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Dinosaurs from the Maastrichtian-type area (southeastern Netherlands, northeastern Belgium)

Dinosaures de la région-type maastrichtienne (Sud-Est des Pays-Bas, Nord-Est de la Belgique)

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Abstract

In comparison to pre-1980 records of nonavian dinosaur remains from the Maastrichtian type strata, material collected during the past 20 years is both fairly common and diverse, consisting mostly of isolated cranial and post-cranial remains of hadrosaurids. With the exception of the type specimen of *Megalosaurus bredai* Seeley, a fragmentary right femur, no theropod material is represented in collections screened by us. In the present contribution, specimens recognised in various collections subsequent to our last tabulation (1999) are illustrated and briefly discussed. Although we are fully aware that the material is too limited to draw meaningful conclusions from, the specimens are here tied-in with a preliminary sequence-stratigraphic interpretation of the type Maastrichtian, which is currently being refined by strontium-isotope studies of coleoid cephalopods. ***To cite this article: J.W.M. Jagt, E.W.A. Mulder, A.S. Schulp, R.W. Dortangs, R.H.B. Fraaije, C. R. Palevol 2 (2003) 67–76.***

Résumé

En comparaison avec les documents, antérieurs à 1980, concernant des restes de dinosaures non aviens en provenance de strates maastrichtiennes, le matériel récolté durant les 20 dernières années est à la fois plutôt commun et varié, composé essentiellement de restes isolés crâniens et post-crâniens d'hadrosauridés. À l'exception d'un spécimen type de *Megalosaurus bredai* Seeley, un fragment de fémur droit, il n'y a pas de restes de théropode dans les collections réalisées par nos soins. Dans

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le présent article, des spécimens reconnus dans différentes collections postérieures à notre dernière liste (1999) sont illustrés et brièvement discutés. Bien que nous soyons pleinement conscients du fait que le matériel est trop restreint pour qu'on puisse en tirer des conclusions significatives, les spécimens sont reliés selon une interprétation stratigraphique séquentielle de type maastrichtien, qui est en cours d'affinement grâce à des analyses isotopiques du strontium de céphalopodes coléoïdes. ***Pour citer cet article : J.W.M. Jagt, E.W.A. Mulder, A.S. Schulp, R.W. Dortangs, R.H.B. Fraaije, C. R. Palevol 2 (2003) 67–76.***

Keywords: Ornithopoda; Theropoda; Maastrichtian; Distribution; The Netherlands; Belgium; sequence stratigraphy

Mots clés : Ornithopodes ; Théropodes ; Maastrichtien ; Répartition ; Pays-Bas ; Belgique ; stratigraphie séquentielle

1. Introduction

With the possible exception of a single phalanx, first recorded in 1985 [3], all nonavian dinosaur remains from the extended type area of the Maastrichtian Stage (Fig. 1), are confined to strata assigned to the Maastricht Formation. This means that these all are of Late Maastrichtian age (*Belemnitella junior* and *Belemnella kazimiroviensis* belemnite zones; 66.1 Ma and younger). Although for a few finds the exact stratigraphic provenance is unknown, the material is comparatively well dated, having been collected from fully marine carbonate rock sequences with good biostratigraphic control. However, these specimens have the

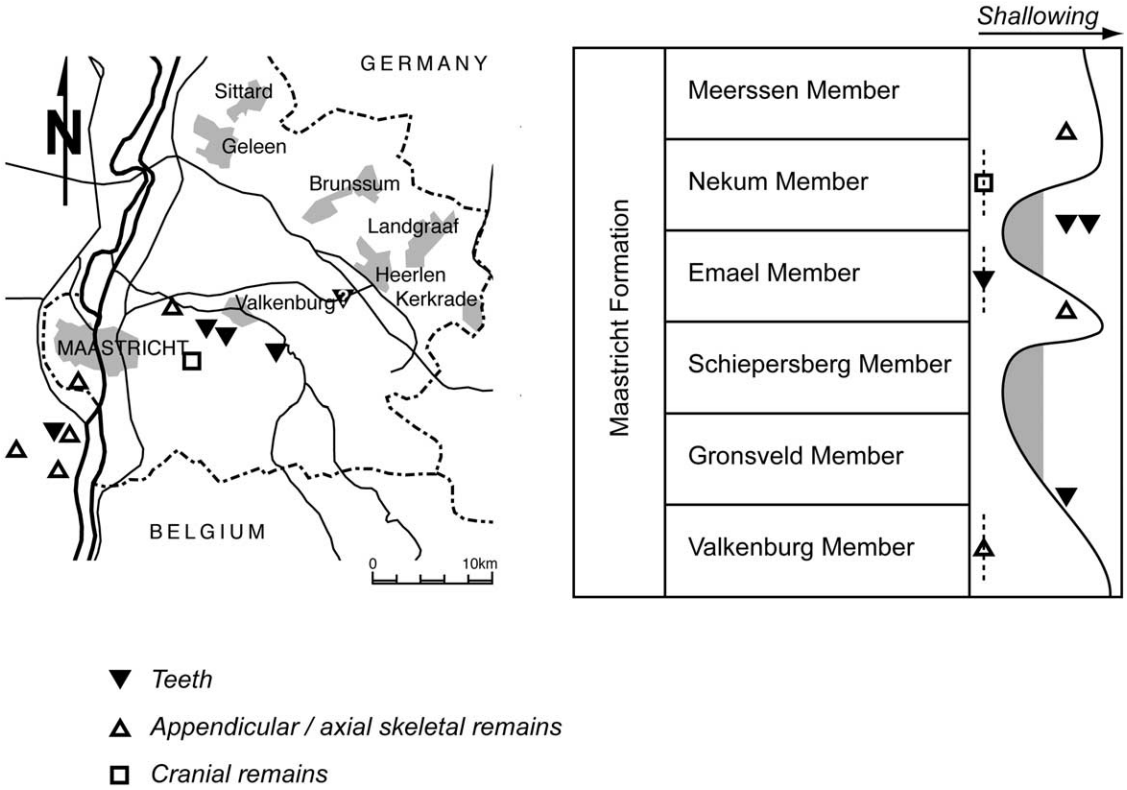

Fig. 1. Map of the study area, with all stratigraphically well-documented nonavian dinosaur remains known to date plotted, and local stratigraphy (Maastricht Formation), with sea-level curve (from [16]).

Fig. 1. Carte de la zone d'étude, représentant tous les restes de dinosaures non aviens connus et bien documentés stratigraphiquement, et stratigraphie locale (formation de Maastricht), avec la courbe du niveau de la mer.

disadvantage that, as a rule, they comprise isolated and often fragmentary material only, which is difficult to assign firmly to genus and/or species.

To date [20], from the Maastrichtian type area, which includes the southern part of the Dutch province of Limburg, the contiguous Belgian territory (provinces of Limburg and Liège) [8] and the Aachen area (Germany) [10], only isolated skeletal elements have been recorded. Possible exceptions are the type lot of *Orthomerus dolloi* Seeley [17] as well as a set of hadrosaurid limb bones [9, 13] apparently found associated at the Ankerpoort-Curfs quarry (Geulhem, see below); unfortunately, precise documentation of site condition at the time of discovery is lacking.

Subsequent to the latest tabulation [20] of nonavian dinosaur remains from the Maastrichtian type area, a few elements have been recognised recently. These include a much abraded hadrosaurid dentary tooth, a fragmentary hadrosaurid right tibia, and two fragments of limb bones (one possibly representing a femoral shaft) that show a number of bivalve borings as well as adnate bivalves and cheilostome bryozoans.

Although we fully realise that the material currently available is too limited to draw meaningful conclusions from, we have plotted the stratigraphically well-documented specimens (Fig. 1) in a preliminary sequence stratigraphy [16] for the type Maastrichtian. The picture shows most remains coming from the upper part of the Maastricht Formation (Emael and Nekum members, in particular), which represent phases of inundation of nearby landmasses and of maximum flooding. Fewer specimens originate from parts of the sequence that represent regressive phases with presumed increased riverine input (runoff).

Despite the fact that regional tectonics and their influence on Late Cretaceous deposition in the study area are now fairly well understood, details of palaeogeography are largely unknown. As northeastern Belgium and southeastern Netherlands flooded during most of the Late Maastrichtian, the hinterland is generally assumed to have corresponded to a broad area southeast of Aachen and across the Eifel (Germany) towards central Europe (?Bohemia). Naturally, the fact that the nonavian dinosaur remains currently known from the study area are not diagnostic below the family level (at best) seriously hampers any interpretation of geographic provenance and faunal relationships.

Below all previous records of dinosaur remains are briefly discussed, subdivided into two sections (pre- and post-1980 records), complemented by descriptions of recently recognised material. To denote the repository of material referred to in the text, the following abbreviations are used:

- NHM: The Natural History Museum, London (formerly British Museum of Natural History);
- IRScNB: 'Institut royal des Sciences naturelles de Belgique', Brussels;
- MND: Museum Natura Docet, Denekamp;
- NHMM: 'Natuurhistorisch Museum Maastricht' (RD-R.W. Dortangs collection; RN - R. van Neer Collection);
- OGP: 'Oertijdmuseum de Groene Poort', Boxtel;
- TM: Teylers Museum, Haarlem.

2. Pre-1980 records

The earliest record (see [8] for details) of dinosaur remains from the type Maastrichtian refers to the type lots [17] of the hadrosaurid '*Orthomerus dolloi*' (NHM R 42954–42957) and of the theropod *Megalosaurus bredai* (NHM R 42997). The former comprises fragmentary right and left femora, a left tibia and a metatarsal, the latter a single right femur, originally forming part of the J.G.S. van Breda Collection. Whether or not the remains of '*O. dolloi*' were found associated, and thus could have belonged to a single individual, can no longer be determined. Nor is their precise stratigraphic provenance known; having been collected from the Maastricht area, they may be assumed to have come from the Maastricht Formation. It should be borne in mind that in Van Breda's days (between 1820 and 1865), there were numerous small pits at the St Pietersberg, south of Maastricht, where local people dug chalk for various purposes. In addition, there still was a lot of quarrying activity in subterranean galleries and workmen collected fossils and sold them on to interested parties. In such cases, details of stratigraphic provenance were rarely recorded, if ever.

Current views [19] consider the type material of *Orthomerus dolloi* to be hadrosaurid indet. Interpretations of *Megalosaurus bredai* by subsequent authors have varied considerably: ornithomimid [15], Theropoda indet. [19], ceratosauroid (?abelisaurid) [12], or closely comparable to *Dryptosaurus* [4]. Despite these uncertainties of assignment, this is the sole

record of theropod dinosaurs from the Maastrichtian type area; all other finds pertain to ornithopods.

Possibly conspecific with '*O. dolloi*' are two isolated vertebrae (IRScNB collections, ex C. Ubaghs Collection), one probably representing the first or second caudal, the other a median caudal. The fact that both specimens display saw marks means that they must have been collected by people working in subterranean galleries. This then makes it more than likely that the material comes from the Nekum Member (Maastricht Formation) of the Maastricht area (St Pietersberg). The state of preservation of one of these specimens in particular would rule out transportation over large distances, suggesting it may have come from a (partial) floating carcass.

The IRScNB collections also include two teeth that have been ascribed to dinosaurs [18]. One of these is from the Kunrade area (southern Limburg, the Netherlands), from an unknown level within the Kunrade limestone facies (Maastricht Formation). In this area, the upper part of this facies is highly fossiliferous, and the fact that Ubaghs [18] noted that he found the tooth together with a sacrum of the cheloniid *Allopleuron hofmanni* suggests that it originated from this part of the sequence. Compared to the Maastricht Formation (tuffaceous chalk facies) exposed in the Maastricht

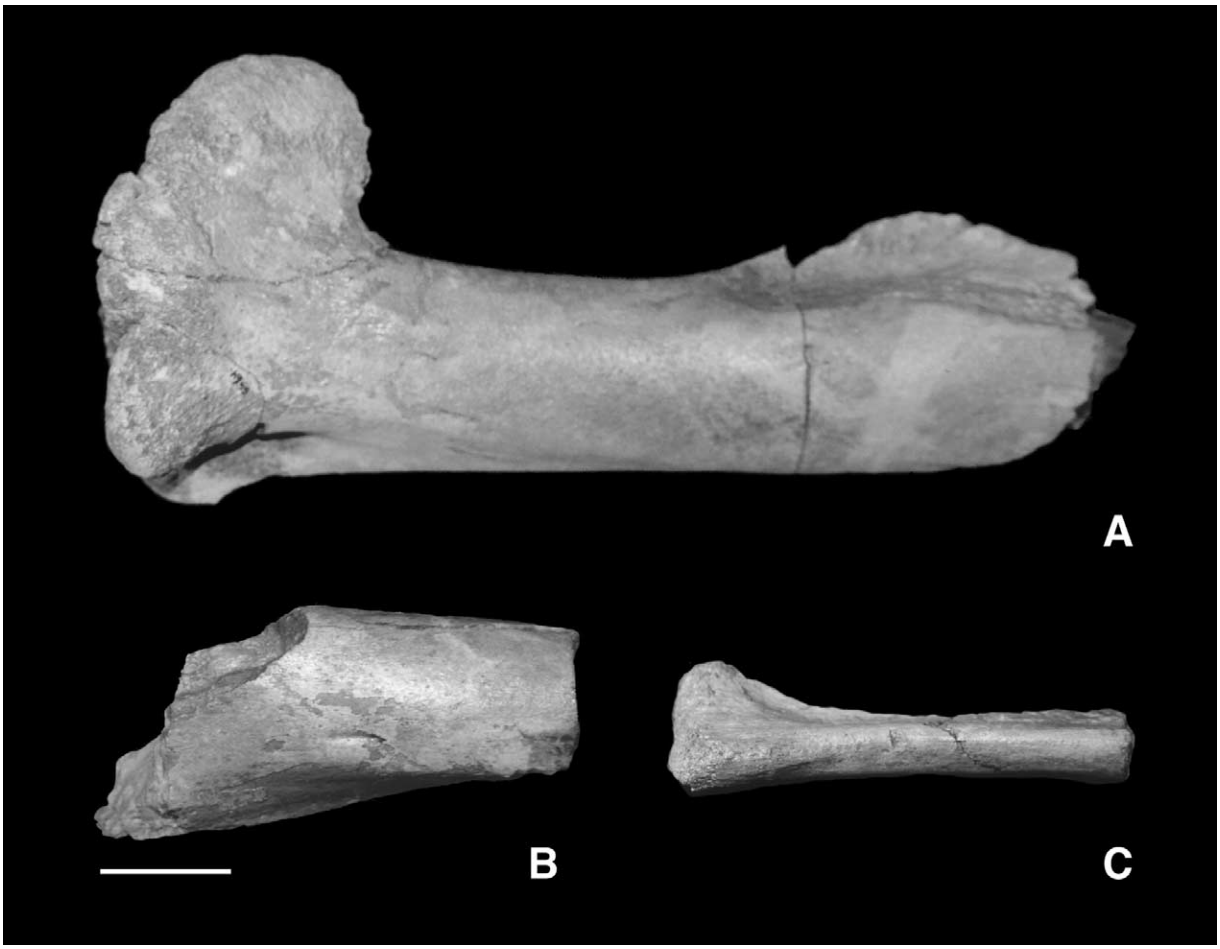

Fig. 2. Indeterminate hadrosaurid limb bones from the Ankerpoort-Curfs quarry (Geulhem, Berg en Terblijt). **A**, Fragmentary left femur (MND K 21.04.003); **B**, fragmentary left tibia (MND K 21.04.004); **C**, fragmentary left fibula (MND K 21.04.005). Scale bars equal 50 mm.
Fig. 2. Os de membres d'hadrosauridé indéterminé provenant de la carrière d'Ankerpoort-Curfs (Geulhem, Berg en Terblijt). **A**, Fragment de fémur gauche (MND K 21.04.003) ; **B**, fragment de tibia gauche (MND K 21.04.004) ; **C**, fragment de fibule gauche (MNK K 21.04.005). Barres d'échelle égales à 50 mm.

area, this part of the Kunrade facies would correspond to the lower Emael Member. The other tooth illustrated by Ubaghs [18] is from near Maastricht, from the higher part of the Maastricht Formation (Nekum or Meerssen members). We here follow [12] in interpreting one of these specimens (figs 4, 5 in [18]) as a mosasaurid (?pterygoid) tooth, but have doubts about the other (figs 1–3 in [18]). Without having seen the original, we cannot comment on this record in more detail.

3. Post-1980 records

What was stated above for the type lot of '*O. dolloi*' also holds for the find (in September 1967) of three hadrosaurid limb bones from the section then exposed at the Curfs quarry (now Ankerpoort-Curfs; Geulhem, the Netherlands). The colour and size of these bones suggest they may have originated from a single individual; however, outcrop conditions and exact provenance have not been recorded. This lot (leg. L. de Heer; Fig. 2) comprises a fragmentary left femur (MND K 21.04.003), a fragmentary left tibia (MND K 21.04.004) and a fragmentary left fibula (MND K 21.04.005). One of us [13] previously favoured assignment of these remains to *Telmatosaurus dolloi* (= '*Orthomerus dolloi*'). The stratigraphic provenance was determined on the basis of an analysis of bioclast assemblages [9] and held to be the basal part of the Meerssen Member, with burrows piping down into the underlying Nekum Member. The adhering rock was noted to be indurated (?in places), pointing to one of the 'hardgrounds' that characterise the lower Meerssen Member. However, a renewed study of a matrix block associated with MND K 21.04.003, as well as reconsideration of a previous list of associated macrofossils [13], suggest there may be an alternative interpretation. Macrofossil taxa identified in this matrix block and listed previously include Diploctenium [scleractinian], *Hemiaster prunella* and *Faujasia apicalis* [echinoids], *Nerita rugosa* [= *Otostoma retzii*, gastropod], *Baculites vertebralis* [ammonite] as well as Glycymeris sp., *Avicula geulemensis* [= *Tenuipteria argentea*], a venerid, and *Syncyclonema* sp. [all bivalves]. Such an association is well known from the upper Meerssen Member, characterising the upper part of section IVf-6, directly below the K/T boundary in the area [2].

As for the type lot of '*O. dolloi*', assignment of MND K 21.04.003–005 to the Hadrosauridae is beyond doubt, but with unresolved relationships within this group.

The first skull material on record from the Maastrichtian type area is a partial right dentary (NHMM 198027) of a hadrosaurid (with unresolved relationships) from the Ankerpoort-'t Rooth quarry at Bemelen (southern Limburg, the Netherlands). As based on outcrop conditions during the discovery, this is definitely from the Maastricht Formation, and more precisely from the ?Nekum Member [3, 14]. Unfortunately, the jaw does not preserve any teeth, which would have facilitated assignment of isolated teeth collected in recent years (see below).

A fragmentary left metatarsal III (NHMM 1996001, leg. J.H. Kuypers) was recorded [14] from the Ankerpoort-Marnebel quarry at Eben Emael (Bassenge, Belgium), collected from 0.25 m above the base of the Emael Member (Maastricht Formation). This specimen compares well to other hadrosaurid metatarsals illustrated in the literature, but cannot be assigned to genus or species.

Closely comparable, albeit much larger, is an isolated fragmentary right metatarsal III (NHMM RD 241) from the nearby CBR-Romontbos quarry at Eben Emael (Bassenge, Belgium), collected from the Valkenburg Member (Maastricht Formation). This is large, but relatively gracile for a hadrosaurid [20].

To date, four isolated teeth of a type characteristic of hadrosaurids [5–7] are on record from the Maastrichtian type area, three of which have been described previously [20]. A right maxillary tooth (NHMM 1999012, leg. E. Croimans) (Fig. 3a and b) is from the Ankerpoort-Marnebel quarry at Eben Emael (Bassenge, Belgium), collected from the lower Gronsveld Member (Maastricht Formation). This has a height/width ratio of 0.34; the straight primary ridge is slightly offset and angled distally, suggesting it came from the mesial portion of the dentition. The apex of the crown is slightly lingually recurved, typical of hadrosaurid maxillary teeth, and faint fluting is seen across the enamelled regions mesial and distal to the primary ridge; very small marginal denticles are restricted towards both sides of the apex. These features allow assignment to the Hadrosauridae, but where this specimen belongs within this large clade is impossible to say. A larger crown (NHMM 1997274, leg. J. Vol-

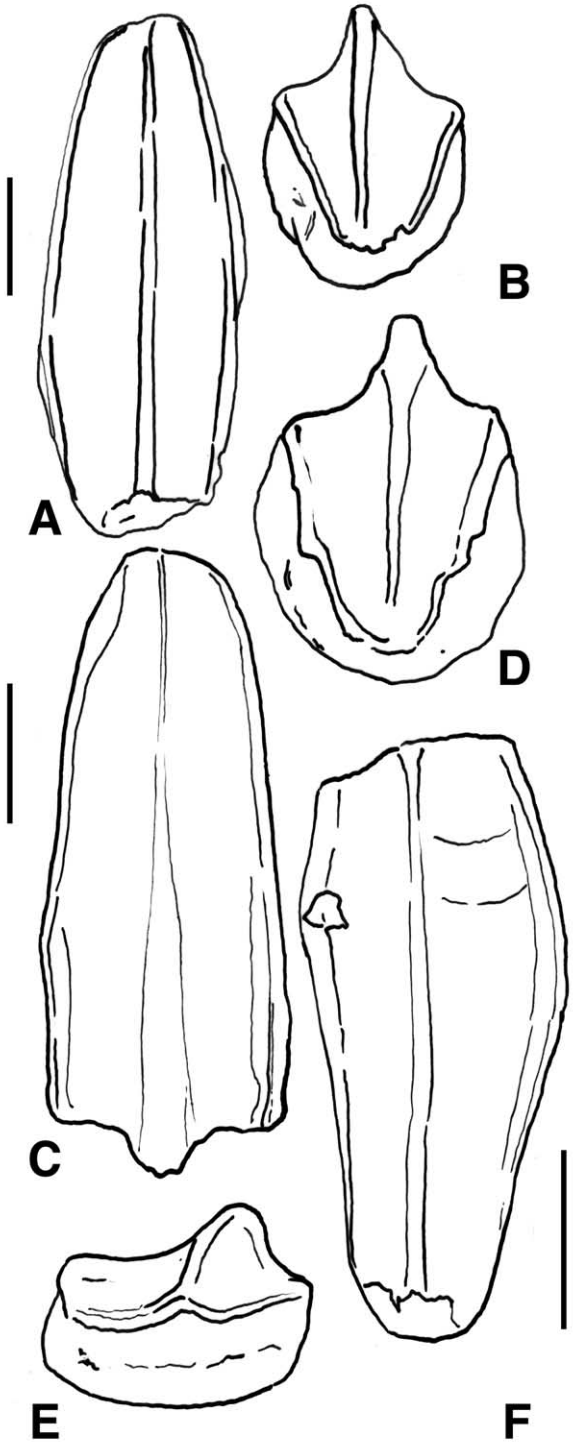

Fig. 3**.** Isolated hadrosaurid teeth (scale bar: 5 mm). **A**, **B**, Right maxillary tooth (NHMM 1999012, leg. E. Croimans), from the Ankerpoort-Marnebel quarry at Eben Emael (Bassenge, Belgium), lower Gronsveld Member (Maastricht Formation); **C**, **D**, ?right maxillary tooth (NHMM 1997274, leg. J. Vollers), from Sibbe (Valkenburg aan de Geul, southern Limburg, the Netherlands), Maastricht Formation, level unknown (?Emael Member); **E**, **F**, (?left) dentary tooth (NHMM RD 214), from former Blom quarry, Berg en Terblijt (southern Limburg, The Netherlands), basal Nekum Member (Maastricht Formation); possibly euhadrosaurian.

Fig. 3. Dents isolées d'hadrosauridés (barres d'échelle : 5 mm). **A**, **B**, Dent du maxillaire droit (NHMM 1999012, leg E. Croimans), provenant de la carrière d'Ankerpoort-Marnebel à Eben Emael (Bassenge, Belgique), membre inférieur de Gronsveld (formation de Maastricht) ; **C**, **D**, dent du maxillaire droit (?) (NHMM 1997274, leg. J. Vollers), de Sibbe (Valkenburg aan de Geul, Sud Limburg, Pays-Bas), formation de Maastricht, niveau inconnu (membre d'Emael ?) ; **E**, **F**, dent de dentaire gauche (?), (NHMM RD 214), de l'ancienne carrière de Blom, Berg en Terblijt (Sud Limburg, Pays-Bas), membre basal de Nekum (formation de Maastricht); euhadrosaurien possible.

lers; see Fig. 3c and d) is probably also from the right maxilla (height/width ratio 0.37), and is from Sibbe (Valkenburg aan de Geul, southern Limburg, The Netherlands). Although certainly originating from the Maastricht Formation, the exact level is unknown (?Emael Member). Features displayed by this tooth show it to be from the central region of dentition; there are no obvious enamel fluting and marginal denticles, but this may be due to wear. The specimen is assignable to the Hadrosauridae, with unresolved relationships within the clade.

The single (?left) dentary tooth (NHMM RD 214; see Fig. 3e and f) is from the former Blom quarry (now infilled) at Berg en Terblijt (southern Limburg, the Netherlands), having been collected from the basal Nekum Member (Maastricht Formation). The crown is distally recurved and the primary ridge offset distally, especially towards the root. Modestly developed denticles are seen on the upper elevated mesial and distal rims of the lingual crown surface. Apparently, this specimen is assignable to Euhadrosauria, the clade of hadrosaurids that excludes *Telmatosaurus transsylvanicus*, with unresolved relationships within this more inclusive group.

In the Teylers Museum collections (Haarlem), a poorly preserved fragmentary (?right) humerus (TM 11253) of some sort of hadrosaurid, from the St Pietersberg, Maastricht (Maastricht Formation, level unknown), has recently been recognised [20]. Its gracile form as well as other features noted [20] suggest that this may represent a non-lambeosaurine hadrosaurid.

An isolated phalanx [?first phalanx of 4th toe in left hindlimb from Pache-Lowe (Eben Emael, Bassenge, Belgium) was collected from an unknown level [3] within the upper Gulpen Formation or Maastricht Formation, as was a fragmentary left ulna from the

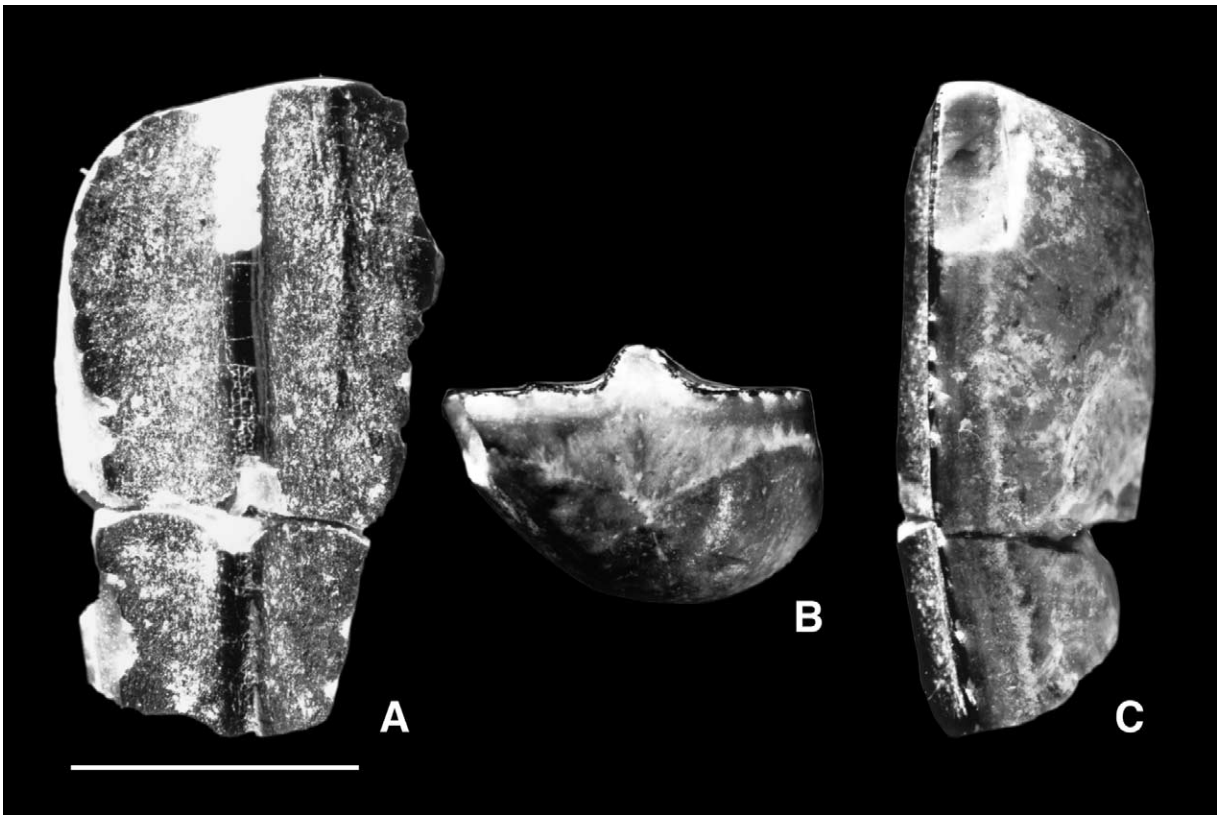

Fig. 4. Isolated ?euhadrosaurian (?right) dentary tooth (NHMM RN 28), from former Blom quarry, Berg en Terblijt (southern Limburg, the Netherlands), basal Nekum Member (Maastricht Formation) - compare Fig. 3e and f. Scale bar: 5 mm.
Fig. 4. Dent isolée de dentaire (droit ?) d'euhadrosaurien ? (NHMM RN 28), de l'ancienne carrière de Blom, Berg en Terblijt (Sud Limburg, Pays-Bas), membre basal de Nekum (formation de Maastricht) – comparer Fig. 3e et f. Barre d'échelle : 5 mm.

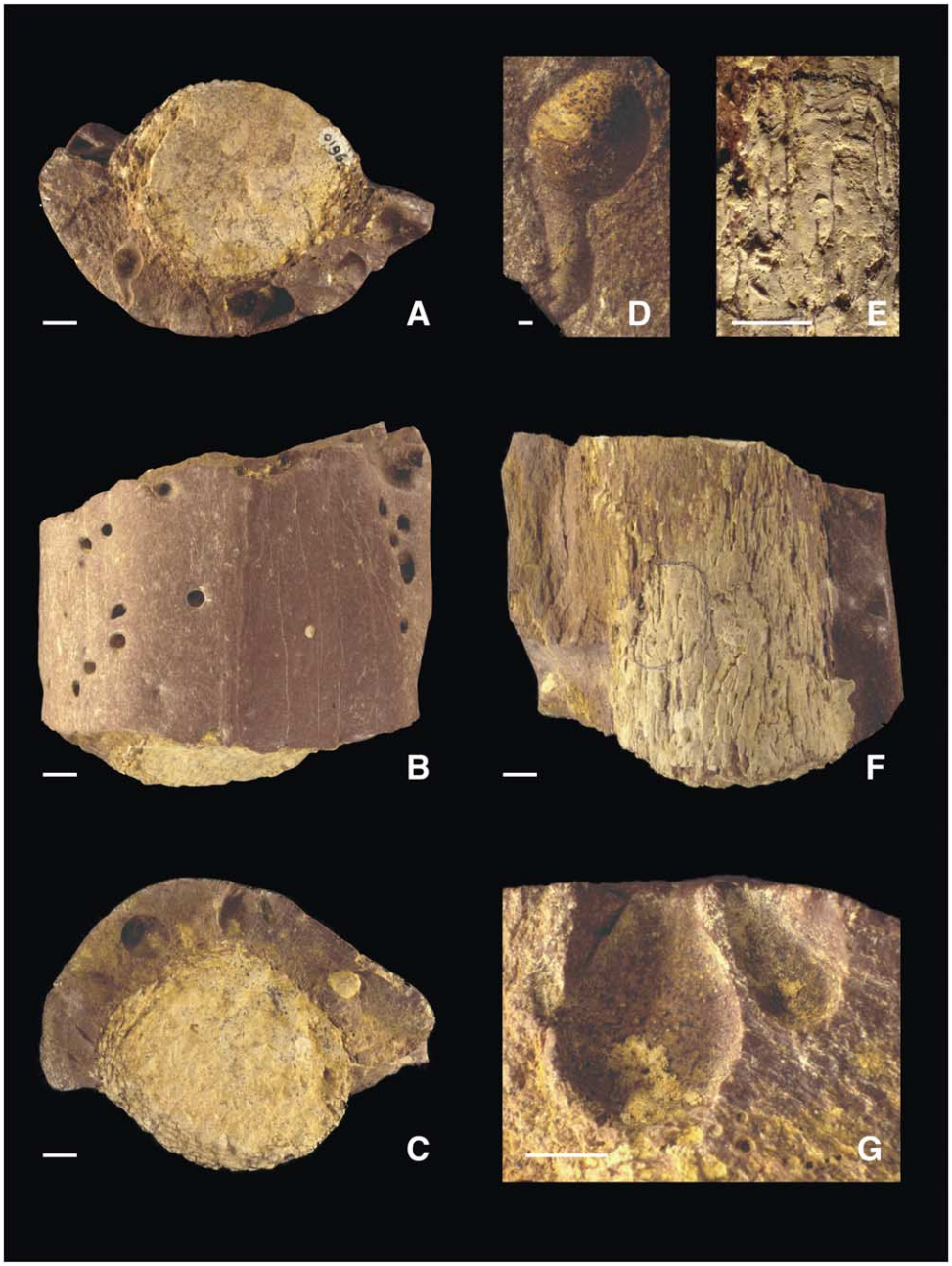

Fig. 5. Indeterminate fragment of femoral shaft (OGP 0196) in various aspects (**A–C, F**), showing *Gastrochaenolites*-type bivalve borings (**D, G**), as well as adnate exogyrine oysters and cheilostome bryozoans (**E**), probably from the Geulhem area, and Maastricht Formation (?upper part, Nekum or Meerssen members). Scale bars: 10 mm, except in D, 1 mm.

Fig. 5. Fragment indéterminé de fémur (OGP 0196) sous différents aspects (**A–C**, **F**), creusé par des bivalves de type *Gastrochaenolites* (**D**, **G**), montrant également des huîtres exogyres adnates et des bryozoaires chéilostomes (**E**), provenant probablement de la région de Geulhem et de la formation de Maastricht (membres supérieurs Nekum ou Meerssen ?). Barres d'échelle : 10 mm, excepté en D, 1 mm.

Ankerpoort-Marnebel quarry at Eben Emael, from an unknown level within the Maastricht Formation. Typically hadrosaurid, the latter specimen must remain indeterminate at the generic and specific levels [3].

Nonavian dinosaur material recognised recently includes the following specimens.

- NHMM RN 28 (Fig. 4) is a fragmentary, much abraded dentary (?right) tooth from the former Blom quarry at Berg en Terblijt (southern Limburg, the Netherlands). As preserved, this specimen appears close to NHMM RD 214, also collected from the basal Nekum Member (Maastricht Formation), in showing an obvious curvature of the single primary ridge on the enamelled lingual surface.
- OGP 2111 (not illustrated), reportedly from the Geulhem area (?Ankerpoort-Curfs quarry), is a poor fragment (ca 98 mm in length, estimated diameter ca 50 mm) of dinosaur limb bone. The state of preservation, highly fragmentary, abraded and bored, precludes definite assignment. It is here listed in view of the presence of a number of bivalve borings. OGP 0196 (Fig. 5) is here interpreted as a fragment of a femoral shaft (with unresolved relationships), as based on its considerable dimensions and the typical outline of the compact bone which makes us suspect the proximity of a lateral trochanter (Fig. 5c). It is remarkable in showing numerous bivalve borings of the *Gastrochaenolites* ichnogenus type [11], adnate pycnodonteine and exogyrine oysters as well as at least five species of cheilostome bryozoans. In addition, bases of spirorbid serpulids and an external mould of a serpulid operculum have been recognised. The bivalve borings and the epibionts clearly show this specimen to have been either reworked and/or to have remained on the seafloor for a considerable period of time, comparable to, e.g., a reworked Miocene whalebone from North Carolina [1].

The exact stratigraphic provenance of OGP 0196 and OGP 2111 is unknown, but may be assumed to have been the upper part of the Maastricht Formation (?upper Nekum or basal Meerssen members).

Finally, the proximal portion of a right hadrosaur tibia (NHMM 2002067) is presented in Fig. 6, from the upper Nekum Member or lower Meerssen Member (Maastricht Formation) of southern Limburg (The Netherlands; precise locality data are lacking) is presented. This specimen, 263-mm long (as preserved),

Fig. 6. Fragmentary [proximal portion] right tibia of hadrosaurid (NHMM 2002067) from the Maastricht area, in medial view. Scale bar: 50 mm.
Fig. 6. Fragment de tibia droit [portion proximale] d'hadrosauridé (NHMM 2002067) de la région de Maastricht, en vue médiane. Barre d'échelle : 50 mm.

comprises approximately two thirds of the original bone, and has a near-circular shaft with an anteriomedial dent. There are proximal fractures, the head is missing and the surface eroded. A faint remnant of cnemial crest is visible; the position of the foramen for the nutritive artery is slightly closer to the cnemial crest than in MND K 21.04.004 (see above). The largest diameters (measured anteriolaterally-posteriomedially) of the spongeous core and of the compact bone are 36 and 62 mm, respectively (vs 25 and ca 60 mm, respectively, in MND K 21.04.004). In view of the above, it appears that NHMM 2002067 and MND K 21.04.004 are not conspecific, suggesting that more than one species of hadrosaurid is represented (compare isolated teeth; see above).

4. Conclusion

Despite being limited in number of specimens and lacking mostly diagnostic features that would allow material to be assigned to genus and/or species, the nonavian dinosaur remains from the extended type area of the Maastrichtian Stage are shown to include more than one species. At least one type of theropod and more than one taxon of non-lambeosaurine hadrosaurid as well as a possible euhadrosaurian are represented in this material. More, and preferably better preserved, material is needed to establish relationships with other areas in Europe and to make taxonomic assignment more reliable. Based on the pattern of distribution here illustrated (Fig. 1), preferential screening of this part of the Maastrichtian sequence in the area (both at working and disused quarries) could be expected to yield additional material in future.

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