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Mesozoic marine reptile palaeobiogeography in response to drifting plates

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To Alfred Wegener (1880–1930)

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ABSTRACT

During the Mesozoic, various groups of reptiles underwent a spectacular return to an aquatic life, colonizing most marine environments. They were highly diversified both systematically and ecologically, and most were the largest top-predators of the marine ecosystems of their time. The main groups were Ichthyosauria, Sauropterygia, Thalattosauria, and several lineages of Testudinata, Crocodyliformes, Rhynchocephalia and Squamata. Here we show that the palaeobiogeographical distribution of these marine reptiles closely followed the break-up of the supercontinent Pangaea and that they globally used the main marine corridors created by this break-up to disperse. Most Mesozoic marine reptile clades exhibit a cosmopolitan, or at least pandemic, distribution very early in their evolutionary history. The acquisition of morphological adaptations to a fully aquatic life, combined to special thermophysiological characteristics, are probably responsible for these animals to become efficient long-distance open-marine cruisers. Generally, Early Triassic taxa were near-shore animals mainly linked to the Tethys or Panthalassa coastlines. By the end of the Triassic and during the Jurassic, the break-up of Pangaea resulted in the formation of large marine corridors connecting the Tethys to the North Atlantic and Pacific realms, a trend increasing on during the Cretaceous with the expansion of the Atlantic Ocean and the break-up of the southern Gondwana, allowing open-sea marine reptiles to spread out over large distances. However, if large faunal interchanges were possible at a global scale following a dispersal model, some provinces, such as the Mediterranean Tethys, were characterised by a peculiar faunal identity, illustrating an absence of migration with time despite the apparent lack of barriers. So, if Continental Drift enabled global circulations and faunal interchanges via dispersals among Mesozoic marine reptiles, other parameters, such as ecological and biological constraints, probably also played a role in the local endemic distribution of some of these marine groups, as they do today.

Contents

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1. Introduction

Mesosaurus, known from Early Permian strata, is one of the first marine reptiles known in the fossil record (Fig. 1). Its co-occurrence in both Africa (South Africa, Namibia) and South America (Brazil, Uruguay, Paraguay) also made it one of the key-fossils used by the German meteorologist Alfred Wegener (1880–1930) to support his theory of Continental Drift, first briefly published in 1912, then extensively in 1915 and in later editions (Wegener, 1912, 1915).

But *Mesosaurus* was only the 'tip of the iceberg'. Indeed, during the Mesozoic Era, numerous clades of reptiles invaded the aquatic realm, colonizing all marine environments (e.g. Mazin, 2001; Houssaye, 2009). Like the Cenozoic marine mammals, they exemplify convergent evolution and a wide range of adaptations to the marine realm, including both morphological, physiological and ecological characteristics. These reptile clades were highly diversified, both systematically and ecologically, and most became the largest top-predators of the marine ecosystems of their time. Some were exclusively marine and only known during the Mesozoic, such as ichthyosaurs, sauropterygians and thalattosaurs, whereas others included marine representatives at some periods only of their evolutionary history, like chelonians, crocodyliforms, rhynchocephalians and squamates. Adaptations to a marine life are also found in minor diapsid offshoots, such as Late Carboniferous araeoscelidians (DeBraga and Reisz, 1995), several Triassic taxa that are nanchungosaurids (Carroll and Dong, 1991), omphalosaurids (Maisch, 2010), *Helveticosaurus* (Rieppel, 1989), poposauroids (e.g., Li et al., 2012), protorosaurs (e.g., Rieppel et al., 2008) and the phytosaur *Mystriosuchus planirostris* (e.g., Gozzi and Renesto, 2003), as well as in the Late Cretaceous hesperornithiform and ichthyornithiform marine birds (e.g. Chinsamy et al., 1998; Rees and Lindgren, 2005). Some marine reptile lineages survived the Cretaceous–Palaeogene (K/Pg) boundary, being known in the Cenozoic

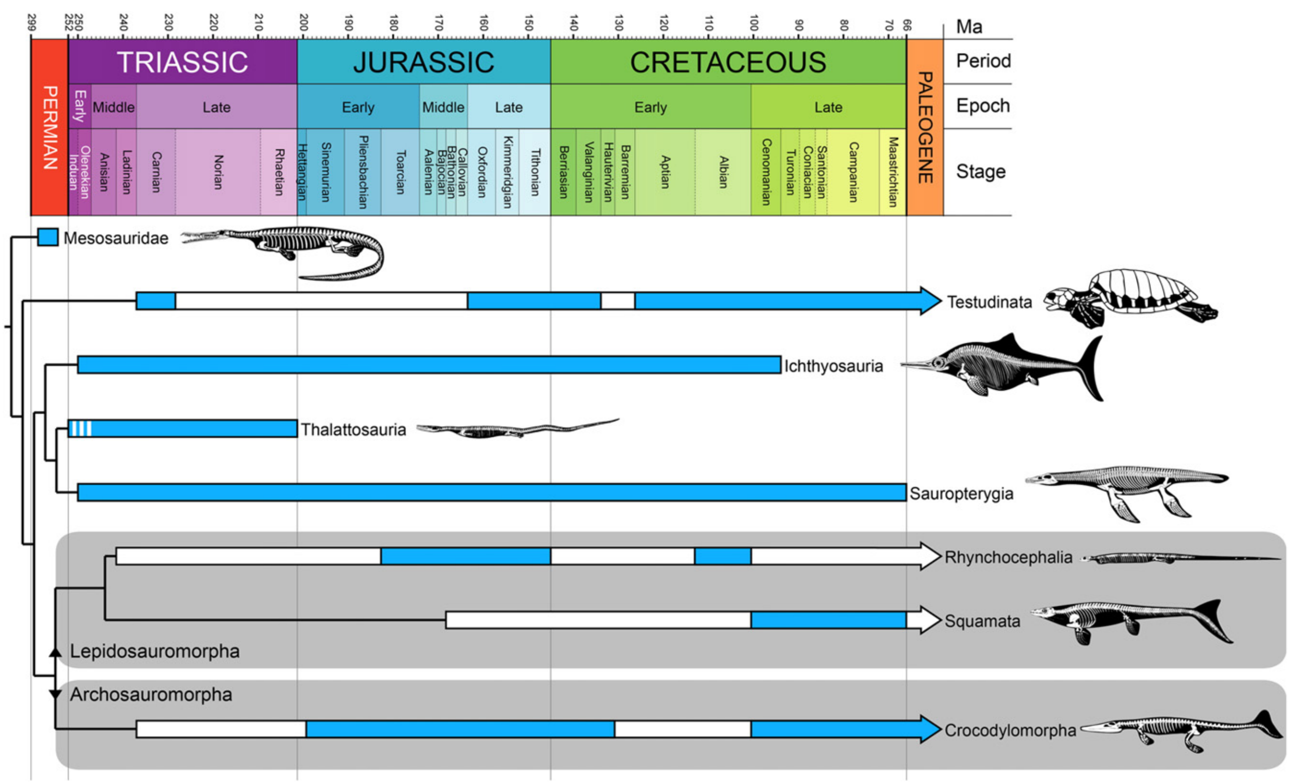

Fig. 1. Schematic phylogenetical relationships of Mesozoic marine reptiles. Blue colour indicates the presence of marine representatives for each clade. Mesozoic marine reptiles were all diapsids, with the possible exception of turtles and ichthyosaurs (depending of the authors). Mesosaurids belong to a distinct clade. Time-scale built and modified from TS-Creator (Ogg et al., 2012). For fossil record and ages, see text except for dyrosaurid crocodylomorphs (Buffetaut and Lauverjat, 1978; Jouve et al., 2008). The dashing indicates that the occurrence of thalattosaurs during the Lower Triassic remains uncertain. Reconstructions of the mesosaurid *Mesosaurus* modified from Modesto (2010), the testudinata *Caretta* from Pérez-García (this paper), the ichthyosaur *Ophthalmosaurus* from McGowan and Motani (2003), the thalattosaur *Askeptosaurus* from Müller (2005), the sauropterygian plesiosaur *Rhomaleosaurus* from Smith and Dyke (2008), the rhynchocephalian *Palaeopleurosaurus* from Carroll (1985), the mosasauroid squamate *Platecarpus* from Lindgren et al. (2010), and the thalattosuchian crocodylomorph *Metriorhynchus* from Hua and Buffetaut (1997). Reconstructions not at scale.