BRAIN EVOLUTION OF EARLY PLACENTAL MAMMALS: THE IMPACT OF THE END-CRETACEOUS MASS EXTINCTION ON THE NEUROSENSORY SYSTEM OF OUR DISTANT RELATIVES

Bertrand, Ornella C.[1], Brusatte, Stephen[1], Shelley, Sarah L.[2], Wible, John R.[2], Williamson, Thomas E.[3], Chester, Stephen G.[4], Holbrook, Luke T.[5], Lyson, Tyler R.[6], Smith, Thierry[7], Meng, Jin[8]

[1]School of Geosciences, University of Edinburgh, Edinburgh, U.K., [2]Section of Mammals, Carnegie Museum of Natural History, Pittsburgh, Pennsylvania, U.S.A., [3]New Mexico Museum of Natural History and Science, Albuquerque, New Mexico, U.S.A., [4]Department of Anthropology and Archaeology, Brooklyn College, City University of New York, Brooklyn, New York, U.S.A., [5]Department of Biological Sciences, Rowan University, Glassboro, New Jersey, U.S.A., [6]Denver Museum of Nature & Science, Denver, Colorado, U.S.A., [7]Directorate Earth and History of Life, Royal Belgian Institute of Natural Sciences, Brussels, Belgium, [8]Division of Paleontology, American Museum of Natural History, New York, New York, U.S.A.

The end-Cretaceous mass extinction, 66 million years ago, profoundly reshaped the biodiversity of our planet. After likely originating in the Cretaceous, placental mammals (species giving live birth to well-developed young) survived the extinction and quickly diversified in the ensuing Paleocene. Compared to Mesozoic species, extant placentals have advanced neurosensory abilities, enabled by a proportionally large brain with an expanded neocortex. This brain construction was acquired by the Eocene, but its origins, and how its evolution relates to extinction survivorship and recovery, are unclear, because little is known about the neurosensory systems of Paleocene species. We used high-resolution computed tomography (CT) scanning to build digital brain models in 29 extinct placentals (including 23 from the Paleocene). We added these to data from the literature to construct a database of 98 taxa, from the Jurassic to the Eocene, which we assessed in a phylogenetic context. We find that the Phylogenetic Encephalization Quotient (PEQ), a measure of relative brain size, increased in the Cretaceous along branches leading to Placentalia, but then decreased in Paleocene clades (taeniodonts,phenacodontids, pantodonts, periptychids, and arctocyonids). Later, during the Eocene, the PEQ increased independently in all crown groups (e.g., euarchontoglirans and laurasiatherians). The Paleocene decline in PEQ was driven by body mass increasing much more rapidly after the extinction than brain volume. The neocortex remained small, relative to the rest of the brain, in Paleocene taxa and expanded independently in Eocene crown groups. The relative size of the olfactory bulbs, however, remained relatively stable over time, except for a major decrease in Euarchontoglires and some Eocene artiodactyls, while the petrosal lobules (associated with eye movement coordination) decreased in size in Laurasiatheria but increased in Euarchontoglires. Our results indicate that an enlarged, modern-style brain was not instrumental to the survival of placental mammal ancestors at the end-Cretaceous, nor to their radiation in the Paleocene. Instead, opening of new ecological niches post-extinction promoted the diversification of larger body sizes, while brain and neocortex sizes lagged behind. The independent increase in PEQ in Eocene crown groups is related to the expansion of the neocortex, possibly a response to ecological specialization as environments changed, long after the extinction.

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