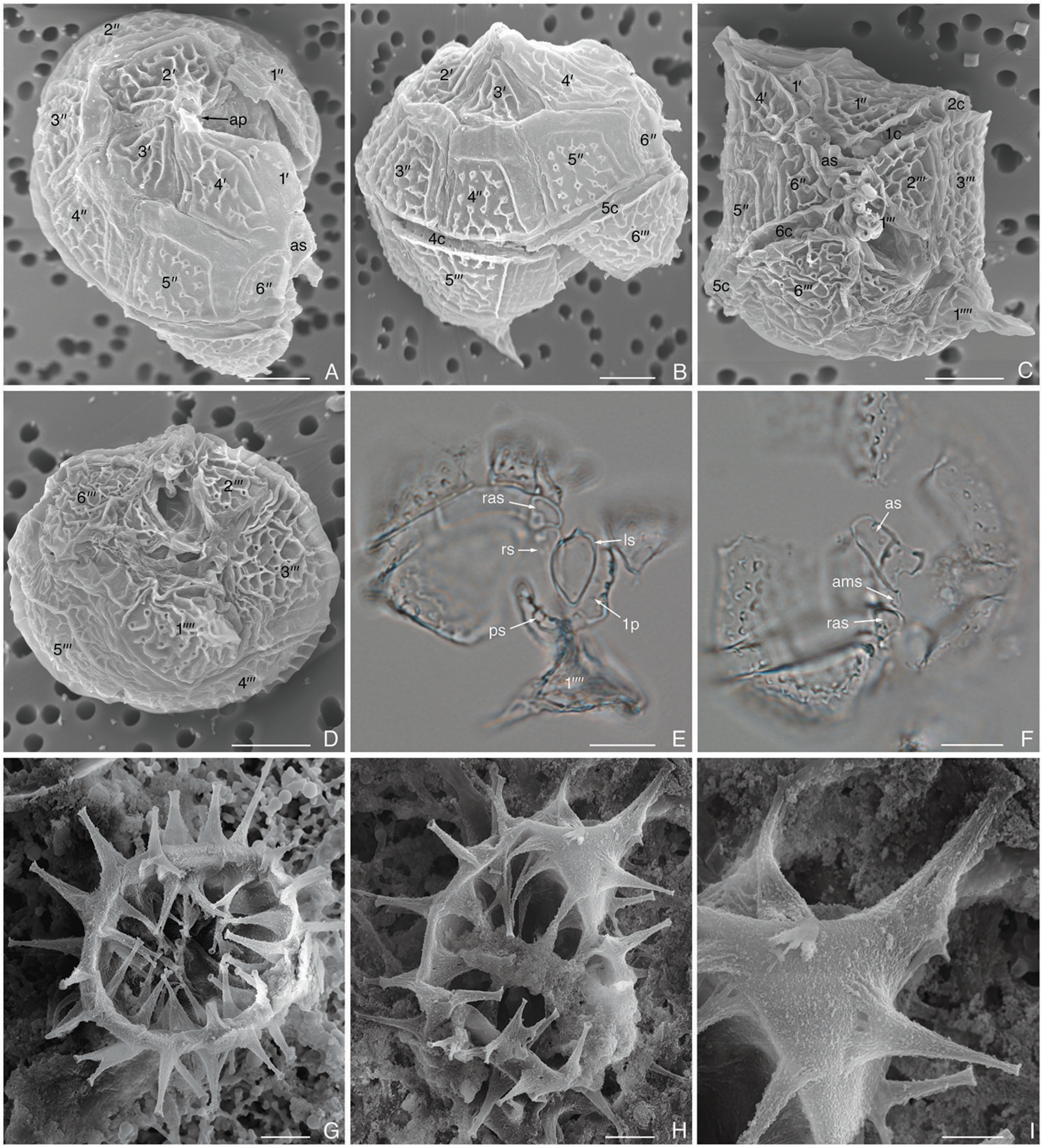


Figure DR5. *Dapsilidinium pastielsii* motile cell used for sequencing, and modern cysts from Station 1, Shioya Bay, Okinawa, Japan. (A–D) SEM images of motile cell germinated from cyst. (E–F) Light microscope image of motile cell dissected to observe the sulcal plates. (G–I) SEM images of modern cysts. Scale bars = 10 µm for A–H, and 5 µm for I.

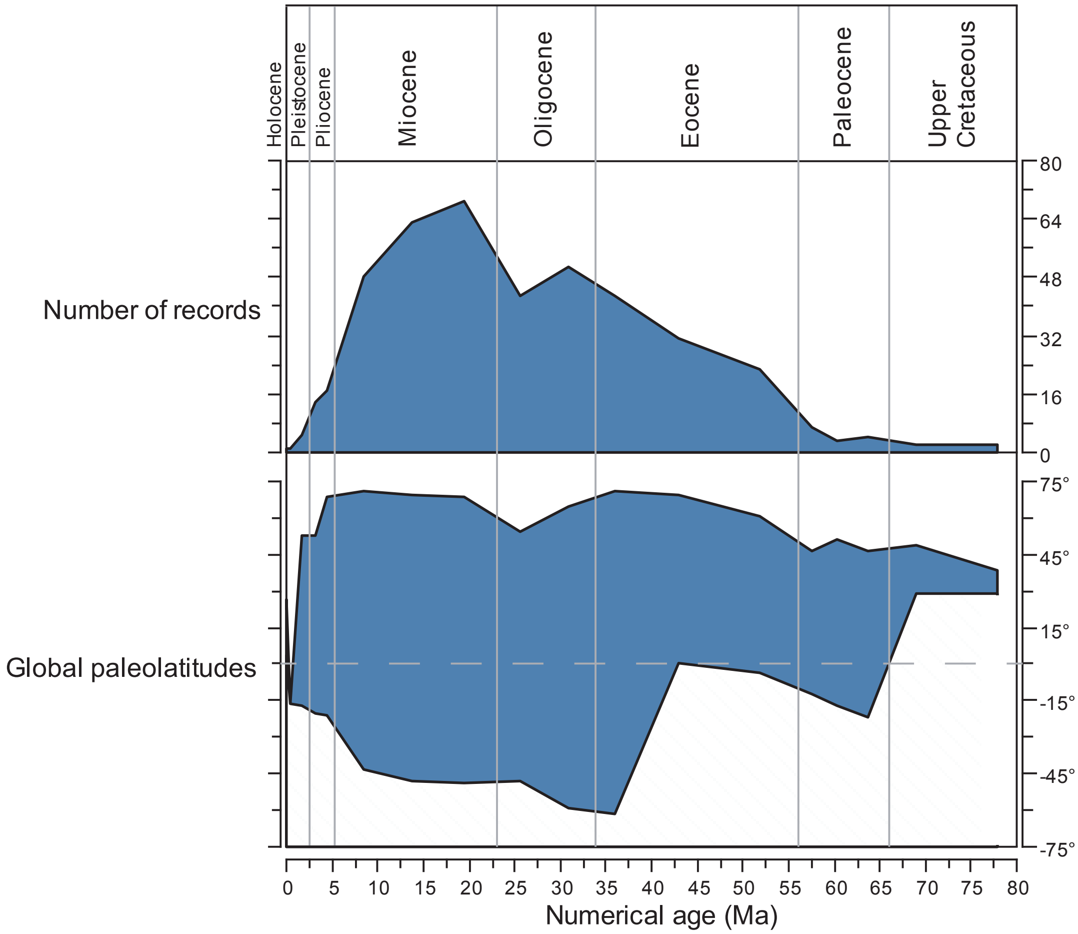


Figure DR6. Numerical age in million years before present (Ma) versus number of records in the literature for *Dapsilidinium pastielsii* (including the junior synonym, *Dapsilidinium pseudocolligerum*) and range of paleolatitudes based on occurrences in the literature. Numerical age is based on ages of the International Chronostratigraphic Chart of January, 2013. Paleolatitudes are calculated by rotating back to their paleo-locations utilizing the GPlates software (www.gplates.org) and the plate model of Seton et al. (2012).

SUPPLEMENTAL TABLES

Table DR1. Details of sampling locations for modern surface-sediment samples.

Location	Station name	Latitude	Longitude	Water depth (m)	Sampling date	Sampling device
Ambon Bay, Indonesia	LC 0–2 cm	3.6519°S	128.2072°E	26.0	11 Dec, 1995	Pushcore
Masinloc, Philippines	St. 1	15.5568°N	119.9365°E	12.3	18 Feb, 1992	TFO corer
Koror, Palau	St. 55	7.3393°N	134.4837°E	3.5	Dec, 1996	TFO corer
Shioya Bay, Okinawa, Japan	St. 1	26.6593°N	128.1197°E	8.9	10 Feb, 2011	TFO corer
Shioya Bay, Okinawa, Japan	St. 3	26.6673°N	128.1060°E	13.6	10 Feb, 2011	TFO corer
East Vietnam Sea, Vietnam	18409-1 0–1 cm	15.6868°N	108.6798°E	40.0	April, 1999	Giant box corer

Table DR2. Details of samples used for the morphological study of *Dapsilidinium pastielsii* from the Eocene through lower Pleistocene.

Age	Locality	Sample name	Reference
Lower Pleistocene	The Clino Core, Bahamas	M8	Head and Westphal (1999)
Lower Pleistocene	The Clino Core, Bahamas	M9	Head and Westphal (1999)
Lower Pleistocene	The Clino Core, Bahamas	K12	Head and Westphal (1999)
Lower Pleistocene	The Clino Core, Bahamas	M7-3	Head and Westphal (1999)
Lower Pleistocene	The Clino Core, Bahamas	CGS-1	Head and Westphal (1999)
Lower Pleistocene	The Clino Core, Bahamas	K11	Head and Westphal (1999)
Upper lower Pliocene	The Clino Core, Bahamas	M3-2	Head and Westphal (1999)
Upper lower Pliocene	The Clino Core, Bahamas	K6-2	Head and Westphal (1999)
Upper lower Pliocene	The Clino Core, Bahamas	M1-4	Head and Westphal (1999)
Upper lower Pliocene	The Clino Core, Bahamas	M2-2	Head and Westphal (1999)
Langhian–Burdigalian, lower to middle Miocene	Zonderschot sands, northern Belgium	A-G 10/1: X27-3	Louwye (2000)
Serravallian, middle Miocene	Porcupine Basin IODP Leg 307 Hole 1318B, off Ireland	97.8 m, 11H6 23-23	Louwye et al. (2008)
Serravallian, middle Miocene	Porcupine Basin IODP Leg 307 Hole 1318B, off Ireland	107.8 m, 12H6 23-25	Louwye et al. (2008)
Middle Oligocene	Blake Plateau, Corehole 5/5B, off South Carolina	Core 19, 1470 ft	Stover (1977)
Lower Rupelian, lower Oligocene	Kallo Borehole, northern Belgium	Kallo -94 m	De Coninck (1999)
Lower Rupelian, lower Oligocene	Kallo Borehole, northern Belgium	Kallo -96 m	De Coninck (1999)
Lower Rupelian, lower Oligocene	Woensdrecht borehole, northern Belgium	Woensdrecht -219 m	De Coninck (1999)
Lower Rupelian, lower Oligocene	Mol Borehole, northern Belgium	Mol -281.2 m	De Coninck (1999)
Lower Rupelian, lower Oligocene	Grimmertingen borehole, northern Belgium	Grimmeringen -3.3 m	De Coninck (1999)
Lower Rupelian, lower Oligocene	Grimmertingen borehole, northern Belgium	Grimmeringen -7.3 m	De Coninck (1999)
Lower Rupelian, lower Oligocene	Kallo borehole, northern Belgium	Kallo -112.10 m	De Coninck (2001)
Lower Oligocene	Suwannee Limestone, Highlands County, Florida, USA	R4677 AB (4)	Brewster-Wingard et al. (1997)
Lower Oligocene	Drummonds Corner beds, City of Newport News, Virginia, USA	R6230 CC (4)	Edwards et al. (2010)
Chickahominy Formation, upper Eocene	Northampton County, Virginia, USA	R6467 FH (3)	Edwards et al. (2009)
Priabonian, upper Eocene	Woensdrecht borehole, Northern Belgium	Woensdrecht -250 m	De Coninck (1999)
Priabonian, upper Eocene	Woensdrecht borehole, Northern Belgium	Woensdrecht -269 m	De Coninck (1995)
Bartonian, middle Eocene	Kysing research borehole, Central Danish Basin	2653	Heilmann-Clausen & Van Simaeys (2005)
Bartonian, middle Eocene	Kallo Borehole, northern Belgium	Kallo -135.5 m	De Coninck (1995)
Bartonian, middle Eocene	Woensdrecht borehole, northern Belgium	Woensdrecht -278 m	De Coninck (1995)
Bartonian, middle Eocene	Mol Borehole, northern Belgium	Mol -290.8 m	De Coninck (1995)
Lower Bartonian, middle Eocene	Mol Borehole, northern Belgium	Mol -295 m	De Coninck (1995)
Lower Eocene	Sheppey, Kent, southeastern England	Sh.4	Davey and Williams (1966)

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