Netherlands Journal of Geosciences / Geologie en Mijnbouw 83 (1): 73-78 (2004)

A new record of *Clidastes* (Squamata, Mosasauridae) from the Upper Campanian of the Münster Basin (NW Germany)

C. Diedrich[1] & E.W.A. Mulder[2]

[1] Nansenstraße 8, D-33790 Halle/Westfalen, Germany; e-mail: cdiedri@gmx.net,
[2] Museum Natura Docet, Oldenzaalsestraat 39, NL-7591 GL Denekamp, the Netherlands, e-mail: eric292@gmx.net

Manuscript received: November 2001; accepted: February 2004

Abstract

From Upper Campanian turbiditic marls at Beckum in the Münster Basin (NW Germany) the anterior portion of a mosasaurid premaxilla with abutting fragments of the left and right maxilla is described and referred to the genus *Clidastes*. It shows the process of tooth replacement very well. This taxon is recorded for the first time from Germany. *Clidastes* co-existed in central Europe with other mosasaurids such as representatives of the genus *Leiodon* and Mosasauridae *indet.*

Key words: Clidastes, mosasaurs, maxilla, premaxilla, Germany, Campanian.

Introduction

From the Upper Campanian of Beckum in the centre of the Münster Basin, NW Germany (Fig. 1), we here record a mosasaur snout tip comprising the anterior portion of the premaxilla with abutting fragments of the left and right maxilla.

The specimen, collected by Giers (1958) at the Phoenix quarry near Beckum, is housed in the collections of the Geologisch-Paläontologisches Museum of the Westfälische Wilhelms-Universität Münster, under registration number A.3D-3. Additional preparation has been carried out by the authors, especially on the ventral part to allow dentition and comparison of tooth replacement to be studied.

Like other non-plesiosaurian reptiles, mosasaurs are poorly known from marine Cretaceous deposits in Germany. The mosasaurs are mostly of Campanian age (Von Meyer 1856; Geinitz 1849, 1872-75; Von der Marck 1858, 1892; Pompeckj 1910; Giers 1958; Bardet et al. 1994; Diedrich 1997, 1999a, b; Sachs 2000). Only the genus *Leiodon* and Mosasauridae *indet.* have so far been recorded and illustrated (Von der Marck 1892) and recently redescribed by Sachs (2000).

Elsewhere in Europe, mosasaurs of Campanian and Maastrichtian age are known notably from the Maastrichtian type area in the SE Netherlands and NE Belgium (Dollo 1882, 1890; Lingham-Soliar 1994, 1995; Kuypers et al. 1998; Mulder 1999; Mulder et al. 1998; Dortangs et al. 2002), from the Mons Basin in southern Belgium (Dollo 1885; Lingham-Soliar 1992; Lingham-Soliar & Nolf 1989), and also from England (Owen 1850, 1851; Lydekker 1888; Milner 2002), southern Sweden (Lindgren 1998; work underway), France (Bardet 1990; Bardet et al. 1997) and central Poland (Machalski et al. 2003).

Stratigraphy

Lower to middle Upper Campanian pelagic facies in the Münster Cretaceous Basin are referred to as

https://doi.org/10.1017/S0016774600020473 Published online by Cambridge University Press

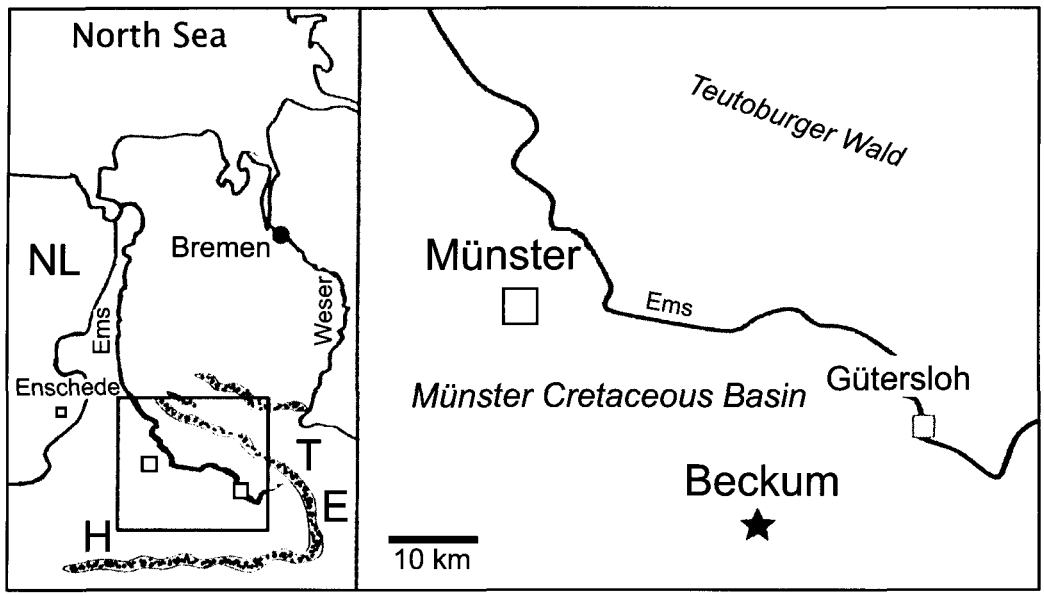

Fig. 1. Geographical position of the locality Beckum (NW Germany). NL: Netherlands, W: Wiehengebirge, T: Teutoburgerwald, E: Eggegebirge, H: Haar.

Beckum Formation (Hiß 1995: p. 62, fig. 11; Fig. 2 here). The underlying and overlying units are the Stromberg Formation and Vorhelmer Formation respectively. The Beckum Formation comprises 10-25 m greyish and chalky marls. These are distributed in the eastern part of the Münster Basin (Arnold 1964; Hiß 1995; Riegraf 1995), whereas in the central and western part the lateral equivalent Coesfeld Formation consists of sandy marls.

The exact stratigraphic provenance of the mosasaur snout tip was indicated by Giers (1958) to be the "Kiebitzbank", an orbulinarite at the top of the Nünningsbank Member. This is the biozone of the ammonite *Hoplitoplacenticeras dolbergense* (Schlüter) (= *dolbergense* Zone) and the belemnite *Belemnitella mucronata* s. str. (compare Riegraf 1995).

Systematic Palaeontology

Class Reptilia
Subclass Diapsida
Supraorder Lepidosauria
Order Squamata
Family Mosasauridae
Subfamily Mosasaurinae
Genus *Clidastes* Cope 1868

Clidastes sp.

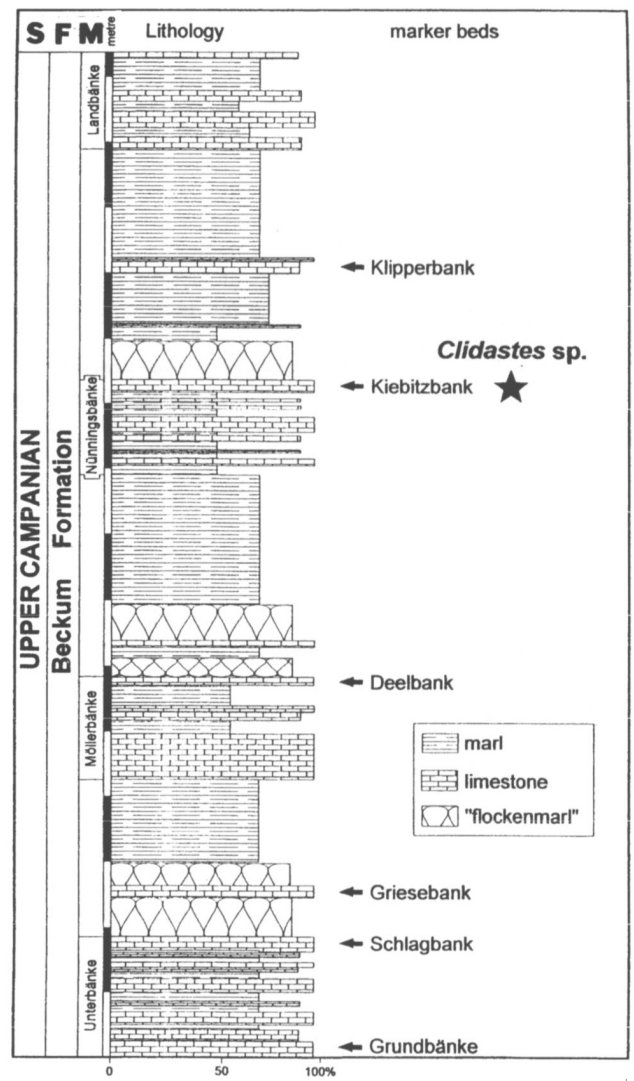

Fig. 2. Stratigraphy (Diedrich, in prep.) of the Beckum Formation and the position of the Kiebitzbank from which the specimen was collected. Percentages refer to CaCO3 content in sediment. S: stage, F: formation, M: member.

https://doi.org/10.1017/S0016774600020473 Published online by Cambridge University Press

Description

Total length, as preserved, is 18 cm; the specimen reveals a fresh fracture. Where the maxillary-premaxillary sutures reach the margin of the snout, the specimen measures 9 cm in width. This size is comparable to that of an anterior fragment of a right dentary, also referred to *Clidastes* sp., from the ?Upper Turonian of Dorking (Surrey, U.K.) (Milner 2002: Plate 64, figure 4). However, our specimen is more than four times as large as the snout tip of the type specimen ANSP 10193 of *Clidastes propython* Cope 1869, housed at the Academy of Natural Sciences, Philadelphia (Everhart 2003).

On the right side, the dentition from the first premaxillary tooth (= PM 1) up to the fourth maxillary tooth (= M 4) is preserved, on the left this goes up to M 3. The replacement teeth are present on the right-hand side with five (PM 1 - M 3a) and on the left with four teeth (PM 1 - M 2 a). Only the tips of these replacement teeth are visible in the resorption pits. In dorsal view the premaxillary foraminae show a special order (Figure 3 B). There are two rows of mostly paired foraminae converging to the front of the tip. On each maxillary lateral surface there is a row of paired or tripled foraminae. In the premaxillary tip the roots of the premaxillary teeth are visible. Much of the tooth crowns is lost. Parts of the crown are preserved only in the right PM 1 and the left PM 2. These teeth reveal two cutting edges and point straight downwards from the premaxilla. On the crown surface no enamel sculpture is preserved.

The left maxillary fragment contains roots of M1 and M2, having split from the rest of the bone along the root of M3.

The right maxillary fragment contains the root of

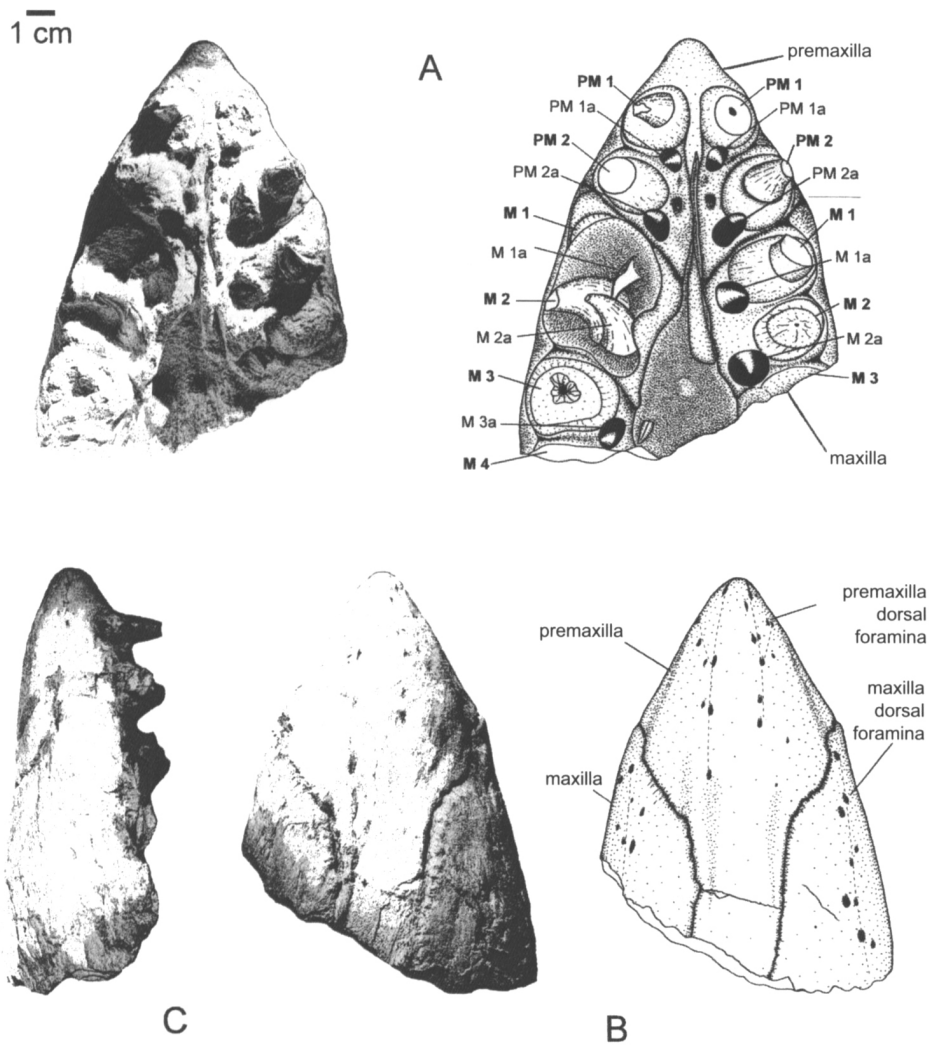

Fig. 3. Snout tip of *Clidastes* sp. from the Upper Campanian of Beckum (NW Germany). A. ventral, B. dorsal, C. right lateral view, Geologisch-Paläontologisches Museum of the Westfälische Wilhelms-Universität Münster, no. A.3D-3.

https://doi.org/10.1017/S0016774600020473 Published online by Cambridge University Press

M3. The roots of M1 and M2 are nearly completely lost. The right maxillary fragment has broken apart from the rest of the bone along the root of M4 (Fig. 3A).

Ventrally the right maxillary fragment shows a substantial part of the replacement tooth M2a. Of all other preserved replacement teeth the tips of the crowns are visible in the resorption pits in the roots of the mature premaxillary and maxillary teeth (Fig. 3A). Therefore the mechanism of tooth replacement in mosasaurs, as described by Lee (1997) and Zaher & Rieppel (1999), can be observed.

Discussion

'In *Clidastes* a short, acute, protruding rostrum produces a V-shaped dorsal profile and, as far as is known, is peculiar to that genus' (Bell 1997: 297). Notably because of this character the specimen described above is referred to *Clidastes*.

As was described for *Clidastes liodontus* Merriam 1894 and *Clidastes propython* by Russell (1967: 128, 130), in specimen A.3D-3 the preserved tip of the premaxilla is 'V'-shaped in horizontal cross-section (Fig. 3 A-B). There is a small predental rostrum anterior to the position of the premaxillary teeth, as in *C. liodontus* and *C. propython* (cf. Russell 1967: text-fig. 74; Bell 1997: fig. 5 B). It can be observed that the teeth of A.3D-3 were pointed straight downwards from the premaxilla, as in *C. liodontus* and *C. propython*.

Clidastes has been recorded from the Turonian-Campanian of the United Kingdom, al-though only very few of these records could be identified as such (Milner 2002) and from the Campanian of southern Sweden (Lindgren & Siverson, in press). Here the genus is presented for the first time from the Campanian of NW Germany. The transatlantic distribution of the genus during the Late Cretaceous is apparent.

As matters stand, two mosasaurid genera are positively identified from the Upper Campanian of the Münster Cretaceous Basin. Until now *Leidon* is found in the more sandy facies of the Coesfeld Formation, whereas *Clidastes* is recorded from the pelagic turbiditic facies of the Beckum Formation. Both formations are coeval. (See e.g. Hiß 1995: Fig. 11).

Acknowledgements

We thank Dr M. Bertling (Geologisch-Paläontologisches Museum of the Westfälische Wilhelms-Universität Münster) for information and permission to publish this find. I. Rei-nicke (same institute) assisted in the photographic work. Furthermore, we thank Dr J.W.M. Jagt and Drs A.S. Schulp (both Natuurhistorisch Museum Maastricht), who critically read the typescript and made useful suggestions. We acknowledge the help of M. Everhart (Sternberg Museum of Natural History, Fort Hays State University, Hays, Kansas), who sent us information on North American mosasaurs and some unpublished photos for comparison.

References

Arnold, H., 1964. Zur Lithologie und Zyklik des Beckumer Campans. Fortschritte der Geologie in Rheinland und Westfalen 7: 679-690.

Bardet, N.,1990. Première mention du genre *Hainosaurus* (Squamata, Mosasauridae) en France. Comptes Rendus de l'Académie des Sciences de Paris (2) 311: 751-756.

Bardet, N., Barbin, V., Laurin, M. & Janin, M.-C., 1997. Première découverte du mosasaure *Prognathodon giganteus* (Squamata) dans le Campanien (Crétacé supérieur) de Champagne, France. Revue de Paléobiologie 16: 225-230.

Bardet, N., Wellnhofer, P. & Herm, D., 1994. Discovery of ichthyosaur remains (Reptilia) in the Upper Cenomanian of Bavaria. Mitteilungen der Bayerischen Staatssammlung für Paläontologie und historische Geologie 34: 213-220.

Bell Jr, G.L., 1997. A phylogenetic revision of North American and Adriatic Mosasauroidea. *In*: Callaway, J.M. & Nicholls, E.L. (Eds): Ancient Marine Reptiles. Academic Press (New York / London): 293-332.

Cope, E.D., 1868. (Remarks on *Clidastes iguanavus*, *Nectoportheus validus* and *Elasmosaurus*). Proceedings of the Academy of Natural Sciences of Philadelphia 20: 181.

Cope, E.D., 1869. On the reptilian orders Pythonomorpha and Streptosauria. Proceedings of the Boston Society of Natural History 12: 250-266.

Diedrich, C., 1997. Ein Dentale von *Coniosaurus crassidens* OWEN (Varanoidea) aus dem Ober-Cenoman von Halle/Westf. (NW-Deutschland). Geologie und Paläontologie Westfalens 47: 43-51.

Diedrich, C., 1999a. Erster Nachweis von *Dolichosaurus longicollis* Owen (Varanoidea) aus dem Ober-Cenoman von Halle/Westf. (NW-Deutschland). Neues Jahrbuch für Geologie und Paläontologie, Monatshefte 1999 (6): 372-384.

Diedrich, C., 1999b. Ein Humerus der Chelonide *Rhinochelis* (?) cf. *carusiana* (Geinitz 1872-75) aus dem Mittel-Cenoman von Halle/Westf. (NW-Deutschland). Neues Jahrbuch für Geologie und Paläontologie, Monatshefte 1999 (9): 541-550.

Dollo, L., 1882. Note sur l'ostéologie des *Mosasauridae*. Bulletin du Musée royale d'Histoire naturelle de Belgique 1: 55-74, 3 pls.

Dollo, L., 1885. Première note sur le Hainosaure, Mosasaurien nouveau de la craie brune phosphatée de Mesvin-Ciply, près Mons. Bulletin du Musée royale d'Histoire naturelle de Belgique 4: 25-35

Dollo, L., 1890. Première note sur les mosasauriens de Maestricht. Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie 4: 151-169, pl. 8.

Dortangs, R.W., Schulp, A.S., Mulder, E.W.A., Jagt, J.W.M., Peeters, H.H.G. & De Graaf, D.T., 2002. A large new mosasaur from the Upper Cretaceous of the Netherlands. Netherlands Journal of Geosciences 81: 1-8.

Everhart, M., 2003. www.oceansofkansas.com.

Geinitz, H. B., 1849. Das Quader-sandsteingebirge oder Kreidegebirge in Deutschland. Craz und Gerlach Verlag (Freiberg): 290 pp.

https://doi.org/10.1017/S0016774600020473 Published online by Cambridge University Press

Geinitz, H. B., 1872-75. Das Elbthalgebirge in Sachsen. Zweiter Theil. Der mittlere und obere Quader. Palaeontographica 20: vii + 245 pp.

Giers, R., 1958. Die Mukronatenkreide im östlichen Münsterland. Beihefte zum Geologischen Jahrbuch 34: 1-148.

Hiß, M., 1995. Kreide. *In*: Hilden, H.D. (Ed.): Geologie im Münsterland. Geologisches Landesamt Nordrhein-Westfalen (Krefeld): 41-66.

Kuypers, M.M.M., Jagt, J.W.M., Peeters, H.H.G., De Graaf, D.Th., Dortangs, R.W., Deckers, M.J.M., Eysermans, D., Janssen, M.J. & Arpot, L., 1998. Laat-kretaceische mosasauriërs uit Luik-Limburg: nieuwe vondsten leiden tot nieuwe inzichten. Publicaties van het Natuurhistorisch Genootschap in Limburg 41: 5-47.

Lee, M.S.Y., 1997. On snake-like dentition in mosasaurian lizards. Journal of Natural History 31: 303-314.

Lindgren, J., 1998. Early Campanian mosasaurs (Reptilia; Mosasauridae) from the Kristianstad Basin, southern Sweden. Examensarbete i geologi vid Lunds Universitet 20 (95): 1-25.

Lindgren, J. & Siverson, M., in press. The first record of the mosasaur *Clidastes* from Europe and its palaeogeographic implications. Acta Palaeontologica Polonica.

Lingham-Soliar, T., 1992. The Tylosaurine Mosasaurs (Reptilia, Mosasauridae) from the Upper Cretaceous of Europe and Africa. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre 62: 171-194.

Lingham-Soliar, T., 1994. The Mosasaur *Plioplatecarpus* (Reptilia, Mosasauridae) from the Upper Cretaceous of Europe. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre 64: 177-211.

Lingham-Soliar, T., 1995. Anatomy and functional morphology of the largest marine reptile known, *Mosasaurus hoffmanni* (Mosasauridae, Reptilia) from the Upper Cretaceous, Upper Maastrichtian of the Netherlands. Philosophical Transactions of the royal Society of London B347: 155-180.

Lingham-Soliar, T. & Nolf, D., 1989. The mosasaur *Prognathodon* (Reptilia, Mosasauridae) from the Upper Cretaceous of Belgium. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre 59: 137-190.

Lydekker, R., 1888. Catalogue of the fossil reptilia and amphibia in the British Museum (Natural History). I Ornithosauria, Crocodilia, Dinosauria, Squamata, Rhynchocephalia and Proterosauria. British Museum (Natural History) (London) 309 pp.

Machalski, M., Jagt, J.W.M., Dortangs, R.W., Mulder, E.W.A. & Radwanski, A., 2003. Campanian and Maastrichtian mosasaurid reptiles from central Poland. Acta Palaeontologica Polonica 48 (3): 397-408.

Merriam, J.C., 1894. Über die Pythonomorphen der Kansas Kreide. Palaeontographica 41: 1-39.

Milner, A.C., 2002. Reptiles. *In*: Smith, A.B. & Batten, D.J. (Eds): Fossils of the Chalk. Palaeontological Association Field Guides to Fossils 2: 325-343. Second edition, revised and enlarged.

Mulder, E.W.A., 1999. Transatlantic latest Cretaceous mosasaurs (Reptilia, Lacertilia) from the Maastrichtian type area and New Jersey. *In*: Jagt, J.W.M., Lambers, P.H., Mulder, E.W.A. & Schulp, A.S. (Eds): Proceedings of the Third European Workshop on Vertebrate Palaeontology, Maastricht, May 6-9, 1998. Geologie en Mijnbouw 78: 281-300.

Mulder, E.W.A., Jagt, J.W.M., Kuypers, M.M.M., Peeters, H.H.G. & Rompen, P., 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.

Owen, R., 1850. Description of the fossil reptiles of the Chalk formations *In*: Dixon, F. (Ed.): The geology and fossils of the Tertiary and Cretaceous formations of Sussex. Longman, Brown, Green and Longman (London): 378-405.

Owen, R., 1851. A monograph of the fossil Reptilia of the Cretaceous formations. Part I. Chelonia (Lacertilia & C.). Monographs of the Palaeontological Society 1851-64: 1-118.

Pompeckj, J.F., 1910. Über einen Fund von Mosasaurier-Resten im Ober-Senon von Haldem. Jahresberichte des niedersächsischen geologischen Vereins 3: 122-140.

Riegraf, W. 1995. Radiolarien, Diatomeen, Cephalopoden und Stratigraphie im pelagischen Campanium Westfalens (Ober-kreide, NW-Deutschland). Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen 197: 129-200.

Russell, D.A., 1967. Systematics and morphology of American Mosasaurs (Reptilia, Sauria). Peabody Museum of Natural History, Bulletin 23: viii +240 pp.

Sachs, S., 2000. Mosasaurier-Reste aus der Ober-Kreide von Nordrhein-Westfalen. Geologie und Paläontologie Westfalens 56: 35-44.

Von der Marck, W., 1858. Über einige Wirbeltiere, Cruster und Cephalopoden der Westfälischen Kreide. Zeitschrift der deutschen geologischen Gesellschaft 10: 231-271.

Von der Marck, W., 1892. Die vorzeitlichen Reptilien und Fische Westfalens. *In*: Landois, H. (Ed.): Westfalens Tierleben in Wort und Bild. Band 3. Die Reptilien, Amphibien und Fische. 1. Buch. Schöningh (Paderborn): 440 p.

Von Meyer, H., 1856. *Helochelis Danubia*, aus dem Grünsande von Kehlheim in Bayern. Palaeontographica 4: 96-105.

Zaher, H. & Rieppel, O., 1999. Tooth implantation and replacement in squamates, with special reference to mosasaur lizards and snakes. American Museum Novitates 3271: 1-19.

https://doi.org/10.1017/S0016774600020473 Published online by Cambridge University Press