



A possible azhdarchid pterosaur from the Crato Formation (Early Cretaceous, Aptian) of northeast Brazil

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Abstract

The partially articulated, distal portion of a left wing finger of a pterosaur from the Crato Formation of northeast Brazil has a T-shaped cross-section to the second and third phalanges. This cross-sectional shape is one of several characters diagnostic of the pterodactyloid pterosaur family Azhdarchidae (Unwin & Lu 1997). Until now, this family of pterosaurs was known exclusively from the Late Cretaceous. The specimen described here may be the first recorded azhdarchid from the southern hemisphere and the earliest recorded member of the family.

Introduction

Pterosaurs are well known from the Romualdo Member (Santana Formation) of the Chapada do Araripe, with the first occurrence reported in the early 1970s (Price 1971). Since then, many specimens of several, morphologically diverse genera have been reported from these deposits (Wellnhofer 1991). Frey & Martill (1994) recorded pterosaurs from the slightly older Crato Formation in the Araripe Basin. Although the Crato Formation pterosaurs have commonly been flattened due to compaction, these specimens are usually complete, or nearly so, and sometimes have evidence of soft-tissue preservation (Martill & Frey 1998a). Several genera are known now, but the pterosaurs appear to be distinct from those of the Romualdo Member (Campos & Kellner 1997). Here we record an isolated wing of a pterosaur of Early Cretaceous age, which may have affinities with azhdarchid pterosaurs from the northern hemisphere.

Locality and stratigraphy

The new specimen was purchased from a commercial fossil dealer who had obtained it from one of the

numerous small quarries in the area between Nova Olinda and Santana do Cariri in the southernmost region of the state of Ceará (NE Brazil; Figure 1). This area is famous for the abundance and quality of preservation of its fossils from the Santana and Crato formations, both of which outcrop on the flanks of the Chapada do Araripe as well as on some isolated outliers (Martill 1993).

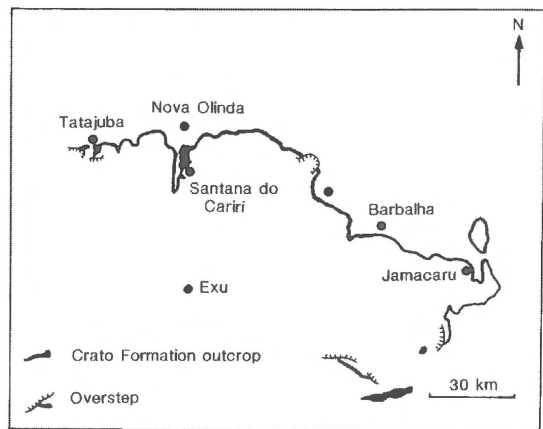


Figure 1. Sketch map showing the distribution of the Crato Formation in the northeastern region of the Chapada do Araripe (Brazil).



Figure 2. Possible azhdarchid pterosaur wing finger and metacarpal (SMNK 2342 PAL), from the Nova Olinda Member (Crato Formation) of Ceará, northeast Brazil. The specimen comprises the metacarpal and phalanges 1, 2, and part of 3 of the wing finger. There is also a small, incomplete bone that might be the terminal portion of an incomplete metacarpal; approx $\times 0.5$.

The specimen described here is from the Nova Olinda Member of the Crato Formation, a stratigraphic unit that has begun to yield pterosaurs of remarkable preservation and diversity in the last ten years (Martill & Frey 1998a). The Nova Olinda Member comprises up to eight metres of millimetrically laminated micritic limestones that contain abundant insects, plants, and the small fish *Dastilbe crandalli*. Sediments above and below the Nova Olinda Member have been dated by Pons et al. (1990), who – on the basis of palynomorph assemblages – suggest an Aptian (Early Cretaceous) age for the formation as a whole. Although the Nova Olinda Member crops out around most of the eastern end of the Chapada do Araripe, the majority of fossils from this unit that are offered for sale in fossil shops and at fossil fairs around the world come from the region described here.

The new specimen

The new specimen is housed in the Staatliches Museum für Naturkunde, Karlsruhe (SMNK 2342 PAL) (Figures 2–3). It comprises a partially articulated, left-wing finger of a medium-sized (wing span calculated at 2100 mm) pterodactyloid pterosaur preserved in a slab of laminated micritic limestone typical of the Nova Olinda Member. The bones are dark brown and slightly crushed, but three-dimensional characteristics can be seen in those parts of bones that are robustly constructed. The slab was broken in several places and has been repaired. Bones project beyond edges of the slab, indicating that some of the specimen has been lost.

The specimen comprises a wing metacarpal, phalanges 1 and 2 of the wing finger, the proximal portion of phalanx 3, and a small portion of bone that might represent the terminal portion of an incomplete metacarpal. The position of the articulated bones describes a rectangle. The bones appear to have been

folded back at the articulations, perhaps due to desiccation of anteriorly located tendons. The following linear dimensions of the wing spar elements have been determined: wing metacarpal = 180 mm; phalanx 1 = 235 mm; phalanx 2 = 165 mm; proximal portion of phalanx 3 = 78 mm. The distal end of a possible metacarpal is 15 mm long. Other dimensions are considered unreliable because of compaction damage, which has caused horizontal spreading of the long bones.

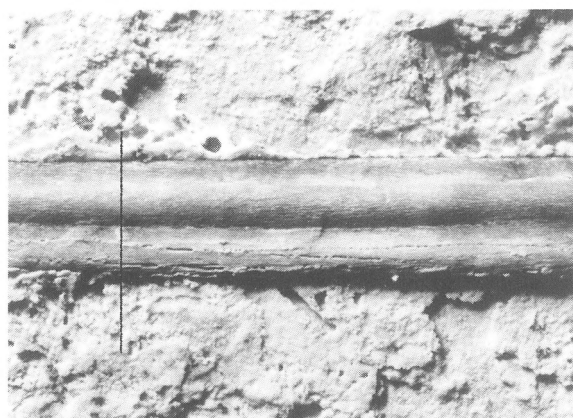
Phalanges 2 and 3 have a T-shaped cross-section, with the termination of each branch of the T bluntly rounded. The cross-bar of the T is the dorsal surface. These elements have largely resisted compaction. The vertical element of the T is situated medially or very slightly posteriorly.

Discussion

Azhdarchid pterosaurs are best known from the Upper Cretaceous of North America and are typified by the giant *Quetzalcoatlus*, which may have had a wing span reaching 11 m (Lawson 1975). Azhdarchids are characterised by possessing a T-shaped cross-section of the distal phalanges and by the possession of long necks in which there is hyper-elongation of the cervical vertebrae 3–7. In the case of the Jordanian *Arambourgiania*, this resulted in a neck length estimated at slightly more than 3 m (Frey & Martill 1996, Martill & Frey 1998b). Complete examples of azhdarchid pterosaurs are unknown, although the Late Cretaceous Chinese genus *Zhejiangopterus* is known from an almost complete skeleton lacking only the skull, as well as from isolated skull material referred to the same taxon (Unwin & Lu 1997).

Howse & Milner (1993) have shown that *Doratorhynchus* Seeley 1875, a pterosaur with relatively elongate cervical vertebrae from a succession at the Jurassic/Cretaceous boundary in Dorset, England, does not belong to the Azhdarchidae as Wellnhofer (1991: 113) had hinted at. The oldest certain azhdarchid pterosaurs are therefore from the Turonian-Coniacian of Uzbekistan (Wellnhofer 1991). If our assignment of this new specimen to the Azhdarchidae is correct, this is the oldest representative of the family, some 45 million years older than other members of the group.

Although the anatomy of azhdarchids is still poorly understood, a number of features of the skeleton appear to distinguish them from other pterosaurs. Some



A



Figure 3. A: detail of phalanx 2 of SMNK 2342 PAL, with the T-shaped cross-section seen as an elongate ridge running along the ventral margin of the phalanx. B: cross-sectional shape across phalanx 2 of SMNK 2342 PAL A. This T-shaped cross-section is a feature of the more distal phalanges of azhdarchid pterodactyloid pterosaurs; approximately $\times 1.5$. C: cross-sectional shape through wing phalanx 2 of *Quetzalcoatlus* sp. from the Javalina Formation (Texas, TMM 42138.1).

of these features are shared by other pterosaur families, but the combination of them allows their status as a higher taxon to be recognised, while hinting at their possible relationships with other pterosaur families. Some azhdarchids achieved large sizes, but immense size is not diagnostic for the group. Padian et al. (1995) described a supposedly adult azhdarchid, *Montanazhdarcho*, with a wing span of approx. 2 m, while *Zhejiangopterus linhaiensis* had a wing span of around 3.5 m (Unwin & Lu 1997).

Azhdarchids were toothless, a feature also found in Pteranodontidae, Tapejaridae and perhaps some Dsungaripteridae. Until now, most fragmentary skull material of toothless pterosaurs from the Araripe Basin has been assigned to either *Tapejara* or *Tupuxuara*, neither of which are known to have the T-shaped cross-section of the distal phalanges (D. Unwin, pers. comm.). It is possible that some of this fragmentary material could be from azhdarchid pterosaurs and should be re-examined. They have hyper-elongated cervical vertebrae in which the neural canal has descended into the corpus of the centrum, a feature that appears to be unique to the Azhdarchidae (Padian 1984), but no

hyper-elongated vertebrae have been reported from the Araripe Basin to date.

Specimens of *Quetzalcoatlus* wings in which the distal two phalanges of the wing digit are preserved show the highly characteristic T-shaped cross-section. In the 'small wing specimen' of *Quetzalcoatlus* (Texas Museum, TMM 42138.1), the vertical portion of the T-shape is situated anteriorly (Figure 3(c)). As far as we are aware, this cross-sectional shape has not been reported from any other pterodactyloid pterosaur family.

Pterosaurs assigned to the Azhdarchidae have been reported from Texas (Lawson 1975), Montana (Padian 1984, Padian et al. 1995), Canada (Currie & Russell 1982), China (Unwin & Lu 1997), Senegal (Monteillet et al. 1982), Jordan (Arambourg 1954, 1959, Frey & Martill 1996, Martill & Frey 1998b) and possibly France (Buffetaut et al. 1997). The specimen described here is possibly the first azhdarchid pterosaur from the southern hemisphere, but it is not conclusive proof. More complete specimens will either demonstrate the presence of azhdarchids in the Araripe Basin, or they may show that the T-shaped cross-sectional shape is a feature of other pterosaurs.

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