AMEGHINIANA (Rev. Asoc. Paleontol. Argent.) - 43 (1): 245-248. Buenos Aires, 30-03-2006 ISSN 0002-7014

NOTA PALEONTOLÓGICA

Neornithine bird coracoid from the Upper Cretaceous of Patagonia

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Introduction

The fossil record of Mesozoic neornithine birds is restricted to the Upper Cretaceous (Campanian, Maastrichtian) from America, Europe, Asia, and Antarctica (Hope, 2002). Most of the Cretaceous neornithines recorded at present, correspond to aquatic groups (e.g., Charadriiformes, Anseriformes; Olson and Parris, 1987; Elzanowski, 1995), but a few terrestrial forms were also documented (e.g., Psittaciformes, Galliformes, and probably Paleognathae; Stidham, 1998; Hope, 2002). This diversity of taxa constitutes the best available evidence to discuss the timing and branching sequence of clades of modern birds.

With regard to the Mesozoic record of birds from South America, it is dominated by the Enantiornithes (Walker, 1981; Chiappe, 1996), an extinct group of worldwide distribution, considered to be the sister taxon of Ornithuromorpha (e.g., *Patagopteryx* plus Ornithurae; Chiappe, 2001). In contrast, the remains of Mesozoic neornithine birds in South America are restricted to a tarsometatarsus of the presumed loon (Gaviiformes) *Neogaeornis wetzeli* (Olson, 1992), from the Maastrichtian of Chile.

The specimen here described consists of a partial coracoid, found in the Portezuelo Formation (Turonian-Coniacian, Late Cretaceous; Cruz *et al.*, 1989; Leanza, 1999) of Sierra del Portezuelo, NW Patagonia (figure 1). Albeit fragmentary, the bone shows distinct neornithine features. The fossil was found in association with remains of pelecipods, turtle plates, and a number of appendicular bones and vertebrae pertaining to small-sized ornithopods, as well as teeth of dipnoans, crocodiles, sauropods, and non-avian theropods. A few meters above this fossiliferous level, several non-avian theropods were recovered: the alvarezsaurid *Patagonykus puertai* Novas, 1997, the bizarre tetanuran *Megaraptor namunhuaiquii* Novas, 1998, the basal dromaeosaurid *Unenlagia comahuensis* Novas and Puerta, 1997, and *Neuquenraptor argentinus* Novas and Pol, 2005.

The present discovery enlarges our knowledge of the Late Cretaceous terrestrial faunas of Patagonia, but also adds relevant data about the timing and early radiation of neornithine birds.

Institutional abbreviations. PVPH, Museo Carmen Funes, Paleontología Vertebrados, Plaza Huincul.

Systematic paleontology

Aves Linne, 1758
Neornithes Gadow, 1893
Genus and species indeterminate

Referred material. PVPH 237, proximal end of a right coracoid.

Locality and Horizon. Sierra del Portezuelo, Neuquén Province, Patagonia, Argentina. Portezuelo Formation (Turonian-Coniacian, Late Cretaceous; Cruz *et al.*, 1989; Leanza, 1999).

Description

The coracoid (figure 2.B-E) is broken at mid-shaft, lacking its sternal extremity; its preserved shoulder end is not abraded, but retains the well-finished external surface of the bone. The coracoid is small, with a maximum preserved length of 9.2 mm and a maximum width of 5.5 mm. Its whole length is estimated in 3 cm, a size comparable with that of the Californian quail (*Lophortyx californica* Shaw), which reaches approximately 25 cm long from beak to tail (Olrog, 1968).

The acrocoracoid is dorsomedially projected. The acromial process and the brachial tubercle of the acrocoracoid are short and rounded, being separated by a shallow groove, as it occurs in the Early Tertiary galliforms *Ameripodius* (Quercymegapodiidae; Alvarenga, 1995; Mourer-Chauviré, 2000) and *Paraortyx* (Paraortygidae; Mayr, 2000). The ligament scar of the

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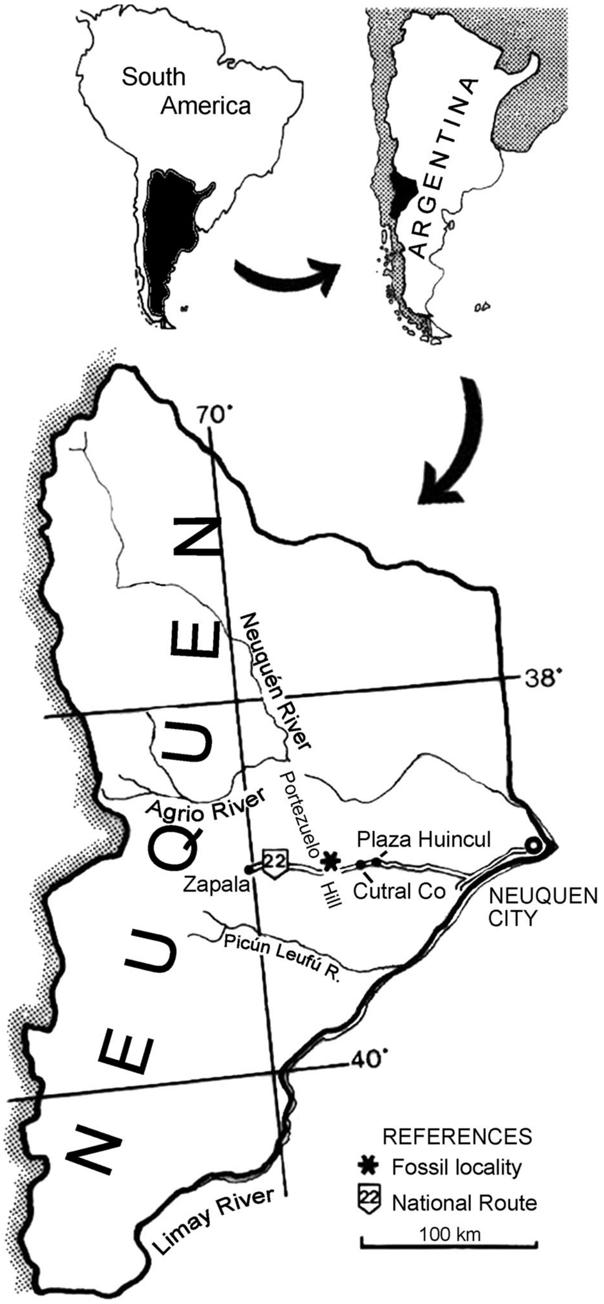

Figure 1. Map indicating fossil locality / *mapa indicando la localidad fosilífera.*

Muscle acrocoracohumeralis is wide and deep, as in most galliforms (Mayr, 2000). The sulcus for the *M. supracoracoidei* is deep and wide, as it occurs (albeit not uniquely) in Galliformes. The brachial notch is absent. The *facies articularis humeralis* is flat, facing mostly dorsally. The external margin of this surface is remarkably projected outwards, thus forming a free lateral flange (figure 2.C), thus resembling that of megapodiid and quercymegapodiid galliforms.

The *cotyla scapularis* is wide, shallow, and oval in shape. A procoracoidal process is nearly absent, a condition that shares with galliforms. The coracoidal neck is slender, straight, and rounded in cross-section.

Comparison

The coracoid has derived characters that are present in most birds, exclusive of *Archaeopteryx*: strut-like condition and a rounded *cotyla scapularis*, indicating a mobile articulation with the scapula (Chiappe, 2001). However, the presence of a well defined and concave *cotyla scapularis*, as well as, a laterally projected *facies articularis humeralis*, are synapomorphies shared with *Ichthyornis*, *Ambiortus*, and Neornithes, thus suggesting that the Neuquenian bird belongs to a group of birds more derived than Hesperornithiformes, *Patagopteryx*, and Enantiornithes (figure 3). Moreover, the coracoid exhibits two derived traits considered diagnostic of Neornithes (Hope, 2002): *facies articularis humeralis* not extended distally beyond the *cotyla scapularis*, and absence of a medial tilting of the *facies articularis humeralis*. Within Neornithes, the coracoid from Patagonia shares an apomorphic trait with Galliformes (figure 3): presence of a distinct scar for the insertion of *M. acrocoracohumeralis* (Mayr, 2000). The coracoid also resembles galliforms in having a reduced procoracoidal process (Alvarenga, 1995), a condition also present in Tinamiformes (C. Tambussi, pers. comm. 2004).

Within Galliformes, the coracoid here described resembles the extinct Quercymegapodiidae, Gallinuloididae, and Paraortygidae, and the living Megapodiidae (Mayr, 2000; Mourer-Chauviré, 1992) in having a laterally expanded *facies articularis humeralis*, and an ovoid-shaped and concave *cotyla scapularis*. In contrast, in most living members of Galliformes the *cotyla scapularis* is elliptical and flat or slightly convex (Alvarenga, 1995; Mayr, 2000), and the *facies articularis humeralis* is not laterally expanded.

Discussion

Up to now, undoubted neornithine remains come from beds not older than Santonian (Hope, 2002). Purported neornithine records of older age (e.g., Early Cretaceous) have been questioned (e.g., Padian and Chiappe, 1998; Hope, 2002). Then, the coracoid from Neuquén constitutes one of the oldest known Neornithes yet recorded.

Classically, the origin of the extant lineages of birds was interpreted as to have occurred at the end of the Cretaceous and to have been succeeded by their evolutionary "explosion" in early Tertiary times (Olson, 1985; Feduccia, 1995). However, such view has been recently challenged by both paleontological evidence

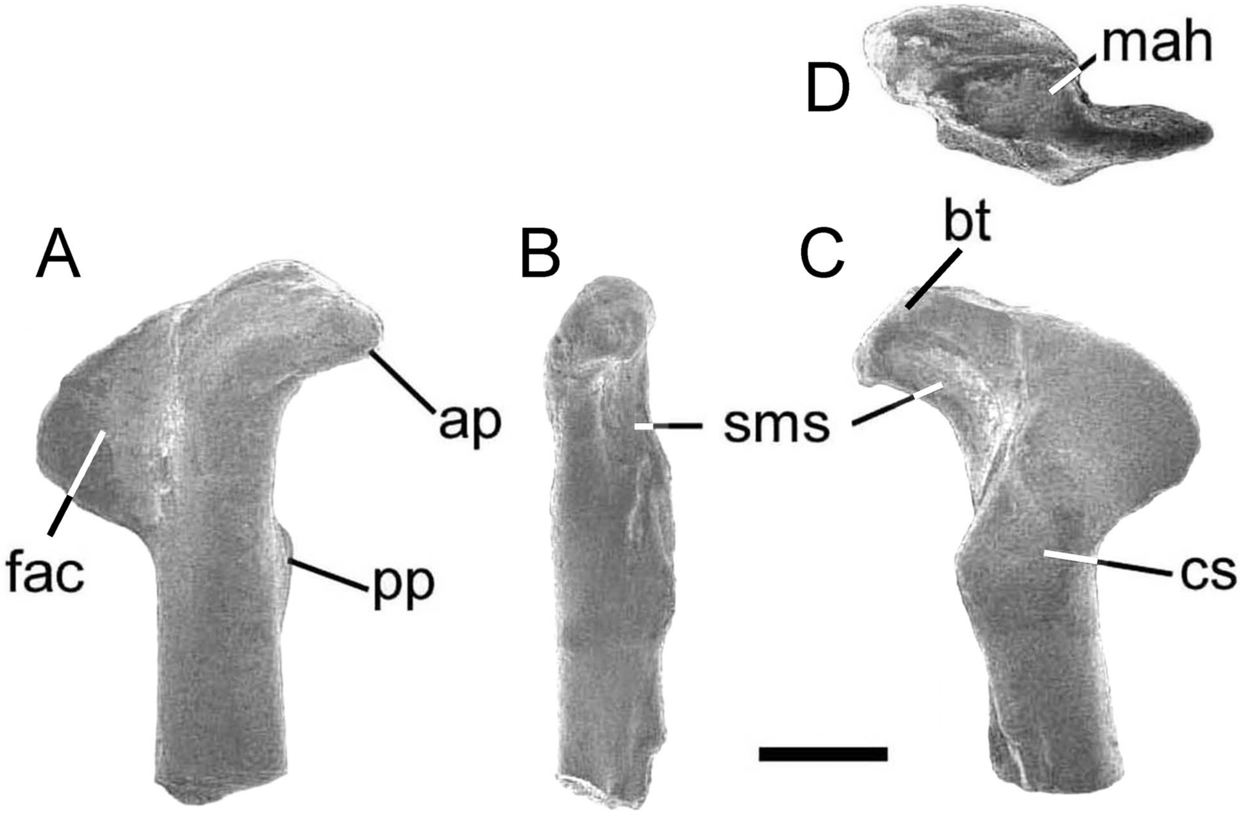

Figure 2. PVPH 237, **A**, proximal end of right coracoid in ventral; **B,** medial; **C,** dorsal and **D,** proximal views. Scale bar: 2 mm / *PVPH 237,* ***A,*** *extremo proximal de coracoides derecho en vistas ventral;* ***B,****medial;* ***C,*** *dorsal y* ***D,*** *proximal. Escala: 2 mm.* Abbreviations: **ap,** acrocoracoidal process; **bt,** brachial tubercle; **cs,** *cotyla scapularis*; **fac,** facies *articularis humeralis*; **mah,** scar for the *M. acrocoracohumeralis*; **pp,** procoracoidal process; **sms,** sulcus *M. supracoracoidei* / *Abreviaturas:* ***ap,*** *proceso acrocoracoideo;* ***bt,*** *tubérculo braquial;* ***cs,*** cotyla scapularis; ***fac,*** *facies* articularis humeralis; ***mah,*** *superficie para el* M. acrocoracohumeralis; ***pp,*** *proceso procoracoidal;* ***sms,*** *sulcus* M. supracoracoidei.

(Hope, 2002) and calibration of molecular phylogenies (Hedges *et al.*, 1996; Cooper and David, 1997). Currently, most authors consider that Neornithes radiated well before the end of the Cretaceous, interpretation that is in accordance with that predicated by molecular biologists, which calculated that major divergence time for neornithine orders around 90-100 my (e.g., Hedges *et al.*, 1996; Dyke and Van Tuinen, 2004), or even earlier (Cooper and David, 1997). Discovery of Neornithine remains in the Turonian-Coniacian Portezuelo Formation (88-92 My) is in agreement with this last interpretation, suggesting that the divergence of modern groups of birds was well in progress during the Turonian.

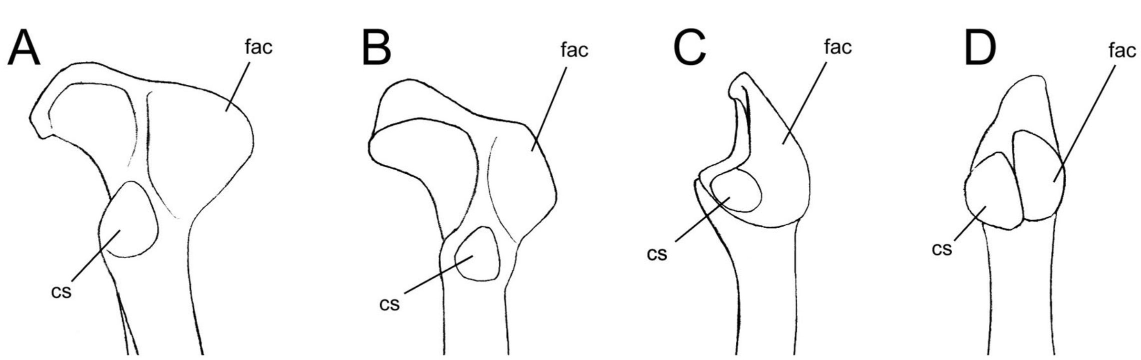

Figure 3. Comparison between PVPH 237 and several coracoids of living and extinct birds, in medial view. Not to scale / *comparación entre PVPH 237 y algunos coracoides de aves vivientes y extintas, en vista medial. No a escala.* **A,** PVPH 237; **B,** ***Ameripodius silvasantosi*** (from Alvarenga, 1995); **C,** ***Ichthyornis*** sp. (from Hope, 2002); **D,** ***Enantiornis leali*** (from Walker, 1981). Abbreviations: **cs,** *cotyla scapularis;* **fac,** *facies articularis humeralis / **A,** PVPH 237; **B,*** **Ameripodius silvasantosi** *(tomado de Alvarenga, 1995);* ***C,*** **Ichthyornis** *sp. (tomado de Hope, 2002);* ***D,*** **Enantiornis leali** *(tomado de Walker, 1981). Abreviaturas:* ***cs,*** cotyla scapularis; ***fac,*** facies articularis humeralis.

Acknowledgements

We thank to C.P. Tambussi (Museo de La Plata), J. Navas, and P. Tubaro (Museo de Ciencias Naturales, Buenos Aires) for access to ornithological collections under their care; F. Tricárico for SEM (Scan Electronic Microscope) images; C.P. Tambusi, L.M. Chiappe, H. Alvarenga, and A.M. Báez for valuable comments and discussion of the manuscript; The National Geographic Society and Agencia Nacional de Promoción Científica y Tecnológica, for their financial support.

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Recibido: 8 de julio de 2004.
Aceptado: 30 de junio de 2005.