

Punctuated gradualism in the earliest Eocene species *Helio-discoaster mahmoudii*

David Bord, Marie-Pierre Aubry

Department of Earth and Planetary Sciences, Rutgers University, New Brunswick, NJ

The mode and tempo of evolution of species have not yet been resolved using the fossil record. Despite their continuous record and remarkable abundance, only a few studies have used microfossils to test the models of gradual evolution (Darwin, 1859) and punctuated equilibrium (Eldredge and Gould, 1972).

We have conducted a morphometric analysis on the distinctive, short-ranged calcareous nannoplankton species *Helio-discoaster mahmoudii* that is essentially restricted to the earliest Eocene (Biochron NP9b). This is small discoaster with 5 to 7 rays that possesses two knobs, one on the proximal (concave) and one the distal (convex) face. Each knob is lobate, the number of lobes corresponding to the number of rays. The shape of the proximal knob shows a remarkable variability in the lower part of the range of the species and then stabilizes. We have conducted a morphometric analysis to describe this morphological change using specimens collected from the El Mahmiya Member of the Esna Shale Formation, exposed in the Dababiya Quarry located 35 km south of Luxor. There, *H. mahmoudii* occurs over an 18 m thick interval. Because the species is very rare in the upper part of its range, we have studied only the lower 13 m part of the range (level DBH 5.4 to DBD 9.5).

The mean diameter of the proximal knob fluctuates between 3 and 7 μm in the lower three meters of the range of the species, and then stabilizes at $\sim 5 \mu\text{m}$ for the next 10 meters. The coefficient of variation for this knob varies between 30–50 % in the lower two meters of the range of the species, and then it decreases to $\sim 15\%$ in the next meter. From there it increases and stabilizes at $\sim 20\%$. The coefficient of variation is the ratio (mean/standard deviation) representing the amount of change around the mean diameter of the proximal knob. We interpret these data as indicating high variability in the lower range of the species followed by the fixation of a morphotype. The ancestor of *H. mahmoudii* is unknown at this time but this suggests an evolutionary modality similar to that found by Malmgren et al. (1983) in the Neogene planktonic foraminiferal species *Globorotalia tumida*, a mechanism to which they referred as punctuated gradualism. The evolutionary mode of *H. mahmoudii* may reflect ecological stability following the rise of the species immediately after the environmental disruptions associated with the Paleocene/Eocene boundary.

References:

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Autor(en)/Author(s): Bord David, Aubry Marie-Pierre

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