



Dinosaur remains from the type Maastrichtian: an update

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Abstract

Isolated cranial and post-cranial remains of hadrosaurid dinosaurs have been collected from various outcrops in the type area of the Maastrichtian stage during the last few years. In the present contribution, dentary and maxillary teeth are recorded from the area for the first time. Post-cranial elements comprise a newly collected, fragmentary, large right metatarsal III and a broken ?right humerus, recently recognised in the collections of Teylers Museum (Haarlem). Unfortunately, none of these remains can be identified to species level. The available material suggests, however, that more than one taxon of non-lambeosaurine hadrosaurid and a possible euhadrosaurian are represented. Most of the new finds are stratigraphically well documented, which means that they may be linked to the recently published sequence-stratigraphic interpretation of the type Maastrichtian. Dinosaur remains recorded previously from the Maastrichtian type area are tabulated.

Abbreviations: BM(NH): Natural History Museum, London (formerly British Museum [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); TM: Teylers Museum, Haarlem

Introduction

In the shallow-marine facies represented by the upper Gulpen Formation (Lanaye Member) and the Maastricht Formation (Valkenburg, Gronsvelt, Schiepersberg, Emael, Nekum, and Meerssen Members) of the Maastrichtian type area (Figure 1), latest Cretaceous (Maastrichtian) dinosaurs are obviously extremely rare. Although dinosaur remains in marine strata have the advantage that they can commonly be well dated, they have the disadvantage – with very few exceptions (see, among others, Coombs & Deméré 1996) – that they comprise, as a rule, isolated and often fragmentary, material only, which is difficult to assign to a genus and/or species (Baird & Horner

1979, Buffetaut & Le Loeuff 1991, Le Loeuff 1991, Buffetaut 1994, Le Loeuff et al. 1994, Wellnhofer 1994). So far, only isolated cranial and appendicular skeletal elements have been recorded from the type Maastrichtian. Material collected during recent years includes three dentary and maxillary hadrosaurid teeth, and a fragmentary, large right metatarsal III. From the collections of Teylers Museum (Haarlem) comes a fragmentary ?right humerus, which was probably collected at the end of the nineteenth century but was never described or figured. The new material suggests that more than one hadrosaurid dinosaur taxon is represented, although relationships within the clade remain unresolved (Jagt et al. 1998).



Figure 1. Map of southern Limburg (the Netherlands) and contiguous areas in Belgium, showing localities and provenance of dinosaur remains mentioned in the text. A: appendicular and/or axial skeletal remains; T: teeth; C: cranial remains.

Previous finds of dinosaur remains in the type Maastrichtian generally suffer from a lack of stratigraphic and geographic detail. Table 1 lists all dinosaur remains from the type area of the Maastrichtian stage recorded to date, with current repositories and pertinent literature references. Although dinosaur remains are scanty in the shallow-marine facies of the upper Gulpen and Maastricht Formations, their distribution (using only material collected in situ) appears to be intimately linked to relative sea-level fluctuations in the area (Schjøler et al. 1997).

Description of new material

The new material comprises teeth and appendicular skeletal remains, which will be described in the following subsections.

Teeth

Of the two newly collected maxillary teeth, the smaller one (cast NHMM 1999012; original in E. Croimans Colln), with a crown height of approx. 22 mm (as preserved) comes from the right maxilla and has a height/width ratio of 0.34 (Figure 2). The straight primary ridge is slightly offset and angled distally, most likely indicating that it comes from the mesial portion of the dentition. None of the root is preserved. The apex of the crown is slightly lingually

curved, which is typical of hadrosaurid maxillary teeth. The mesial and distal margins of the crown are raised as ridges. Faint fluting is found across the enamelled regions mesial and distal to the primary ridge and very small marginal denticles are restricted towards both sides of the apex. These features indicate that this specimen can be referred unambiguously to Hadrosauridae (Weishampel & Horner 1990, Weishampel et al. 1993; see also Coombs 1988, Laurent et al. 1997, Norman & Kurzanov 1997, Company et al. 1998, Casanovas et al. 1999), but there are no characters to indicate where this tooth belongs within this large clade.

The larger crown (NHMM 1997274, ex J. Vollers Colln) has a crown height of 22 mm, as preserved, and is also probably from the right maxilla, with a height/width ratio of 0.37 (Figure 3). Compared with NHMM 1999012 (see above), this larger crown is slightly water-worn. The primary ridge is straight and only very slightly offset and angled distally, indicating that it came from the central region of the dentition. Like NHMM 1999012, the apex of the present tooth is slightly lingually curved and the mesial and distal margins of the crown are raised as ridges. There is no obvious enamel fluting mesial and distal to the primary ridge and there are no marginal denticles towards the apex, which may be due to surface erosion of the crown. This specimen also belongs to Hadrosauridae, with unresolved relationships within the clade.

The single dentary tooth (NHMM RD 214) is slightly worn, has a crown height of 16.5 mm, as preserved, and is probably from the left side of the jaw, with a height/width ratio of 0.36 (Figure 4). The crown is recurved distally, a condition reflected in the obvious curvature of the single primary ridge on the enamelled lingual surface. In addition, the primary ridge is offset distally, especially towards the root. Denticles are modestly developed on the upper elevated mesial and distal rims of the lingual crown surface. Unlike the maxillary crowns described above, the apex of the present specimen exhibits wear, exposing the underlying dentine. This specimen appears to belong to Euhadrosauria, i.e., the clade of hadrosaurids that excludes *Telmatosaurus transsylvanicus* (see Weishampel et al. 1993), with unresolved relationships within this more inclusive group.

Appendicular skeletal remains

The newly collected right metatarsal III from the Valkenburg Member (Maastricht Formation) as ex-

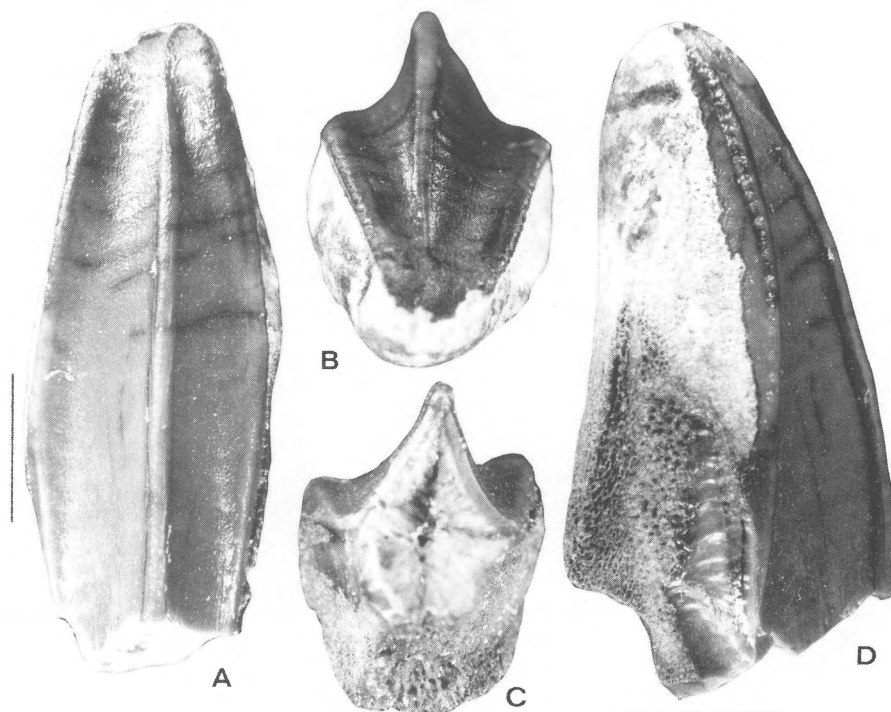


Figure 2. Hadrosaurid maxillary tooth (NHMM 1999012) in various aspects; Ankerpoort-Marnebel quarry, Eben Emael-Bassenge (Liège, Belgium), Maastricht Formation, lower Gronsveld Member (ENCI Horizon). Scale bar: 5 mm.

posed at the CBR-Romontbos quarry (Eben Emael, Bassenge, province of Liège; NHMM RD 241) is large, but relatively gracile for a hadrosaurid (Figure 5). It is missing its proximal end, but its uncrushed lower half is nearly complete, albeit slightly abraded along the margins of the distal condyle. Its medial surface presents a broad surface that extends nearly to the distal end of the element for articulation with metatarsal II. Cranially along this surface, there is a shallow longitudinal eminence that may have reinforced the articulation between metatarsals II and III, while the rugose nature of this articular surface indicates that the two metatarsals were strongly bound together ligamentously. Laterally, a low, rounded vertical ridge is visible immediately below the midshaft break; this ridge marks the articulation with the medial surface of metatarsal IV. Distally, the shaft expands into a large, well-developed articular condyle. The articular surface, which extends onto both cranial and caudal surfaces, is highly pitted and saddle shaped, with a shallow intercondylar groove. The medial aspect of the condyle is relatively flat and scarred for the attachment of the lateral collateral metacarpophalangeal ligament,

while medially the bone bears a distinct ovoid fossa or pit that marks the attachment of the medial collateral metacarpophalangeal ligament.

The fragmentary ?right humerus in the collections of Teylers Museum (TM 11253) is represented by the lower half of the shaft and the distal condyles, of some sort of hadrosaurid (Figure 6). It appears to be uncrushed but somewhat abraded and gives the impression of being rather gracile in comparison to most other hadrosaurids. The shaft is nearly circular in cross-section and there is no indication of the base of the more proximal deltopectoral crest. The ulnar condyle is slightly larger, more rounded, and projects slightly farther cranially than the radial condyle. The ulnar epicondyle is also more extensive than the radial epicondyle and bears a modest rugose crest onto the more proximal shaft. The flexor intercondylar groove is well defined, while – in contrast – there is virtually no extensor intercondylar groove. This condition is surprising given the presence of an extensor groove in all known hadrosaurids and other ‘higher’ iguanodontians (Weishampel & Horner 1990, Norman & Weishampel 1990). The absence of this extensor

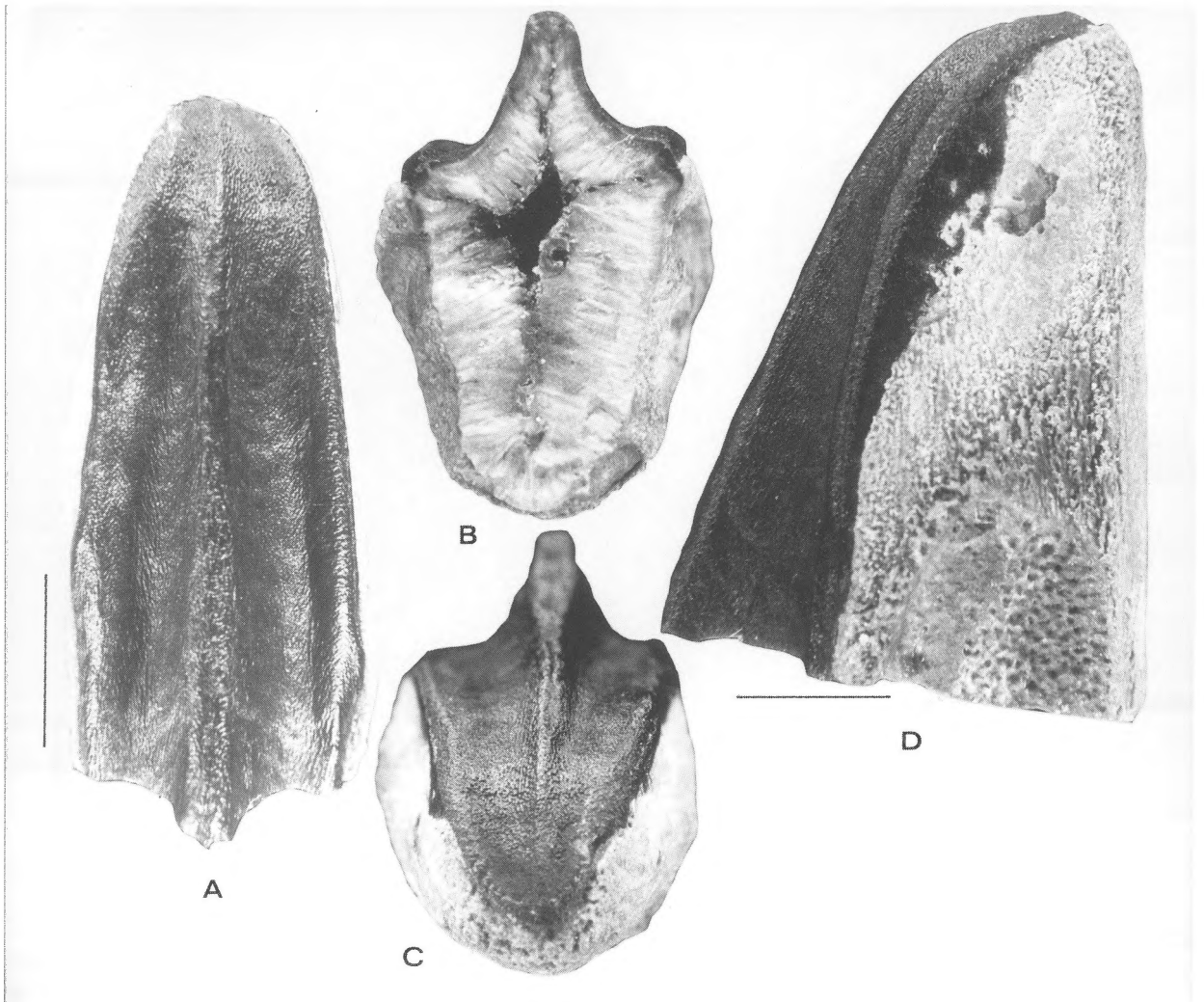


Figure 3. Hadrosaurid maxillary tooth (NHMM 1997274) in various aspects; Sibbe near Valkenburg aan de Geul (southern Limburg, the Netherlands), Maastricht Formation, ?Emael Member (level unknown). Scale bar: 5 mm.

groove may be due to deformation, which is unlikely given the nature of the material. If it is real, however, reduction of the extensor groove may be diagnostic for this form, a claim which obviously requires more and better material. The gracile nature of this humerus indicates anyway that, if all of these assumptions are correct, it may have come from a non-lambeosaurine hadrosaurid (Weishampel et al. 1993).

The present specimen has puzzled many previous investigators. Winkler (1865) recorded it in his catalogue of Teyler's collections, but was not certain as to its identity, listing it as a humerus of the mosasaurid lizard *Mosasaurus camperi* Von Meyer 1832 (= *M. hoffmanni* Mantell 1829). In a letter dated 1955 (now lost) to Dr C.O. van Regteren Altena, then cur-

ator of Teylers Museum, W.E. Swinton expressed the view that it could well be a humerus of *Megalosaurus bredai* Seeley 1883, the only theropod dinosaur to have been recorded from the type Maastrichtian strata. Seeley (1883), however, based his taxon on a single, fragmentary right femur. In his interpretation, Swinton may have been misled by the absence of the extensor intercondylar groove in TM 11253, so that he could not correctly interpret its hadrosaurid origin.

Dinosaur distribution in the type Maastrichtian

Mulder et al. (1997, 1998) have recently noted that previous records of dinosaur remains from the

Table 1. Dinosaur remains from the Maastrichtian type area recorded in the literature, with current repositories and pertinent references.

Repository	Type of bone	Locality and stratigraphy	References
IRScNB (Ubaghs Colln)	Caudal vertebra	Maastricht area (St Pietersberg);	Dollo (1883)
	Caudal vertebra	Maastricht Formation (level unknown)	
IRScNB (Ubaghs Colln)	Tooth	Kunrade area (southern Limburg, the Netherlands; Maastricht Fm, Kunrade limestone facies)	Ubaghs (1893)
	Tooth	Maastricht area; Maastricht Fm, higher part (level unknown)	Ubaghs (1893)
BMNH 42997	Right femur <i>Megalosaurus bredai</i>	Maastricht area; probably Maastricht Fm (level unknown)	Seeley (1883), Russell (1972), Le Loeuff (1992)
BMNH 42955	Right femur <i>Orthomerus dolloi</i>	"	Seeley (1883)
BMNH 42957	Left femur <i>Orthomerus dolloi</i>	"	
BMNH 42954	Left tibia <i>Orthomerus dolloi</i>	"	
BMNH 42956	Metatarsal <i>Orthomerus dolloi</i>	"	
MND K 21.04.003	Left femur	Ankerpoort-Curfs quarry, Geulhem, (southern Limburg, The Netherlands); Maastricht Formation, base Meerssen Member	Mulder (1984), Felder (1984)
MND K 21.04.004	Left tibia		
MND K 21.04.005	Left fibula		
NHMM 198027	Right dentary	Ankerpoort-'t Rooth quarry (Bemelen, southern Limburg, The Netherlands), Maastricht Formation, ?Nekum Member	Buffetaut et al. (1985)
NHMM 1996001	Left metatarsal III	Ankerpoort-Marnebel quarry, Eben-Emael (Liège, Belgium); Maastricht Formation, Emael Member, base + 0.25 m	Mulder et al. (1997)
NHMM 1999012	Right maxillary tooth	Ankerpoort-Marnebel quarry, Eben-Emael (Liège, Belgium); Maastricht Formation, lower Gronsveld Member	This paper
NHMM 1997274	(?Right) maxillary tooth	Sibbe (Valkenburg area, southern Limburg); Maastricht Formation, ?Emael Member (level unknown)	"
NHMM RD 214	(?Left) dentary tooth	Blom quarry, Berg en Terblijt (southern Limburg); Maastricht Formation, base Nekum Member	"
NHMM RD 241	Right metatarsal III	CBR-Romontbos quarry, Eben-Emael (Liège, Belgium); Maastricht Formation, Valkenburg Member	"
TM 11253	(?Right) humerus	St Pietersberg, Maastricht; Maastricht Formation, level unknown	"
Garcet Colln (unregistered)	Phalanx	Pach-Lowe, Eben-Emael (Liège, Belgium); Gulpen or Maastricht Formation, level unknown	Buffetaut et al. (1985)
	Left ulna	Ankerpoort-Marnebel quarry, Eben-Emael (Liège, Belgium); Maastricht Formation, level unknown (?Emael/Nekum members)	"

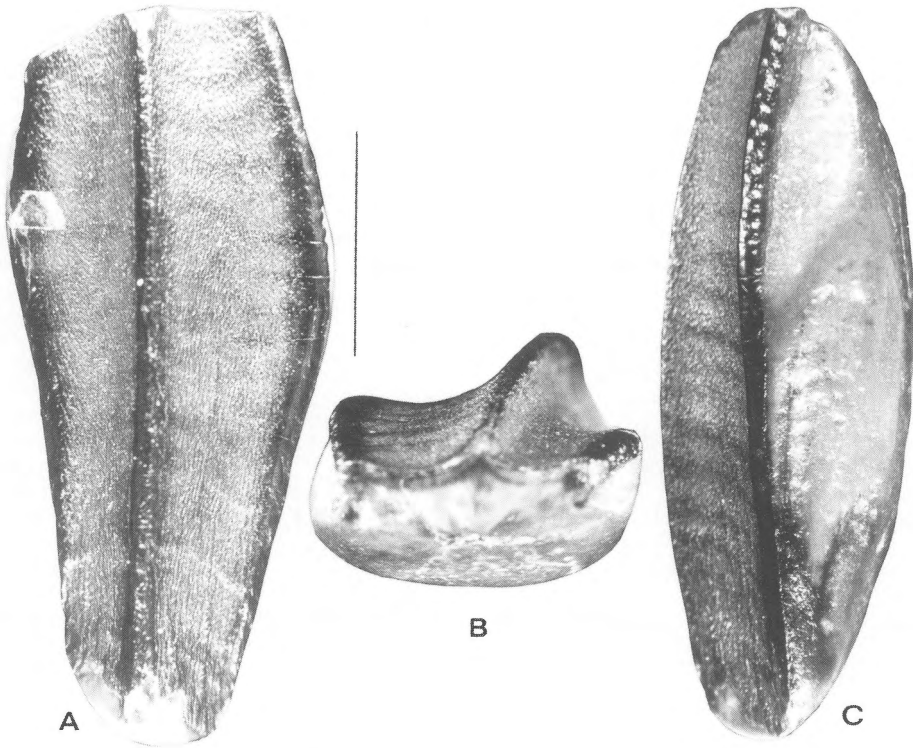


Figure 4. ?Euhadrosaurian dentary tooth (NHMM RD 214) in various aspects; Blom quarry, Berg en Terblijt (southern Limburg, the Netherlands), Maastricht Formation, base Nekum Member. Scale bar: 5 mm.

Maastrichtian type area were either stratigraphically rather poorly documented within the Gulpen and/or Maastricht Formations, or were confined to the basal Meerssen Member (Maastricht Formation), of late Maastrichtian age (see Table 1). Using only material collected in situ, and plotting these specimens in Schiler et al.'s (1997) recent sequence-stratigraphic interpretation of the type Maastrichtian, results in the following picture of dinosaur distribution in the area (Figure 7). It appears that dinosaur remains, limited in number as they may be, are either associated with regressive phases (shallowing) during which riverine input may be considered to have been more important, or with the onset of transgressive pulses and/or with actual highstand periods, during which neighbouring (low relief?) land areas were inundated.

So far, no articulated remains are known from the area, with the possible exception of the type material of *Orthomerus dolloi* recorded by Seeley (1883) and a subsequent find of post-cranial remains referred to the same taxon by Mulder (1984). Unfortunately, whether these remains were found associated, and could thus stem from a single individual, can no

longer be determined. All other remains known to date consist of isolated specimens only. The picture illustrated in Figure 7 is thus of a preliminary nature, but does suggest that concentrated collecting from the levels indicated could ultimately yield additional dinosaur material. This would enable us to tie the type Maastrichtian dinosaurs in with the broader picture of latest Cretaceous dinosaur evolution, which has been shown to have been considerably influenced by sea-level changes (Haubold 1990, Horner et al. 1992, Le Loeuff et al. 1994).

A final note: with the exception of Seeley's (1883) *Megalosaurus bredai* Seeley, which has previously been interpreted as an ornithomimid (see Russell 1972) or a ceratosauroidean (?abelisaurid; see Le Loeuff 1992), but the systematic placement of which is still unresolved, all subsequent dinosaur remains recorded from the type Maastrichtian pertain to hadrosaurids. The new material suggests that more than one taxon is represented.

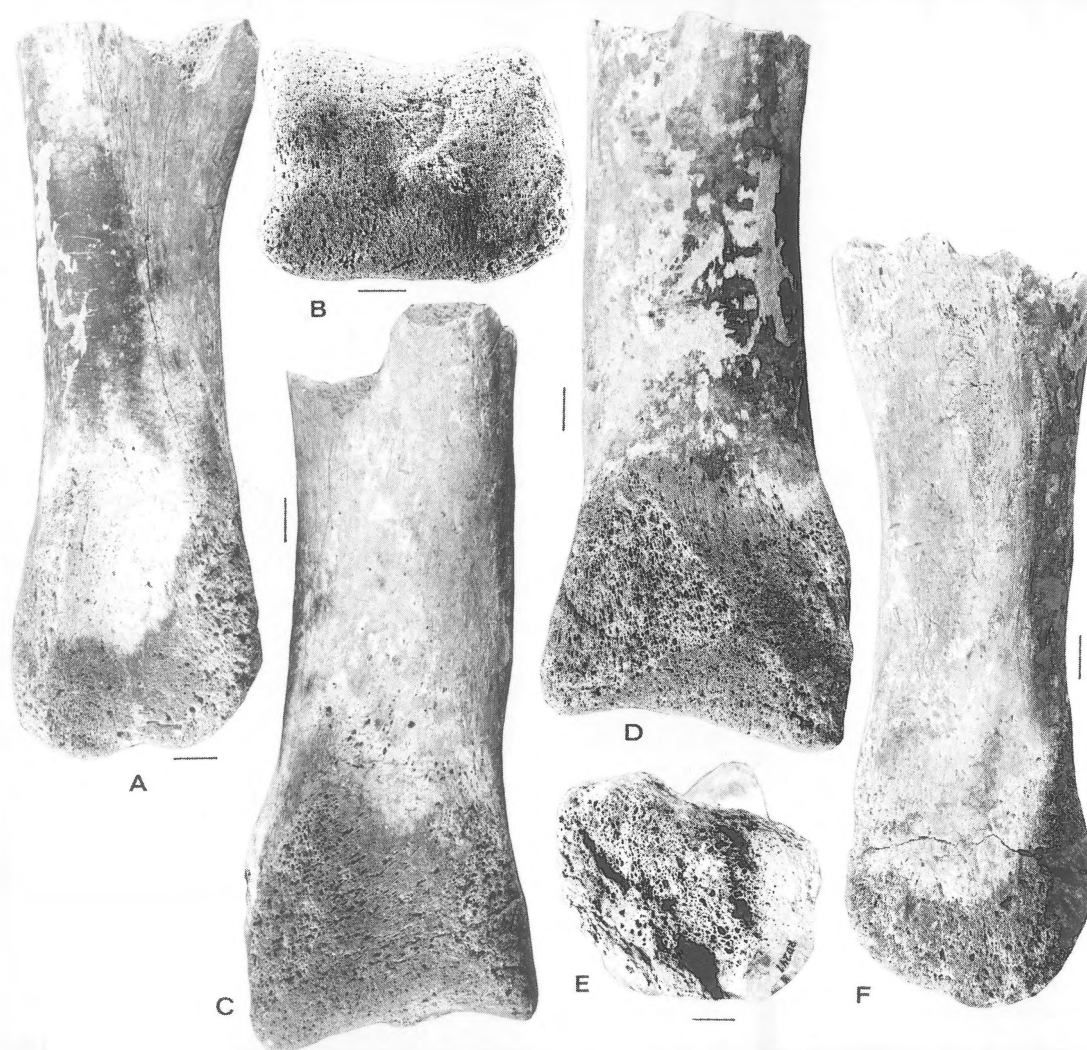


Figure 5. Hadrosaurid right metatarsal III (NHMM RD 241) in various aspects; CBR-Romontbos quarry, Eben Emael-Bassenge (Liège, Belgium), Maastricht Formation, Valkenburg Member. Scale bar: 10 mm.

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References

- Baird, D. & J.R. Horner 1979 Cretaceous dinosaurs of North Carolina – *Brimleyana* 2: 1–28
- Buffetaut, E. 1994 The significance of dinosaur remains in marine sediments: an investigation based on the French record – *Berliner Geowiss. Abh.* E13: 125–133
- Buffetaut, E. & J. Le Loeuff 1991 Late Cretaceous dinosaur faunas of Europe: some correlation problems – *Cret. Res.* 12: 159–176
- Casanovas, M.L., X. Pereda Suberbiola, J.V. Santafé & D.B. Weishampel 1999 A primitive euhadrosaurian dinosaur from the uppermost Cretaceous of the Ager syncline (southern Pyrenees, Catalonia) – *Geol. Mijnbouw* 78 (3/4): 345–356 (this issue)
- Company, J., A. Galobart & R. Gaete 1998 First data on the hadrosaurid dinosaurs (*Ornithischia*, *Dinosauria*) from the Upper Cretaceous of Valencia, Spain – *Oryctos* 1: 121–126

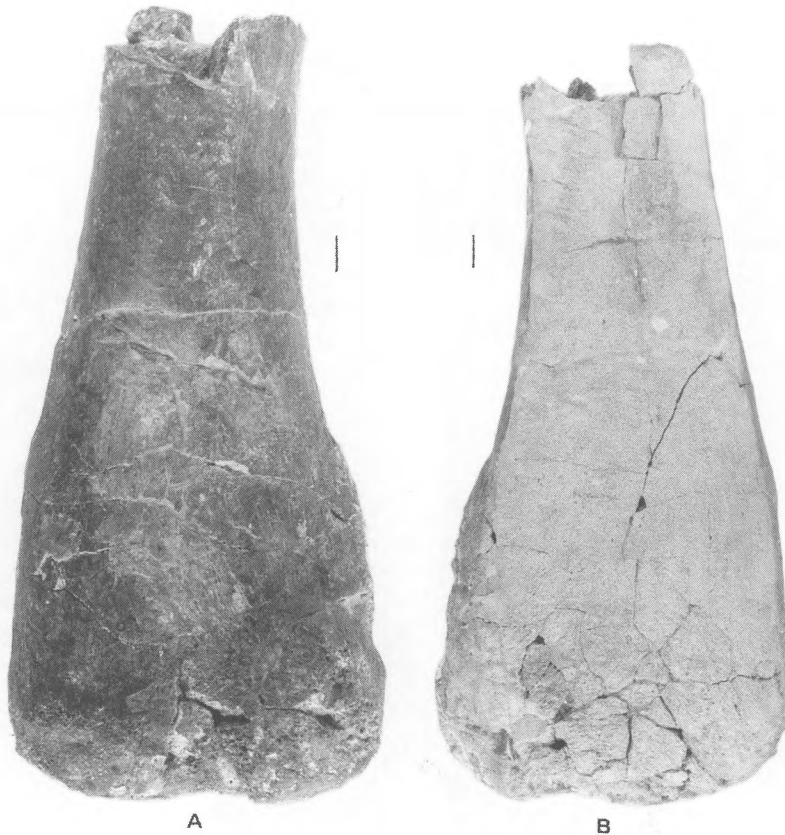


Figure 6. Fragmentary ?right humerus of a ?non-lambeosaurine hadrosaurid (TM 11253, ex Henkelius Colln); St Pietersberg, south of Maastricht, Maastricht Formation, level unknown. Scale bars:1 10 mm.

- Coombs Jr, W.P. 1988 The status of the dinosaurian genus *Diclonius* and the taxonomic utility of hadrosaurian teeth – *J. Paleont.* 62: 812–817
- Coombs Jr, W.P. & T.A. Deméré 1996 A Late Cretaceous nodosaurid ankylosaur (Dinosauria: Ornithischia) from marine sediments of coastal California – *J. Paleont.* 70: 311–326
- Haubold, H. 1990 Dinosaurs and fluctuating sea levels during the Mesozoic – *Hist. Biol.* 4: 75–106
- Horner, J.R., D.J. Varricchio & M.B. Goodwin 1992 Marine transgressions and the evolution of Cretaceous dinosaurs – *Nature* 358: 59–61
- Jagt, J.W.M., R.W. Dortangs, M.M.M. Kuypers, E.W.A. Mulder, A.S. Schulp & D.B. Weishampel 1998 Dinosaur remains in the type Maastrichtian: an update. In: Jagt, J.W.M., P.H. Lambers, E.W.A. Mulder & A.S. Schulp (eds) 3rd Eur. Workshop Vert. Palaeont., Maastricht, 6–9 May 1998, Progr. Abstr. Field guide: 35
- Laurent, Y., J. Le Loeuff & E. Buffetaut 1997 Les Hadrosauridae (Dinosauria, Ornithopoda) du Maastrichtien supérieur des Corbières orientales (Aude, France) – *Rev. Paléobiol.* 16: 411–423
- Le Loeuff, J. 1991 The Campano-Maastrichtian vertebrate faunas from southern Europe and their relationships with other faunas in the world; palaeobiogeographical implications – *Cret. Res.* 12: 93–114
- Le Loeuff, J. 1992 Les vertébrés continentaux du Crétacé supérieur d'Europe: paléocologie, biostratigraphie et paléobiogéographie – *Mém. Sci. Terre Univ. Paris* 92/3
- Le Loeuff, J., E. Buffetaut & M. Martin 1994 The last stages of dinosaur faunal history in Europe: a succession of Maastrichtian dinosaur assemblages from the Corbières (southern France) – *Geol. Mag.* 131: 625–630
- Mantell, G.A. 1829 A tabular arrangement of the organic remains of the county of Sussex – *Trans. Geol. Soc. London* 3: 201–216
- Mulder, E.W.A. 1984 Resten van *Telmatosaurus* (Ornithischia, Hadrosauridae) uit het Boven-Krijt van Zuid-Limburg – *Grondb. Hamer* 38: 108–115
- Mulder, E.W.A., M.M.M. Kuypers, J.W.M. Jagt & H.H.G. Peeters 1997 A new late Maastrichtian hadrosaurid dinosaur record from northeast Belgium – *N. Jb. Geol. Paläont. Mh.* 1997/6: 339–347
- Mulder, E.W.A., J.W.M. Jagt, M.M.M. Kuypers, H.H.G. Peeters & P. Rompen 1998 Preliminary observations on the stratigraphic distribution of Late Cretaceous marine and terrestrial reptiles from the Maastrichtian type area (SE Netherlands, NE Belgium) – *Oryctos* 1: 55–64
- Norman, D.B. & S.M. Kurzanov 1997 On Asian ornithopods (Dinosauria: Ornithischia). 2. *Arstanosaurus akkurganensis* Shilin and Suslov, 1982 – *Proc. Geol. Ass.* 108: 191–199

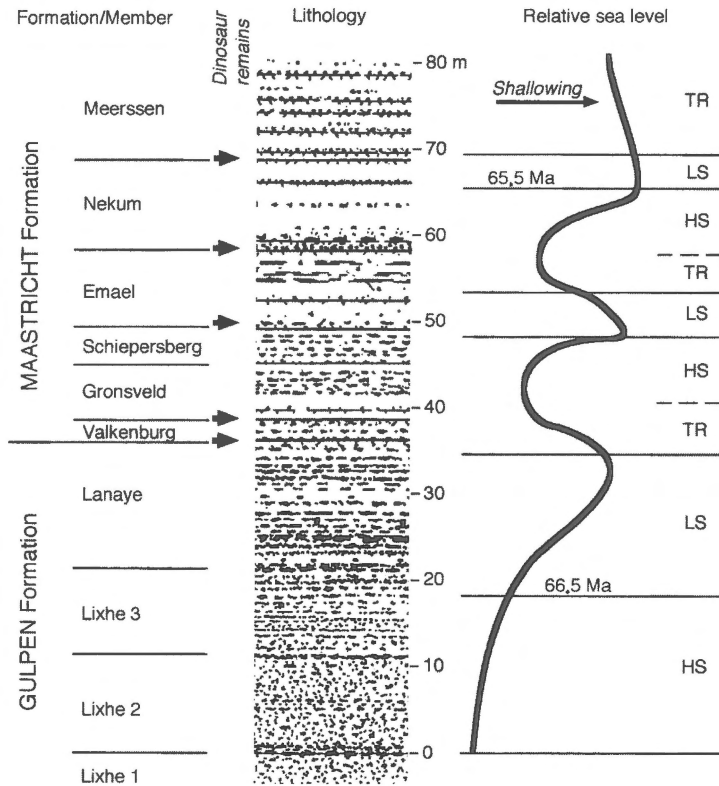


Figure 7. Lithostratigraphy of section exposed at the ENCI-Maastricht BV quarry (Maastricht), relative sea-level changes and sequence-stratigraphic interpretation (modified after Schilker et al. 1997), and all dinosaur remains collected in situ known to date (i.e., from localities other than the ENCI quarry) plotted (arrows).

Norman, D.B. & D.B. Weishampel 1990 Iguanodontidae and related ornithomorphs. In: Weishampel, D.B., P. Dodson & H. Osmólska (eds) *The Dinosauria*. Univ. California Press, Berkeley: 510–533

Russell, D.A. 1972 Ostrich dinosaurs from the Late Cretaceous of Western Canada – *Can. J. Earth Sci.* 9: 375–402

Schiøler, P., H. Brinkhuis, L. Roncaglia & G.J. Wilson 1997 Dinoflagellate biostratigraphy and sequence stratigraphy of the Type Maastrichtian (Upper Cretaceous), ENCI Quarry, The Netherlands – *Mar. Micropaleont.* 31: 65–95

Seeley, H.G. 1883 On the Dinosaurs from the Maastricht Beds – *Q. J. Geol. Soc. London* 39: 246–253

Von Meyer, H. 1832 *Palaeologica zur Geschichte der Erde und ihrer Geschöpfe* – S. Schmerber (Frankfurt am Main)

Weishampel, D.B. & J.R. Horner 1990 Hadrosauridae. In: Weishampel, D.B., P. Dodson & H. Osmólska (eds) *The Dinosauria*. Univ. California Press, Berkeley: 534–561

Weishampel, D.B., D.B. Norman & D. Grigorescu 1993 *Telmatosaurus transylvanicus* from the Late Cretaceous of Romania: the most basal hadrosaurid – *Palaeontology* 36: 361–385

Wellnhofer, P. 1994 Ein Dinosaurier (Hadrosauridae) aus der Oberkreide (Maastricht, Helvetikum-Zone) des bayerischen Alpenvorlandes – *Mitt. Bayer. Staatsslg. Paläont. Hist. Geol.* 34: 221–238

Winkler, T.C. 1865 *Musée Teyler. Catalogue systématique de la collection paléontologique*, 4 – Les Héritiers Loosjes (Haarlem): 459–473