



Environment, diversity, evolution and Cope's Rule: Drivers of size in planktonic foraminifera.

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Within the marine fossil record, size is a fundamental trait providing information on both assemblages and individual species. Changes in size within an assemblage are largely driven by species composition typically related to environmental conditions. Changes in size of an individual species can be an indicator of health and whether optimal growth conditions (i.e. temperature, salinity and food availability) prevail. Over evolutionary timescales, individuals tend to increase in size (Cope's rule) also altering the average size of the population.

The Pliocene provides an excellent opportunity to look at environmental drivers and ecological responses to a warmer world, at high resolution and with extant species. A short glaciation phase, during marine isotope stage (MIS) M2, interrupted the Pliocene global warming between ~ 3.31 – 3.26 Ma. This event provides the ideal framework to quantify how biota, already adapted to warming conditions, respond to a short, but substantial cooling event.

We analysed the size and species composition of samples collected as part of the Pliocene Research, Interpretation and Synoptic Mapping (PRISM) Project from a variety of locations around the globe. The samples cover the Atlantic, Indian and Pacific oceans at a range of latitudes (e.g. DSDP Site 521, 586, 607 and ODP Site 716, 754, 887). We measured the maximum diameter of planktonic foraminifera tests with a fully automated light microscope, enabling high resolution sampling at a multitude of sites, before, during and after the MIS M2 glaciation event. On average 2000 specimens were measured per sample, resulting in over a million analyses in total. Changes in planktonic foraminiferal assemblage composition were characterised by quantifying relative species abundances and augmented by determining the largest species.

Planktonic foraminiferal assemblage size shows a general increase during the Pliocene likely related to warming temperatures. What is unclear is if this change is driven by changes in diversity due to extinction and origination, responses to environmental change or a general increase in size of species found through the record. Here we discuss reactions of species and (or) ecological groups to environmental change and determine the individual drivers of size change across the world's oceans.