



## Critical reappraisal of the early diversification of dinosaurs

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Although the extinction of non-avian dinosaurs at the end of the Mesozoic has been studied extensively, the origin and rise of early dinosaurs is less well understood. Previous hypotheses for the success of early dinosaurs have generally focused on two different scenarios: competition and contingent events (e.g., bolide impacts, mass extinctions, etc.). Unfortunately, most studies have taken a broad, global view to address these hypotheses, which has led to over-generalization about patterns of early dinosaur evolution. Here, I examine the occurrences, species diversity, and relative abundance of early dinosaurs at both regional and global scales to elucidate their early evolutionary history. These data reveal several patterns: in Gondwana and Europe, sauropodomorphs are diverse and common by the late Norian, whereas they are absent from North America until the Early Jurassic; ornithischian dinosaurs are absent from the Triassic of Laurasia, and are rare and species-poor worldwide until the Jurassic; dinosaurs are rare in the Late Triassic of North America, and do not become abundant until the Early Jurassic; and dinosaur body size increases gradually throughout the Late Triassic, rather than abruptly across the Triassic-Jurassic boundary. No single hypothesis fully explains these data. There is little evidence for competition with other groups, but there is also no evidence for a Carnian-Norian extinction leading to early dinosaur success. Elevated dinosaur growth rates are consistent with body size increase, but this trend does not necessarily correlate with a synchronous increase in diversity or abundance. These data suggest that early dinosaur diversification was diachronous across Pangaea, and resulted from multiple complex processes with several underlying causes. Future studies must disentangle space (biogeography), time and paleoecology to understand the processes underlying the origin of dinosaurs.

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