

FIRST TURTLE FROM THE IPUBI FORMATION (EARLY CRETACEOUS), SANTANA GROUP, ARARIPE BASIN, BRAZIL

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ABSTRACT – Up to date turtle remains from the Early Cretaceous Santana Group are known only to the Crato and Romualdo formations (Aptian-Albian) that have yielded five species: *Araripemys barretoii* Price, 1973; *Santanachelys gaffneyi* Hirayama, 1998; *Brasilemys josai* Lapparent de Broin, 2000; *Cearachelys placidoi* Gaffney, Campos & Hirayama, 2001 and *Euraxemys essweini* Gaffney, Tong & Meylan, 2006. Except for *A. barretoii*, known from both, the Romualdo and Crato formations, all other turtle taxa are restricted to the Romualdo Formation. Fragments of the skull, an incomplete lower jaw and carapace of the first turtle remains from the Ipubi Formation are reported here. This material was collected in the shales above the gypsum layer, close to the contact with the Romualdo Formation (Aptian-Albian). Compared to other turtles from the Santana Group, this specimen is referred to Pelomedusoides, excluding *Araripemys* and *Brasilemys*, based on the following characteristics: absence of a *cavum pterygoidei*, absence of cervical scute, absence of fontanel in the carapace, contact between nuchal and first peripheral, and absence of nuchal emargination.

Key words: Early Cretaceous, Araripe Basin, Santana Group, Ipubi Formation, Pleurodira, Pelomedusoides.

RESUMO – Até o momento, restos de tartarugas do Grupo Santana (Cretáceo Inferior) têm sido descritos apenas para as formações Crato e Romualdo (Aptiano-Albiano) e cinco espécies são conhecidas: *Araripemys barretoii* Price, 1973; *Santanachelys gaffneyi* Hirayama, 1998; *Brasilemys josai* Lapparent de Broin, 2000; *Cearachelys placidoi* Gaffney, Campos & Hirayama, 2001 and *Euraxemys essweini* Gaffney, Tong & Meylan, 2006. À exceção de *A. barretoii*, que é encontrada nas formações Crato e Romualdo, todas as outras espécies de tartarugas são restritas a Formação Romualdo. Restos da primeira tartaruga da Formação Ipubi, compostos por fragmentos de crânio, mandíbula e carapaça, são aqui reportados. O espécime foi coletado nos folhelhos betuminosos, acima da camada de gipsita, próximo ao contato com a Formação Romualdo (Aptiano-Albiano). Comparado com as outras tartarugas do Grupo Santana, este espécime é referido a Pelomedusoides, excluindo *Araripemys* e *Brasilemys*, baseado nas seguintes características: ausência do *cavum pterygoidei*, ausência de escudo cervical, ausência de fontanelas na carapaça, contato entre a placa nuchal e a primeira placa periferal e ausência de entalhe na placa nuchal.

Palavras-chave: Cretáceo Inferior, bacia do Araripe, Grupo Santana, Formação Ipubi, Pleurodira, Pelomedusoides.

INTRODUCTION

The Araripe Basin is located in northeastern Brazil between the states of Ceará, Piauí and Pernambuco (Figure 1). The Crato and Romualdo formations (Santana Group, see details in

Neumann & Cabrera, 1999; Valença *et al.*, 2003) that comprise the most fossiliferous strata of this basin, are famous worldwide for the diverse and exquisitely well preserved fossil assemblages (*e.g.* Maisey, 1991). These two different *lagerstätten* were formed during the Lower Cretaceous, Aptian/Albian (Pons *et al.*, 1990;

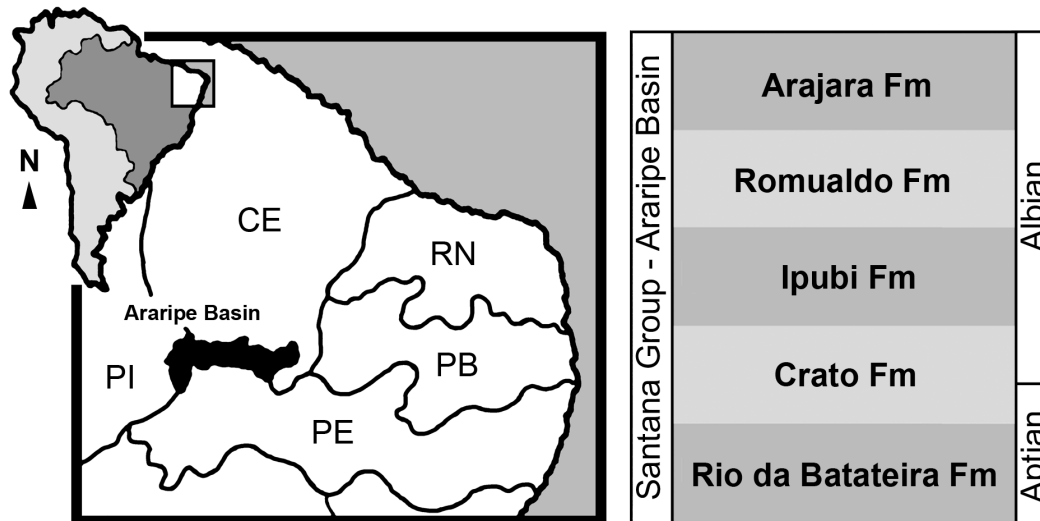


Figure 1. Map showing the location of the Araripe Basin and the formations that compose the Santana Group. Ages based on Valença *et al.* (2003).

Ponte & Ponte Filho, 1996; Neumann & Cabrera, 1999) and have yielded several fossil reptiles such as turtles, dinosaurs, pterosaurs, and crocodylomorphs (*e.g.* Kellner, 1987; Kellner & Campos, 1999, 2000; Fara *et al.*, 2005; Oliveira & Romano, 2007).

Turtles from the Santana Group have been described from the Crato and Romualdo *lagerstätten* (Oliveira & Kellner, 2005; Oliveira & Romano, 2007; Oliveira *et al.*, 2009) but none osteological evidence has been reported from the Ipubi Formation so far. Here we present the first turtle material from latter that increases the distribution of these reptiles in the Santana Group. Recently, Dentzien-Dias *et al.* (2010) published the first ichnological evidence of a swimming tetrapod, a footprint, in the Ipubi Formation (*sensu* Neumann & Cabrera, 1999 and Valença *et al.*, 2003) or Ipubi layers, Crato Formation (*sensu* Assine, 2007). These authors associated the morphology of this footprint as if it had been produced by the autopodium of a turtle while swimming. However, Dentzien-Dias *et al.* (2010) do not rule out the possibility of this footprint belonging to other tetrapod.

It should be noted that Fielding *et al.* (2005:1302) briefly mentioned one turtle from bituminous shales at Mina Pedra Branca, near Nova Olinda that was identified as *cf. Araripemys*; according to one author (JAFGA) this is the same specimen described here.

The specimen studied here is housed in the collection of the Centro de Pesquisas Paleontológicas da Chapada do Araripe of the Departamento Nacional de Produção Mineral, Crato, Ceará under the number CPCA 3560. It consists of crushed fragments of the skull, a partial lower jaw and the carapace. A cast of this material is housed at the Museu Nacional/UFRJ (MN 4122-V).

Institutional abbreviations: CPCA, Centro de Pesquisas Paleontológicas da Chapada do Araripe of the Departamento Nacional de Produção Mineral (DNPM), Crato, Ceará; MN, Museu Nacional, Universidade Federal do Rio de Janeiro. **Anatomical abbreviations:** *ang*, angular; *cos*, costal bone; *de*, dentary; *il*, iliac scar; *ne*, neural bone; *nu*, nuchal bone; *pe*, peripheral bone; *pt*, pterygoid; *py*, pygal bone; *qu*, quadrate; *spy*, suprapygal bone; *sur*, surangular.

GEOLOGICAL SETTING

The Santana Group of the Araripe Basin is subdivided in five formations (Figure 1), named from base to top: Rio da

Batateira, Crato, Ipubi, Romualdo and Arajara formations (Neumann & Cabrera, 1999; Valença *et al.*, 2003). The Ipubi Formation is composed primarily of gypsum and anhydrite, with intercalated beds of black shales (Ponte & Appi, 1990). With maximum thickness of 30 m, the layers of gypsum are common in the area of Santana do Cariri, but are concentrated mostly in the western portion of the basin, from Ipubi to Araripina (Assine, 1992). According to Silva (1988) this evaporitic layer represents the climax of a sedimentary sequence in a lake, whose waters have become increasingly saline due to increased evaporation. In the strata of the Ipubi Formation are found remains of ostracods, fishes and fragments of leaves of *Ginkgo* sp. The specimen described here was collected in the shales above the gypsum layer (Figure 2), close to the contact with the Romualdo Formation, at the mine of Pedra Branca nearby the town of Nova Olinda in the State of Ceará, northeastern Brazil and it is the first osteological evidence of tetrapod to this deposit.

SYSTEMATIC PALEONTOLOGY

TESTUDINES Linnaeus, 1758
CASICHELYDIA Gaffney, 1975
PLEURODIRA Cope, 1864
PELOMEDUSOIDES Cope, 1868
Gen. et sp. indet.
(Figures 3-5; Table 1)

Material. CPCA 3560, crushed fragments of the skull, a partial lower jaw and the carapace; MN 4122-V, a cast of this material.

Locality. Mine of Pedra Branca nearby the town of Nova Olinda, Ceará State, northeastern Brazil.

Stratigraphic unit. Ipubi Formation, Santana Group, Araripe Basin.

Age. Early Cretaceous.

Description. The skull in CPCA 3560 (Figure 3) is represented, as preserved, by left maxilla, pterygoid, quadrate and basisphenoid. The contacts among these elements are difficult to establish due to the poor preservation. The most important anatomical feature that can be determined is the absence of a *cavum pterygoidei*, that is also absent in *Araripemys*, *Euraxemys* and *Cearachelys*, contrasting to the condition observed in



Figure 2. Outcrop at the Mina da Pedra Branca, Nova Olinda, Ceara State, showing contact of the Ipubi and Romualdo formations (thick line). The dotted line marks the contact between the black shale where the turtle specimens CPCA 3560 was collected and the gypsum layer.

Brasilemys and other podocnemidids (e.g. Gaffney *et al.*, 2006; Meylan *et al.*, 2009).

The lower jaw of the specimen is represented only by the dentary, surangular, and angular (Figure 3). The left ramus is almost complete and the right ramus is fragmented posteriorly. Unfortunately most of those elements are incomplete and do not provide any detailed information, except for the dentaries. These bones are nearly complete except for the posterior portion of the right one. They are anteriorly tall near the surangular, becoming progressively lower posteriorly. On each side they contact the surangular posteriorly and the angular posteroventrally. It is not clear if the dentaries are sutured in a midline symphysis (as in *Araripemys*, *Euraxemys* and *Pelomedusa*) or fused (as in bothremydids and podocnemidids). However, it is clear that the symphysis in CPCA 3560 is thickened in contrast to *Araripemys* and some chelids.

The only portion of the shell preserved in CPCA 3560 is the carapace (Figure 4), which is the most informative part of the material. On the counterpart of the slab of the specimen the impression of some peripheral bones are preserved (Figure 5). The carapace is uncrushed showing a rather smooth external surface, in contrast to the sculptured condition with marked pits observed in *Araripemys barretoi* Price, 1973 (see Meylan, 1996; Gaffney *et al.*, 2006).

Due to the splitting of the material, some interior parts of the carapace are exposed. The axillary buttresses are visible below the costal 1 and medial to peripheral 3 on the right side (Figure 4). On the posterior portion of the carapace it is possible to see the iliac scar on costals 7 and 8 (Figure 5). The iliac scar is

triradiated in dorsal view, with anterior, posterior, and posterolateral projections. This feature differs from the condition in non-Pelomedusoides pleurodires which lack well developed projections (Meylan, 1996; Lapparent de Broin & Murelaga, 1999; De La Fuente & Iturralde-Vinent, 2001).

The shell is oval, domed and incomplete. However CPCA 3560 is not as domed as in *Cearachelys*. There is no evidence of nuchal emargination on the anterior portion of carapace, as in *Araripemys*. The posterior portion of the carapace in CPCA 3560 is similar to *Brasilemys* and *Euraxemys*, being wider than in *Cearachelys*.

CPCA 3560 has a complete nuchal bone. At least five neural bones can be determined but the total number of neurals cannot be established. A triangular suprapygal is preserved. The pygal is also represented, partially in bone and partially as an imprint. The specimen has eight pairs of costals, and 11 peripherals bones.

The nuchal is a long element with the anterior border elongated as in *Cearachelys*, differing from *Brasilemys*, where this bone is approximately as wide as long. The nuchal contacts neural 1 posteriorly, costal 1 posterolaterally and peripheral 1 laterally. These features differ from *Araripemys*, where the first peripherals are greatly reduced and do not contact the nuchal (Meylan, 1996; Gaffney *et al.*, 2006). No evidence of a cervical scale is observed in the Ipubi material, indicating that this element was absent in this taxon as in other Pelomedusoides (Gaffney *et al.*, 2001, 2006).

There are no fontanels in CPCA 3560, which are also absent in *Brasilemys*, *Euraxemys* and *Cearachelys*, in contrast to the

condition of *Araripemys* which has fontanelles in the carapace and plastron (Price, 1973; Kischlat & Campos, 1990; Schleich, 1990; Meylan, 1996; Oliveira & Kellner, 2005, 2007; Gaffney *et al.*, 2006).

In CPCA 3560 there is no evidence to determine whether the neural series is complete, as in *Araripemys*, *Euraxemys* and *Cearachelys*, or if the costal bones intervene between the last neural and the suprapygal, as in *Brasilemys* and other Pelomedusoides.

The first neural is similar to the one in *Cearachelys* and

Brasilemys, by being six sided and contacting neural 2, the first costal, and by having short and paired contacts with the second costal. The second neural is quadrangular and has a wide contact with costal 2. The third and fourth neurals are hexagonal. Neural 3 has a short contact with costal 2, and a wide contact with costal 3. Neural 4 contacts costals 3 and 4.

The suprapygal has a triangular shape and contacts peripheral 11 and the pygal, there is no evidence that it contacts the last neural. The pygal bone is long and is represented by both bone and imprint.

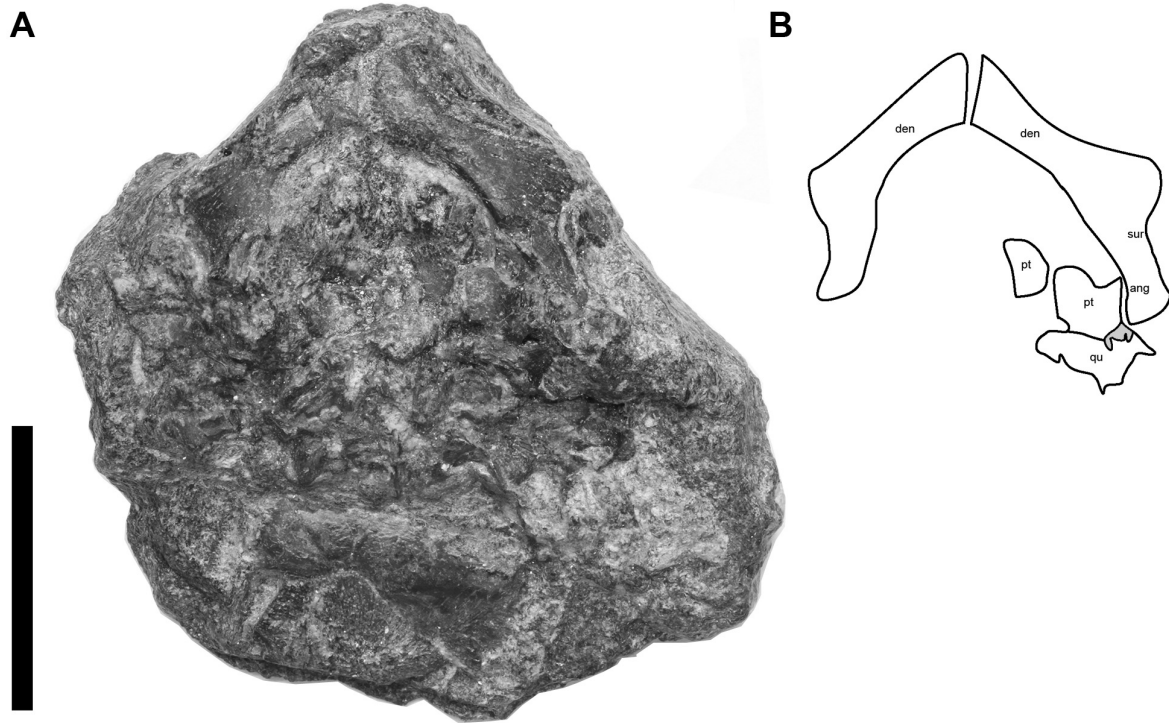


Figure 3. Ventral and ventrolateral view of the skull and lower jaw of CPCA 3560. Scale bar = 20 mm.

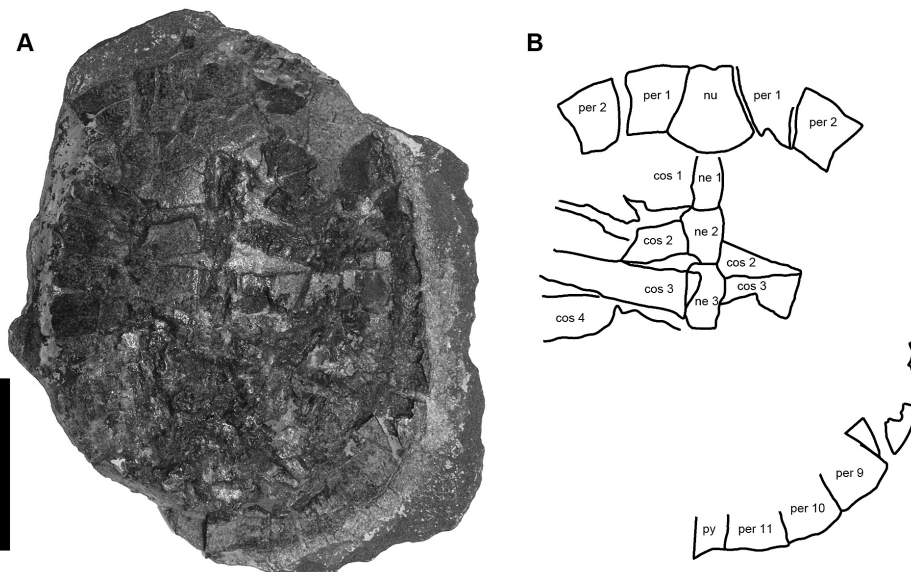


Figure 4. Dorsal view of the carapace of CPCA 3560: photo (A) and outline (B) of preserved bones. Scale bar = 50 mm.

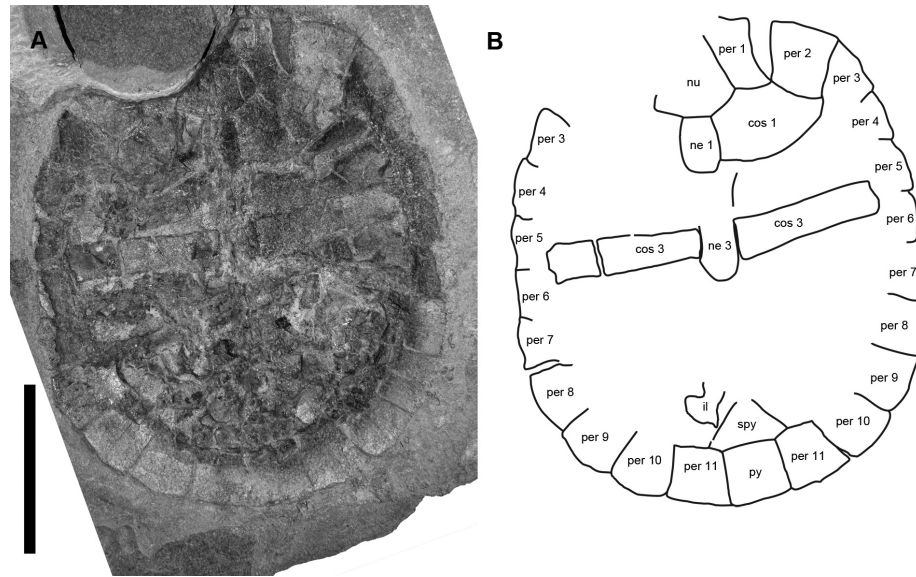


Figure 5. Counterpart of CPCA 3560: photo (A) and outline (B) of preserved bones. Scale bar = 50 mm.

Table 1. Features of the carapace of the Testudines from the Santana Group.

Character	<i>Araripemys</i>	<i>Brasilemys</i>	<i>Cearachelys</i>	<i>Euraxemys</i>	CPCA 3560
Carapacial fontanels	yes	no	no	no	no
Shell height	flattened	domed	domed	domed	domed
Neural number	9	7	8	8	at least five
Neural series complete to suprapygal	yes	no	yes	yes	?
Deep nuchal emargination	yes	no	no	no	no
Surface texture of shell	with pits	smooth	smooth	smooth	smooth

DISCUSSION

Based on the condition of the pelvic girdle sutured to the shell, the specimen described here can be clearly regarded as a pleurodire turtle. Furthermore, the absence of a cervical scale indicates that CPCA 3560 represents a Pelomedusoides.

According to Oliveira *et al.* (2009) the following Pelomedusoides were described from the Araripe Basin: *Araripemys barreto* Price, 1973, *Brasilemys josai* Lapparent de Broin, 2000, *Cearachelys placidoi* Gaffney, Campos & Hirayama, 2001 and *Euraxemys essweini* Gaffney, Tong & Meylan, 2006. Without presenting any argument, Fielding *et al.* (2005) interpreted CPCA 3560 as cf. *Araripemys*. However, this specimen differs from *Araripemys* in several features such as the absence of a nuchal emargination in the anterior portion of carapace and carapacial fontanels.

Brasilemys and other podocnemidids, possess a *cavum pterygoidei*, which is a synapomorphy of Podocnemidinura (*sensu* Gaffney *et al.*, 2006); that feature is absent in CPCA 3560.

From all known Pelomedusoides from the Araripe Basin, CPCA 3560 has more similarities to *Euraxemys essweini*, including the outline and shape of the shell and the absence of a *cavum pterygoidei*. This genus is diagnosed by the morphology of the skull, which, unfortunately, is not sufficiently preserved in the Ipubi turtle for a more detailed comparison. The same is true for *Cearachelys placidoi*. Despite the fact that this specimen comes from a distinct stratigraphic level than any other turtle material from the Santana Group, it lacks a unique diagnostic feature or any

particular combination of characters that would allow us to refer CPCA 3560 to any known species or establish a new taxon (see discussion in Kellner, 2010). Nonetheless, based on the comparisons above (Table 1), it is clear that the Ipubi turtle does not represent *Araripemys* (*contra* Fielding *et al.*, 2005) – the most common turtle in the Araripe Basin (Oliveira & Kellner, 2005; Oliveira, 2007; Naish, 2007) – or *Brasilemys*.

Although incomplete, CPCA 3560 expands the record of the turtle fauna of the Araripe Basin to the Ipubi Formation. It is also the first tetrapod collected in that stratigraphic unit showing the potential of new discoveries in those layers.

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