Atolchelys lepida, a new side-necked turtle from the Early Cretaceous of Brazil and the age of crown Pleurodira

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We report a new pleurodiran turtle from the Barremian Morro do Chaves Formation, Sergipe-Alagoas Basin, Brazil. We tested the phylogenetic position of Atolchelys lepida gen. et sp. nov. by including it in a comprehensive cladistic analysis of pleurodires. The new species is a basal member of Bothremyidi and simultaneously the oldest unambiguous crown Pleurodira. The biogeographic and chronostratigraphic significance of the finding has implications for the calibration of molecular clocks studies by pushing back the minimum age of crown Pleurodira by more than 12 Ma (ca 125 Ma). The reanalysis of Pelomedusoides relationships provides evidence that the early evolution and relationships among the main lineages of side-necked turtles can be explained, at least partially, by a sequence of vicariance events.

1. Introduction

Side-necked turtles (Pan-Pleurodira) have an extensive fossil record dating back to the Late Jurassic. Regardless of the discussion on the phylogeny of stem turtles [1–8], the Triassic Proterochersis robusta has been consistently positioned outside of this clade in recent studies [1,6,8] and the stem lineage is therefore only populated by the clade Platychelyidae [1–12].

All records of Platychelyidae range from the Oxfordian (Late Jurassic) to Valangian (Early Cretaceous) [11,13], whereas the oldest unambiguous crown Pleurodira were previously known from the Aptian (Early Cretaceous). The apparent temporal gap during the Early Cretaceous reveals that the early record of Pleurodira is extremely poor. The earliest Pan-Chelidae, one of the two primary branches of Pleurodira, dates from the Albian [1]. A fragmentary podocnemidoid specimen from the Valangian (ca 135 Ma) of Colombia, by contrast, has been argued to be the earliest record of crown Pelomedusoides, but we are cautious about this interpretation [14] (see §4). Thus, the oldest unambiguous Pelomedusoides are those from Araripe Basin of Brazil (Aptian–Albian): Araripemys (Araripemydidae), Cearachelys (Bothremyidi) and Euraxemys (Euraxemydidae). Of these three taxa, only the first is confirmed from Aptian localities [15], in addition to more fragmentary material referable to Pan-Podocnemididae [16].

Here, we describe a new species of Pelomedusoides from the Lower Cretaceous (Barremian) of the Sergipe-Alagoas Basin in Brazil. This is not the first record of a turtle from the Morro do Chaves Formation [17], but, it is sufficiently complete to allow testing its phylogenetic relationships, discussing its biogeographic and chronostratigraphic significance, and its impact on molecular calibration studies of turtles.
2. Material and methods

In order to test the phylogenetic position of *Atolchelys lepida* gen. et sp. nov., it was included in the most recent published character/taxon matrix [2], including subsequent additions and modifications proposed [5,11,18]. The cladistic analysis was performed using TNT [19] (details in the electronic supplementary material; characters states coded to *Atolchelys* gen. nov. in data matrix: 1111??0??1??1??2??1??0??110??1??1??1??1??1??1???0????? 0????0??1????0????0??1??1??1??1??1??1??1??0???0????0??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1??1?
A previous hypothesis [21,22] suggests that the Pelomedusoides–Chelidae split is consistent with a vicariance event that occurred during the Early Cretaceous (figure 2, node I). Following this split, three sister-group relationships can be identified between African and Brazilian Pelomedusoides species (figure 2, nodes II, II° and II”), of which two (nodes II’ and II”) were not previously recognized [22]. Thus, it is possible to interpret these sister-group relationships as allopatric speciations due to a single vicariance event: the complete opening of the central Atlantic and the separation of Africa from South America. Bothremydidae and Podocnemididae afterwards greatly expanded their range of distribution but also suffered several lineages extinctions.

After recent progress with respect to knowledge about Pelomedusoides phylogeny and diversity [2,3,5,11,18], our findings indicate that the origin and relationships among the main lineages of side-necked turtles is even more complex than previously reported.

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Data accessibility. The electronic supplementary material was deposited in the Dryad repository: doi:10.5061/dryad.f2h6r. The matrix was deposited in Morphobank (Project no. 1194).

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References


