

## Short Communication

# Europe's last Mesozoic bird

Gareth J. Dyke · Rudi W. Dortangs · John W. M. Jagt(✉) · Eric W. A. Mulder · Anne S. Schulp · Luis M. Chiappe

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G.J. Dyke

Department of Zoology, University College Dublin, Belfield, Dublin 4, Ireland

G.J. Dyke

Division of Vertebrate Zoology (Ornithology), American Museum of Natural History, Central Park West at 79th Street, New York, USA

R.W. Dortangs

Hoofdstraat 36, 6436 CG Amstenrade, The Netherlands

J.W.M. Jagt · A.S. Schulp

Natuurhistorisch Museum Maastricht, PO Box 882, 6200 AW Maastricht, The Netherlands

E.W.A. Mulder

Museum Natura Docet, Oldenzaalsestraat 39, 7591 GL Denekamp, The Netherlands

L.M. Chiappe

Department of Vertebrate Paleontology, Natural History Museum of Los Angeles County, 900 Exposition Boulevard, Los Angeles, CA 90007, USA

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E-mail: mail@nhmmaastricht.nl

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**Abstract.** Birds known from more than isolated skeletal elements are rare in the fossil record, especially from the European Mesozoic. This paucity has hindered interpretations of avian evolution immediately prior to, and in the aftermath of, the Cretaceous-Tertiary (K-T) extinction event. We report on a specimen of a large ornithurine bird (closely related to *Ichthyornis*) from the uppermost Cretaceous (Maastricht Formation) of Belgium. This is the first record of a bird from these historic strata and the only phylogenetically informative ornithurine to be recovered from the Mesozoic of Europe. Because this new specimen was collected from 40 m below the K-T boundary (approximate age of 65.8 Ma), it is also the youngest non-neornithine (=non-modern) bird known from anywhere in the world.

# Introduction

For more than a century, our knowledge of avian evolution during the Mesozoic was limited to just a few taxa, including the oldest bird, *Archaeopteryx*, from the Jurassic of Germany. Genealogical relationships among the earliest birds remained elusive. Exceptions to this were provided by the more derived marine "toothed birds" *Hesperornis* and *Ichthyornis* (Marsh 1880), which were for many years the only other well-represented avian taxa from the Mesozoic. This situation has changed in recent decades; large numbers of fossil taxa have been described, and major evolutionary radiations have been documented during the Cretaceous (Chiappe 2001). Most significant was the divergence of Neornithes, including 10,000 species of extant birds. However, the extent to which this lineage can be traced prior to the end-Cretaceous (K-T) extinction event remains controversial because few immediate outgroups have been discovered from the terminal stages of the Mesozoic and because the record of assumed neornithine (=modern) birds from the Cretaceous is extremely poor. We describe a new ornithurine bird from the higher levels of the Belgian Cretaceous. This fossil is the youngest non-neornithine (=non-modern) bird known to date from anywhere in the world- it was collected just 40 m below (equivalent to about 800,000 years before) the K-T boundary.

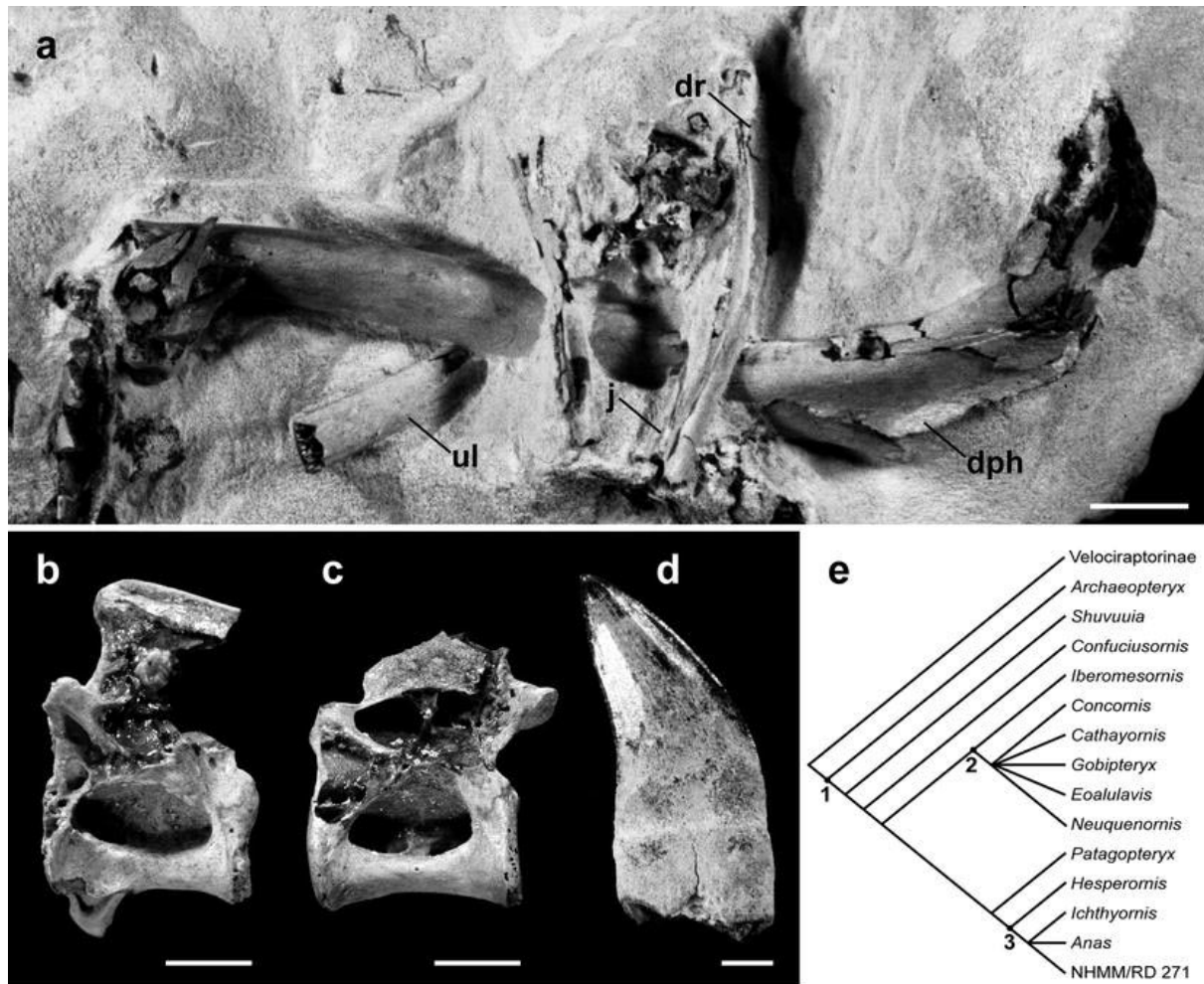
## Systematic palaeontology

Aves Linnaeus 1759

- Ornithurae Chiappe 1991
- Gen. et sp. indet.

## Specimen data

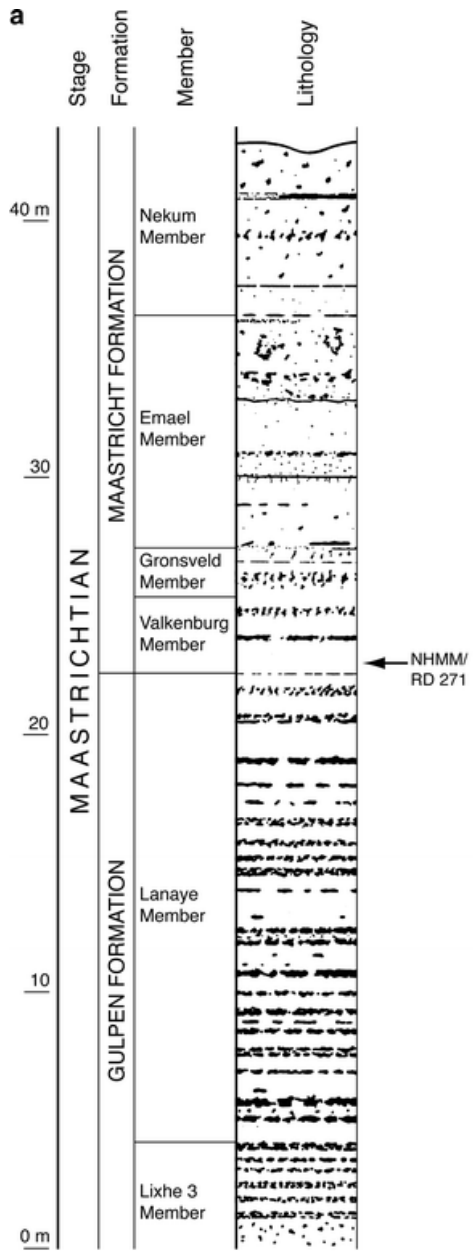
NHMM/RD 271 (Natuurhistorisch Museum Maastricht, The Netherlands, R.W. Dortangs Collection; Fig. 1), is partially encased in a fine-grained biocalcarenite block and comprises an incomplete right humerus, a distal end of a right ulna, a blade of a scapula, a proximal tarsometatarsus, portions of the mandible, two rod-like fragments tentatively identified as jugals, and a fragment tentatively identified as part of a quadrate. Other elements removed from the block include a proximal portion of a right coracoid, three thoracic vertebrae, a proximal tarsal, and a single tooth. Further preparation of NHMM/RD 271 is impossible without compromising existing elements- embedded bones are in extremely fragile condition and the surrounding rock is very friable.



**Fig. 1.** NHMM/RD 271: main block containing humerus, ulna and mandible (**a**), thoracic vertebrae (**b**, **c**), maxillary tooth (**d**), phylogeny depicting the position of NHMM/RD 271 and other Mesozoic birds (**e**). Scale bars 5 mm (**a-c**), 1 mm (**d**); *ul* ulna, *dph* deltopectoral crest of humerus, *j* jugal, *dr* dentary, 1 Aves, 2 Enantiornithes, 3 Ornithurae

## Geological context

NHMM/RD 271 was collected from the base of the Valkenburg Member (*Belemnitella junior* Zone; Fig. 2a), within the Maastricht Formation (Late Maastrichtian, Late Cretaceous) exposed at the CBR-Romontbos Quarry, west of the village of Eben Emael (Bassenge), Province of Liège, Belgium (Fig. 2b). The Cimiterie Belge Réunion (CBR)-Romontbos quarry is a key section in the type area of the Maastrichtian Stage (NE Belgium, SE Netherlands, and the Aachen area of Germany; see Felder and Bosch 2000). The section exposed covers the upper Lixhe 3 Member and the entire Lanaye Member (both Gulpen Formation), as well as the Valkenburg, Gronsveld, Emael members and more than two thirds of the Nekum Member (all Maastricht Formation).



**Fig. 2.** Lithostratigraphic log of CBR-Romontbos quarry (courtesy of W.M. Felder, unpublished), showing provenance of NHMM/RD 271 (a); map of the type area of the Maastrichtian Stage showing location of the CBR-Romontbos and ENCI-Maastricht by quarries (b)

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The upper Gulpen and nearly the entire Maastricht Formation have yielded the index belemnite *Belemnitella junior*. In anticipation of the results of an ongoing study of the *Belemnitella junior* plexus, the lower Maastricht Formation (inclusive of the Valkenburg Member) is considered to be coeval with the *tegulatus/junior* Zone (Late Maastrichtian) of the NW German biozonation (Jagt 1999). Bed-by-bed correlation of sequences exposed at the ENCI-Maastricht, CBR-Romontbos, and Ankerpoort-Curfs quarries mean that NHMM/RD 271 is from approximately 40 m below the K-T boundary (= top unit IVf-7 of the Meerssen Member, Maastricht Formation, equating with Berg en Terblijt Horizon). With an estimated sedimentation rate of approximately 10 cm ky<sup>-1</sup> (Vonhof and Smit 1996), we estimate the age of the specimen at 65.8 Ma.

## Description

Parts of the left and right rami of the mandible of NHMM/RD 271 are embedded in oblique ventral view; the left side is exposed. The dentary is broad and tapers into its articulation with an elongate angular. The dorsal articulations of the mandible are not visible. The single preserved tooth is not in situ and hence it is unclear whether it belongs to the lower mandible or to the skull. It is small, recurved and unserrated, with an elliptical root in cross-section.

The humerus of NHMM/RD 271 is incompletely preserved and is embedded in oblique cranial view. The head is rounded, as is typical of all ornithurine birds (Chiappe 2001); the bicipital crest is large and not markedly expanded cranially. A well-defined sulcus for the transverse ligament is present, the deltopectoral crest is rounded, flat and not cranially deflected, unlike all modern birds (Chiappe 2001; Clarke and Chiappe 2001). The shaft of the humerus is straight, the proximal and distal ends are not offset (as is the case in Enantiornithes and more basal birds, for example *Archaeopteryx*). On the crushed distal end of the humerus, a well-developed brachial fossa is present (although partially obscured by the shaft of the ulna) and both ventral and dorsal condyles are developed and rounded. The entire distal end of this element is deflected cranioventrally. The distal right ulna is incomplete and fragmentary with a subrounded shaft; its articulation with the humerus is offset. A medial fragment of a scapular blade is present; the blade is flat and wide, the distal end is not preserved. The scapula itself is curved sagittally, like in the Late Cretaceous *Patagopteryx deferrariisi* and all ornithurine birds (Chiappe 1996). The shoulder end of the right coracoid is broken above the level of the glenoid facet.

The three well-preserved thoracic vertebrae are not heterocoelic and have small prezygapophyses that project cranially. The centra are elongated; their cranial and caudal surfaces are not perforated by foramina. Large pneumatic fossae are present on the lateral surfaces of these vertebrae. The ratio between the vertebral foramen and the cranial surface is more than 0.5, as is the case in all birds (Chiappe 1996).

## Discussion

Using the recent cladistic analysis presented by Chiappe (2001), we coded NHMM/RD 271. The resultant matrix (for taxa and character list, see Chiappe 2001) was analysed using parsimony (PAUP version 4.01b; Swofford 1998).

This analysis yielded 42 most parsimonious trees (MPTs; 259 steps in length) that all place NHMM/RD 271 within a polytomy (within Ornithurae) along with *Ichthyornis*, the flightless *Hesperornis*, and Neornithes (Fig. 1e). Although NHMM/RD 271 is incompletely preserved, its position within Ornithurae is well supported. NHMM/RD 271 occurs within the *Patagopteryx* + Ornithurae clade because the shaft of the scapula is curved sagittally and the proximal and distal ends of the humerus are expanded in the same plane (Chiappe 2001). This specimen is an ornithurine bird because it shares with other members of this lineage (for example, *Ichthyornis*) a globe-shaped and convex humeral head; NHMM/RD 271 is allied to *Ichthyornis* and Neornithes because of a well-developed brachial depression present on the distal end of the humerus (Chiappe 2001).

NHMM/RD 271 closely resembles *Ichthyornis* but is larger in size [i.e. holotypes of *I. dispar* (Yale Peabody Museum, YPM 1450), length of humerus 58 mm; *I. victor* (YPM 1742), 72 mm; NHMM/RD 271, 98 mm]. However, other than by size, the partial preservation of NHMM/RD 271 makes comparison and differentiation from *Ichthyornis* problematic. More material of this Belgian bird, combined with a review of specimens of *Ichthyornis*, will be required to address this question. However, as in *Ichthyornis*, the small tooth of NHMM/RD 271 is recurved and enameled on both rostral and caudal surfaces, the thoracic vertebrae bear pronounced spinous processes, have small ventral processes, and have large and deeply pneumatized fossae on their lateral surfaces (Fig. 1). Furthermore, the humeral morphology of NHMM/RD 271 is similar to specimens of *Ichthyornis* in having well-developed and hooked ventral and dorsal condyles, a deep brachial impression, a medially deflected distal end, and an extensive deltopectoral crest. These character similarities have yet to be tested within a phylogenetic context.

NHMM/RD 271 is much larger than the recently described ornithurines *Apsaravis* (Norell and Clarke 2001) and the incomplete *Limenavis* (Clarke and Chiappe 2001). NHMM/RD 271 differs from *Apsaravis* on the basis of a wider and less uniformly shaped scapular blade and in the more expanded distal condyles of the humerus. NHMM/RD 271 is distinct from *Limenavis* because of a more acute angle between the dorsal margin of the distal humerus and the dorsal condyle (this approaches 30° as is the case in *Ichthyornis*; Marsh 1880).

Although some avian fossils have been described from the latter stages of the European Mesozoic and considered ornithurine, all previous records are founded on incomplete fossil material, in many cases just single bones (reviewed in Kurochkin 2000; Galton and Martin 2002), rendering their identification problematic. The only ornithurines described from Europe from more than single elements are *Enaliornis* (Elzanowski and Galton 1991) and *Hesperornis* (Kurochkin 2000). *Enaliornis barretti* and *E. sedgwicki* from the ?Lower Cretaceous of the UK (Galton and Martin 2002) are considered closely related to *Hesperornis* (Elzanowski and Galton 1991; Galton and Martin 2002). *Hesperornis rossicus* is known from incomplete postcranial and vertebral elements (Kurochkin 2000) collected from the Upper Cretaceous of Russia.

Although the fossil record of Mesozoic birds has improved dramatically in recent decades (Chiappe 2001), large temporal gaps still exist in our knowledge of avian evolution. The discovery of NHMM/RD 271 confirms that archaic members of Ornithurae were widespread and successful components of the avifauna during the last stages of the Mesozoic. The proximity of this specimen to the K-T boundary demonstrates that birds of this type existed until the end of the Cretaceous, at least in Europe.

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