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A SEMIONOTID FISH FROM THE CRATO FORMATION (APTIAN, LOWER CRETACEOUS) OF BRAZIL: PALAEOECOLOGICAL IMPLICATIONS

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Abstract : A partial example of an articulated fish cf. *Araripelepidotes* sp. from the Nova Olinda Member of the Crato Formation (Aptian, Lower Cretaceous, Araripe Basin, Brazil) is the first record of this taxon from this formation. Fishes other than *Dastilbe* spp. are extremely rare in the Crato Formation and we consider the implications in terms of the overall ichthyofauna diversity and palaeoecology.

Key words: Pisces, Lower Cretaceous, Brazil

Un poisson semionotidé de la Formation Crato (Aptien, Crétacé inférieur) du N. E. du Brésil: implications paléoécologiques

Résumé : Un exemplaire incomplet, articulé, d'un poisson semionotidé, provenant du Membre Nova Olinda de la Formation Crato (Aptien du Bassin d'Araripe, Brésil) est identifié comme étant un cf. *Araripelepidotes* sp. C'est la première fois que ce type de poisson est signalé dans ce niveau. A l'exception de *Dastilbe* spp. les poissons sont extrêmement rares dans la Formation Crato. Le problème de la diversité de l'ichthyofaune et les implications paléoécologiques de cette découverte sont abordées. (traduit par la rédaction).

Mots clés: Pisces, Crétacé inférieur, Brésil

INTRODUCTION

The Crato Formation of the Araripe Basin, north east Brazil is one of the most important Mesozoic fossil conservation lagerstätte, and is particularly well-known for yielding abundant, diverse and well preserved insects and plants (Martill, 1993). As of yet, no detailed palaeoecological analysis of the formation has been published and questions remain as to the exact nature of the palaeoenvironment. The purpose of this paper is to document the first discovery of a semionotid fish; cf. *Araripelepidotes* sp., from the Crato Formation and consider the palaeoecological implications of this fossil in the light of current thoughts on the palaeoenvironment, especially with regard to the palaeosalinity. Although the Nova Olinda Member of the Crato Formation (Aptian, Lower Cretaceous, Araripe Basin, north east Brazil) is well known for its exceptional preservation and abundance of fossils, the ichthyofauna is of very low diversity (only two genera so far being recorded) and only the gonorhynchiform teleost *Dastilbe elongatus* (Silva Santos, 1947) occurs abundantly. On the other hand, winged insects are extremely abundant and include a wide range of insect orders. Other vertebrates such as birds, pterosaurs, crocodiles, lizards and frogs have all been reported (Martill & Filgueira, 1994; Maisey, 1991). Perhaps remarkably, if one excludes *Dastilbe* spp. pterosaurs appear to be more abundant than fish (see Martill & Frey, this volume). Very rare examples of the ichthyodectiform fish *Cladocyclus* sp. from the Crato Formation were first reported by Wenz and Campos (1985) from Barbalha, Ceará. More recently Maisey (1996) claimed that specimens of *Cladocyclus* from the Crato limestones represented a freshwater species of this taxon. We discuss this consideration below.

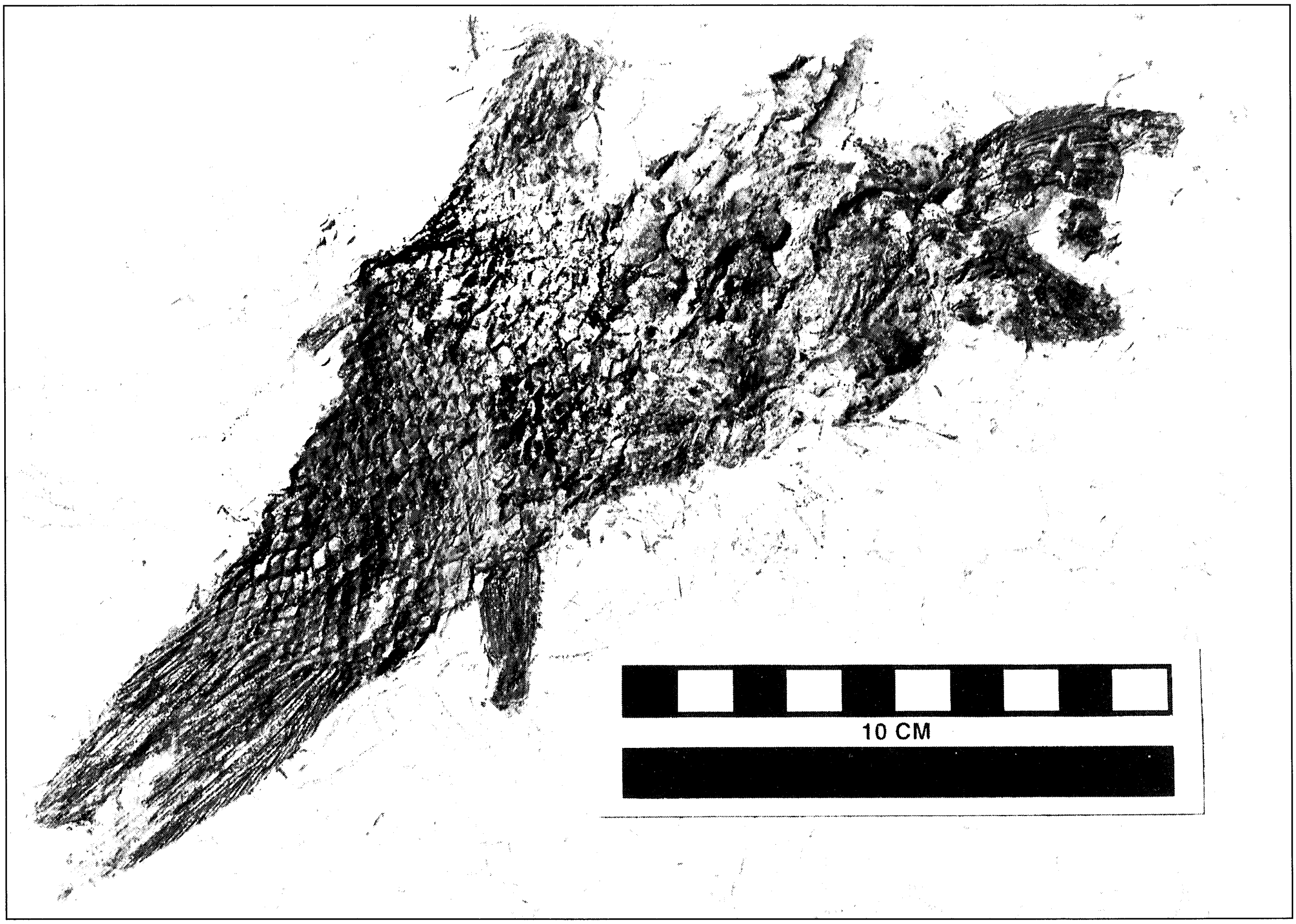
SYSTEMATICS

Class Osteichthyes
Subclass Actinopterygii
Infraclass Neopterygii
Order Semionotiformes
Family Semionotidae
Genus cf. *Araripelepidotes* Silva Santos, 1985
(see also Silva Santos, 1990)

THE NEW SPECIMEN

The present study is based on a single specimen (PMB.VP-144) housed in the Department of Biology of the State University of Rio de Janeiro (UERJ). Although the new specimen is incomplete, it is an articulated example of a semionotid fish on a slab of cream coloured limestone typical of the Nova Olinda Member of the Crato Formation (Figs. 1, 2). It lacks the skull and anterior trunk region, thus preventing accurate generic and specific identification.

Figure 1. cf. *Araripelepidotes* sp. from the Nova Olinda Member of the Crato Formation (Aptian, Lower Cretaceous) of the Araripe Basin, n.e. Brazil. Scale bar in centimetres. Specimen number PMB.VP-144. Photograph showing entire specimen on slab of typical Crato limestone. Note that the skull and anterodorsal part of the trunk appears to have decayed away prior to preservation.



As preserved the specimen is approximately 250 mm in length, and represents a fish with an original estimated length of between 240 mm and 300 mm (this estimate obtained by comparing the length between base of the ventral lobe of the caudal fin and base of pectoral fins with that reconstructed by Maisey (1991, p. 118) for *Araripelepidotes*). The body measures approximately 180 mm from the pectoral girdle to the caudal pedicle. The anomaly between the actual length of the specimen and the estimated length of the complete fish is due to the taphonomic forward flexure of the right pectoral fin. The anteroventral region of the trunk shows some disruption, and the missing skull is due to post mortem loss during drifting. The paired pectoral fins are present, as is the anal fin and parts of the dorsal fin. The caudal fin is entire, although the dorsal and ventral lobes have "closed" slightly to give the caudal region a narrow appearance. A slight taper of the distal portions of the caudal fin suggest that in this specimen the caudal fin is slightly forked (Fig. 2).

The body is subcylindrical with a moderate elevation anterior to the dorsal fin. Dorsal and anal fins are situated in the posterior part of the body. All the fins are preceded by strongly developed fulcra. The body is covered by rhombic, smooth, isometric scales covered by a thick layer of ganoin. The scales differ depending on their position in the body. The most dorsal anterior scales are larger with serrated posterior edges; the mid and posterior scales are diamond shaped and lack serration.

It is difficult to place the Crato specimen precisely in a taxonomic position, as it lacks the skull bones and the body shows only the most generalised characters of the Semionotidae. Semionotids are common in the Mesozoic rift and pre-rift basins in the north-east of Brazil, and are known by at least 4 species of *Lepidotes*, and one species of *Araripelepidotes* in the Santana Formation.

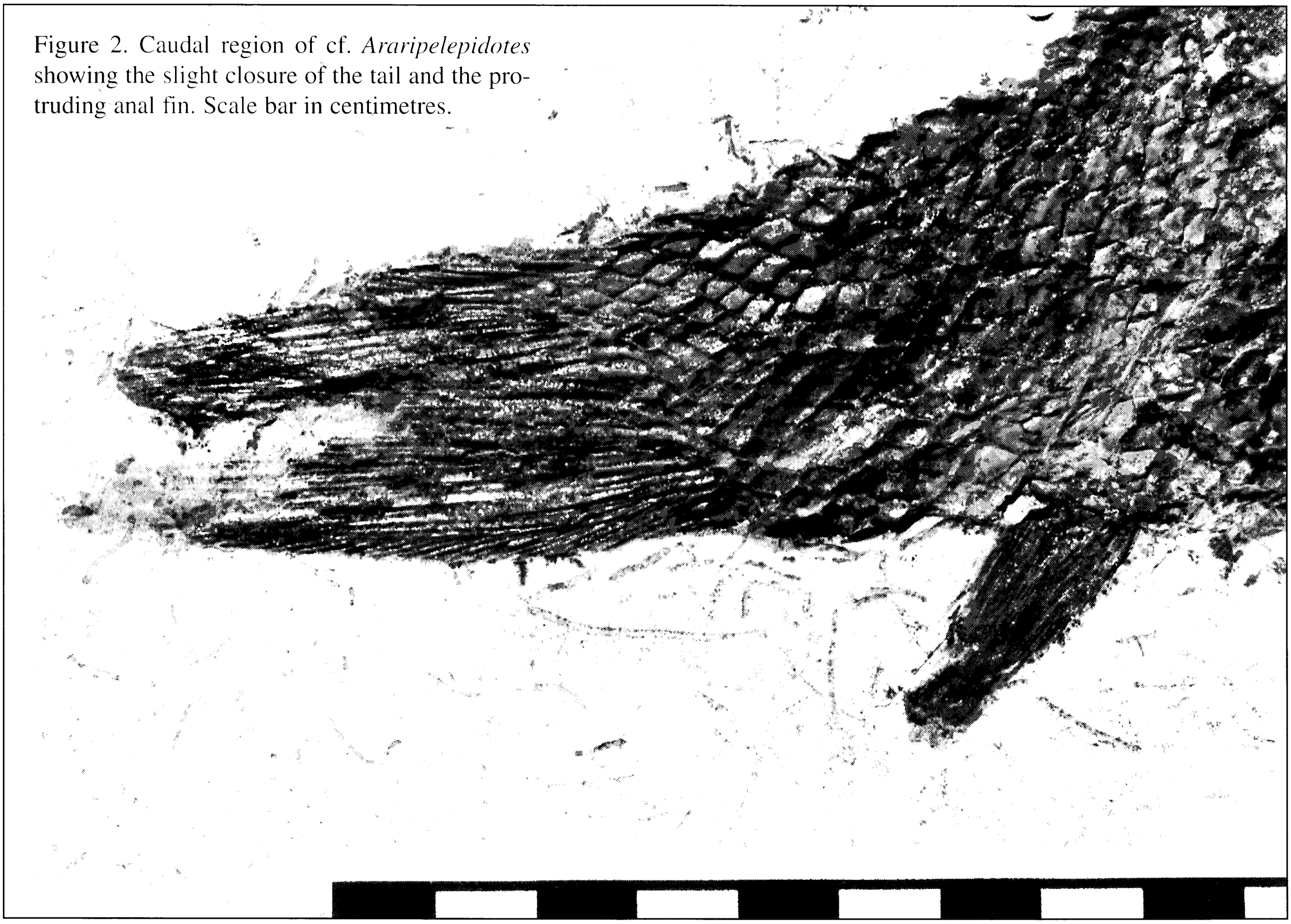


Figure 2. Caudal region of cf. *Araripelepidotes* showing the slight closure of the tail and the protruding anal fin. Scale bar in centimetres.

In the Araripe basin, *Lepidotes* sp. is known only by disarticulated material from the Missao Velha Formation. From the Romualdo Member of the Santana Formation is known *Araripelepidotes temnurus* (Agassiz, 1841), a smaller and more slender semionotid, as well as a possible distinct semionotid taxon, as yet undescribed (Brito & Wenz in prep.). Recently, Wenz & Brito (1992) described two primitive gar fishes; *Obaichthys decoratus* and O*? laevis*, also from the Romualdo Member.

The new Crato specimen can be distinguished from all other *Lepidotes* known in Brazil by its body shape (subcylindrical), the absence of a pronounced hump in front of the dorsal fin and the dimensions of its body.

It can be distinguished from *Obaichthys* by the presence of large scales in the front part of the body (*Obaichthys* spp. have similar sized scales throughout), and the absence of opisthocoelous vertebrae. In addition, the vertebrae of the new specimen are not fully ossified, whereas in gars the vertebrae are well ossified throughout.

Although no single synapomorphy can be pointed out, we can separate the Crato specimen from all other Brazilian semionotiforms *sensu* Olson and McCune 1991 (these authors combine Semionotidae, Macrosemiidae and Lepisosteidae in the Semionotiformes), except *Araripelepidotes*. However, the absence of the skull makes any identification tenuous. The new specimen is certainly more similar to *Araripelepidotes* (e.g. shape of the body, shape and dimension of the scales) than to any other known semionotiform. We here treat it as cf. *Araripelepidotes* sp. *Araripelepidotes temnurus* (Agassiz, 1841) is well-known from the slightly younger Romualdo Member of the Santana Formation which occurs in the same basin just a few metres above the Crato Formation; for descriptions of its anatomy see Maisey, 1991 and Thies, 1996.

THE NOVA OLINDA MEMBER ICHTHYOFAUNA

So far only the teleost fish *Dastilbe elongatus* Silva Santos 1947 and very rare *Cladocyclus* sp. have been recorded from the Nova Olinda Member of the Crato Formation. Blum (1991, pp. 274-283) discusses the anatomy of *Dastilbe* from the Crato Formation and considers that two species may occur; a small species with a dorsal fin ray count of 10 and larger examples with a fin ray count of 13. In the Nova Olinda Member specimens of both large and small *Dastilbe* spp. occur in abundance; smaller individuals in super abundance, whereas examples of *Cladocyclus* are extremely rare, and usually represent small individuals (size range 150 to 300 mm) compared with examples of *Cladocyclus* from the Romualdo Member of the Santana Formation where lengths of over 1 m are recorded (Maisey, 1991: p. 190). The new specimen described here with probable affinities to *Araripelepidotes* indicates that other fish species were entering the Crato Formation water body, but only very rarely.

The low diversity of the Crato Formation ichthyofauna is in marked contrast to the high diversity Santana Formation ichthyofauna which has to date yielded some twenty genera (Maisey 1991; Martill 1993). Of those recorded from the Crato Formation, *Araripelepidotes* and *Cladocyclus* are also well known from the Romualdo Member of the Santana Formation, but the gonorhynchiform *Dastilbe elongatus* has yet to be recorded. This anomaly has important implications for any reconstruction of the palaeoenvironment of the Crato Formation water body. The Santana Formation ichthyofauna probably represents a mixed salinity assemblage with both marine, freshwater and brackish forms. No certain marine fossils (ammonites, brachiopods, etc.) have been found commonly in the Santana Formation although rare echinoids occur just a few metres above the fish bearing concretions, as do marine gastropods.

PALAEOENVIRONMENT

The palaeoenvironment of the Crato Formation has only been discussed briefly (Martill, 1993; Maisey, 1991; Viana, 1992). In reality, the Crato Formation represents many environments ranging from lacustrine (*sensu lato*) to fluvial and terrestrial. Of particular importance is the palaeoenvironment of the suite of laminated limestones of the basal Nova Olinda Member which are the source of so many exquisitely preserved fossils. This environment, whatever its nature and complexity, persisted without apparent interruption in the region of Nova Olinda and Santana do Cariri for some time as the unit is continuous at the same millimetrically laminated scale for up to 6 m. Martill (1993) considered that the environment was that of a saline lake or lagoon over which extended a thin and probably temporary freshwater tongue of water, the volume and extent of which would have been controlled by seasonal fluctuations in fluvial input. Similarly, Viana (1992) considered that the fauna and flora represented a terrestrial and freshwater assemblage, but that the water body may have been saline. On the other hand, Maisey (1996) considers that the Crato Formation limestones represent a freshwater sequence, and supposed that the *Cladocyclus* specimens in the unit must have been a freshwater species.

From a palaeogeographical viewpoint the Crato Formation water body was certainly situated in an internal basin, and any link with marine waters must have been through elongate, probably restricted, fault-bounded grabens to the south, north and possibly west (Berthou, 1990; Maisey, 1991; Martill, 1993). From a palaeontological perspective, the fauna is dominated by a single fish species, usually found in mass mortality assemblages, and by winged insects. Terrestrial invertebrates are also known, including scorpions, spiders and centipedes. What is notably absent is a normal freshwater invertebrate assemblage. Only one choncostracan specimen (*Cyzicus* sp.) was reported by Viana (1992) in what was an extensive period of work collecting assemblages from all levels within the Nova Olinda Member. Freshwater molluscs are unknown from the unit and freshwater insect larvae are rare (larvae of a number of ephemeropterans are common, and possibly represent pelagic larval forms). Also missing from the limestones are ostracodes, which are extremely abundant in other parts of the Crato Formation sequence. Thus the fossil assemblage does not represent that of a normal freshwater body. This raises a number of important issues with regard to interpreting the autecology of those organisms that do occur within the Nova Olinda Member and, in particular, those that only occur very rarely. Does an isolated example of a fish represent a freshwater example washed in from a river system draining into the basin, or does it represent a marine species that came in through one of the restricted links to the sea ?

Some sedimentological considerations suggest that salinities may have been elevated. A general lack of bioturbation is difficult to interpret, although it may have been a result of elevated salinities of bottom water, it may also have been a result of bottom water anoxia. If Viana (1992) is correct that the millimetric lamination is a type of stromatolite, anoxia could be ruled out if the organism responsible for the lamination could be shown to have been an obligate aerobe. Perhaps more convincingly, the widespread occurrence of hopper faced halite pseudomorphs suggest that the Nova Olinda Member was deposited under mainly saline conditions. These probably formed in high salinities developed at the water/air interface during hot and dry seasons and sank when the surface waters were disturbed by winds. They then left impressions in the bottom sediments, but probably redissolved in the slightly lower benthic salinities.

LINKS TO MARINE WATERS

Although the Araripe Basin is currently situated some 600 km inland from the Atlantic Ocean, during Cretaceous high sea stands, this distance was probably reduced considerably. No firm evidence exists for a direct route to a particular marine sedimentary basin, but it has been suggested that links may have existed between the Araripe Basin and the Potiguar Basin to the north, the Parnaiba Basin to the west and to the Jatoba-Reconcavo-Tucano Basin complex to the south (Berthou, 1990), all of which are known to have fully marine Lower Cretaceous sediments.

That marine waters entered the Araripe Basin is unequivocably demonstrated by the presence of marine dinoflagellate cysts, foraminifera and echinoids in the upper parts of the Santana Formation and possibly by the presence of elasmbobranchs in the Romualdo Member nodules of the Santana Formation. It is thus possible that marine waters may similarly have entered the basin during Crato Formation times to give mixohaline conditions.

CONCLUSIONS

Palaeoenvironmental indicators in the Nova Olinda Member of the Crato Formation suggest that it was deposited under saline conditions, although freshwater tongues of surface waters may have been present during wet seasons in front of river mouths and deltas. Elevated salinities are indicated by abundant salt pseudomorphs on many bedding planes throughout the sequence. Mass mortalities of *Dastilbe* may also be due to elevated salinity. Negative evidence for elevated salinities include the lack of normal freshwater invertebrates, such as ostracods, gastropods and bivalves. Amphibians, usually good indicators of freshwater are known from only two examples of frogs, both of which are probably allochthonous.

The large amounts of drifted terrestrial plant material in the Crato Formation might imply that *Dastilbe* too was washed into the lagoon, perhaps during periods of high freshwater input during floods. Later overturn or mixing of a stratified water column resulted in mass deaths of a drifted allochthonous biota. While the presence of cf. *Araripelepidotes* in this formation may also be an example of a freshwater fish washed into the basin, we cannot rule out that it is a marine fish that entered the basin during a brief normal salinity excursion. Thus we urge caution when trying to interpret palaeoecologies on rare specimens from sedimentary systems where the ambient conditions are unclear and may fluctuate widely.

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