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Cover illustration: The ammonite *Dorsetensia liostraca* Buckman from the Lower Bajocian (Middle Jurassic) Giganteuston Member of Öschingen, Middle Swabian Alb, Germany. For details, see Dietze, V. et al.: The Giganteuston Member of Öschingen (Humphriesianum Zone, Lower Bajocian, Swabian Alb), with comments on the genera *Dorsetensia* Buckman, 1892 and *Nannina* Buckman, 1927, pp. 209–236 in this issue.
Back cover: Atrium of the Munich Palaeontological Museum, view from the main entrance.

Umschlagbild: *Dorsetensia liostraca* Buckman, ein Ammonit aus dem Giganteuston des Unter-Bajociums (Mittlerer Jura) von Öschingen, Mittlere Schwäbische Alb, Deutschland. Für weitere Informationen siehe Dietze, V. et al.: The Giganteuston Member of Öschingen (Humphriesianum Zone, Lower Bajocian, Swabian Alb), with comments on the genera *Dorsetensia* Buckman, 1892 and *Nannina* Buckman, 1927, S. 209–236 in diesem Heft.
Rückseite: Lichthof des paläontologischen Museums München, Blick vom Haupteingang.

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First evidence of Elasmosauridae (Reptilia: Sauropterygia) in an erratic boulder of Campanian age originating from southern Sweden or the adjacent Baltic Sea area

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Kurzfassung

Ein einzelner Dorsalwirbel eines Plesiosauriers wurde in einem pleistozänen Geschiebe bei Wismar (Deutschland) gefunden. Das Geschiebe ist ein karbonatisch zementierter Sandstein beziehungsweise ein arenitischer Kalkstein mit siliziklastischen Bestandteilen, vor allem deutlich angularen Quarzen und gut gerundeten Glaukonitkörnern. Lithologische Untersuchungen zeigen, dass das Geschiebe mit dem Köpinge-Sandstein aus dem Ystad-Vomb-Gebiet in Südschweden korreliert werden kann (oberes Untercampanium und unteres Obercampanium). Der Wirbel ist fast vollständig erhalten. Das Zentrum ist 75 mm lang und 80 mm hoch. Der Dornfortsatz ist rechteckig, das distale Ende fehlt. Basierend auf der Morphologie des Neuralbogens und den Proportionen des Wirbelzentrums, kann der Wirbel den Elasmosauridae zugeordnet werden. Für die taxonomische Bestimmung wurde Plesiosaurier-Material aus Südschweden untersucht.

Schlüsselwörter: Plesiosauria, Elasmosauridae, Oberkreide, Südschweden, Geschiebe, *Scanisaurus*

Abstract

An isolated dorsal vertebra from a plesiosaur was found in a Pleistocene erratic boulder (geschiebe) near Wismar (Germany). The geschiebe is a carbonate cemented sandstone or a silica-rich arenitic limestone, containing clear angular quartz and well-rounded glauconitic grains. Lithological studies reveal that it can be correlated with the "Köpinge" sandstone from the Ystad-Vomb area in southern Sweden (upper Lower Campanian to lower Upper Campanian). The vertebra is almost completely preserved. The centrum is 75 mm long and 80 mm high. The neural spine is rectangular, but broken at the distal end. On the basis of the morphology of the neural arch, the proportions of the centrum, and comparisons to plesiosaur material from southern Sweden, the vertebra can be referred to Elasmosauridae.

Key words: Plesiosauria, Elasmosauridae, Upper Cretaceous, southern Sweden, Geschiebe, *Scanisaurus*

1. Introduction

The Plesiosauria were a clade of Mesozoic marine reptiles that evolved from stem-group sauropterygians (Rieppel 1997) and had their major radiation during the Upper Triassic and Jurassic periods. In this time they split into major groups (e. g. Aristonectidae, Cryptoclididae, Elasmosauridae, Pliosauridae and Rhomaleosauridae: Smith 2003; O'Keefe & Street 2009) which were globally distributed. Remains of plesiosaurs from the European Cretaceous are still scarce (Persson 1960, 1963). One major locality for Upper Cretaceous marine reptiles is situated in southern Sweden. The first record of reptiles from this time period was mentioned by Nilsson in 1827. Persson (1954, 1959, 1963) later described and reviewed several plesiosaur and mosasaur specimens. Most recently, new mosasaur material from this area was described (e.g. Lindgren & Siverson 2002). Here we describe a single plesiosaur vertebra that was found in a Pleistocene erratic (geschiebe) of Campanian limestone.

Institutional abbreviations: MB = Museum für Naturkunde, Berlin, Germany; MV = Geologische Landessammlung des Landesamtes für Umwelt, Naturschutz und Geologie Mecklenburg-Vorpommern, Sternberg, Germany; NRM-PZ = Swedish Muse-

um of Natural History – Palaeozoology, Stockholm, Sweden, PMU = Palaeontological Museum, Uppsala, Sweden; ZSRO = Zoologische Sammlung, University of Rostock, Germany.

2. Materials and methods

The material is a Pleistocene geschiebe with a fossil plesiosaur vertebra from a moraine of the Weichselian glaciation which was discovered close to Wismar, northern Germany, in July 2008. Pieces of the erratic block and a cast of the vertebra are deposited at the Geologische Landessammlung Mecklenburg-Vorpommern in Sternberg, with registration number MV011728 a–c; a further cast of the vertebra is deposited at the Zoological Collection of the University of Rostock (ZSRO Re 640). The original vertebrate material remains in the private collection of René Kautz, Wismar.

For the taxonomic classification the vertebra was compared with similar material (*Scanisaurus* cf. *nazarowi* Bogolubov, 1911, Elasmosauridae gen. et sp. indeterminate) from the Palaeontological Collection of the Evolutionary Biology Centre in Uppsala, Sweden, and the Swedish Museum of Natural History in Stockholm, Sweden, and with single vertebrae from *Plesiosaurus* sp. De la Beche & Conybeare, 1821 from the Museum für Naturkunde, Berlin, Germany (MB.R.3990.1 [complete dorsal vertebrae, Lower Jurassic, Lyme Regis, Dorset, England] and MB.R.4135.1 [centra of dorsal vertebrae, Upper Jurassic, Hildesheim, Germany]). In addition, we measured the length and height of the vertebral centrum, calculated the ratio and compared it with measurements of vertebra centra from several plesiosaur species from the Lower and Upper Cretaceous (see Appendix).

3. Geological setting

The geschiebe is a carbonate-cemented sandstone or an arenitic limestone with siliciclastic components, comprising mostly clear, angular quartz and well-rounded glauconitic grains. In general, the glauconitic components are reworked steinkerns of benthic foraminifera. The other microfauna consist of

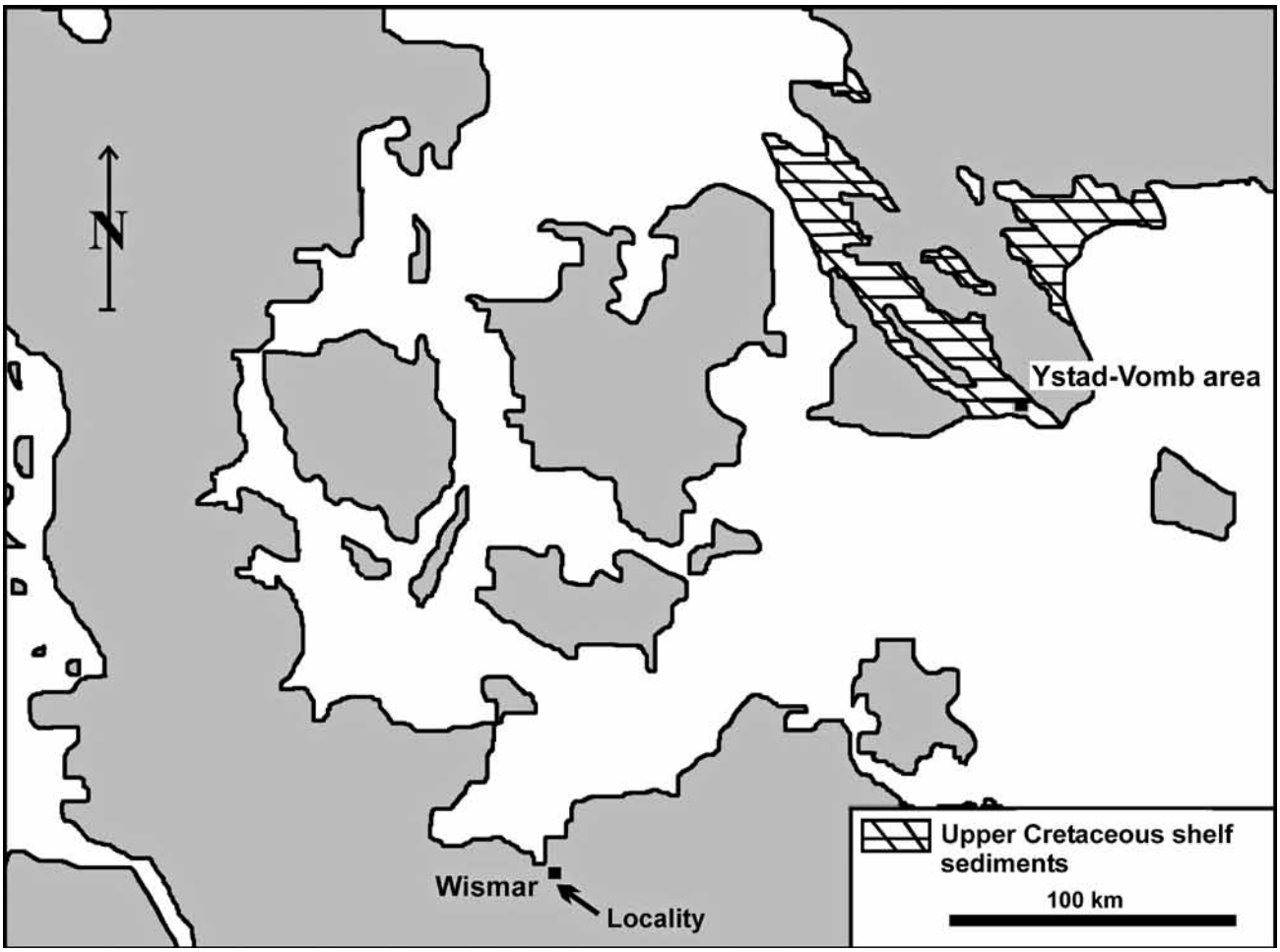

Figure 1: Map of northeast Germany and southern Scandinavia (modified after Christensen 1986; Gravesen 1993). The locality of the vertebra is close to the German town of Wismar. The source area of the geschiebe is probably the Upper Cretaceous sediments of southern Sweden.

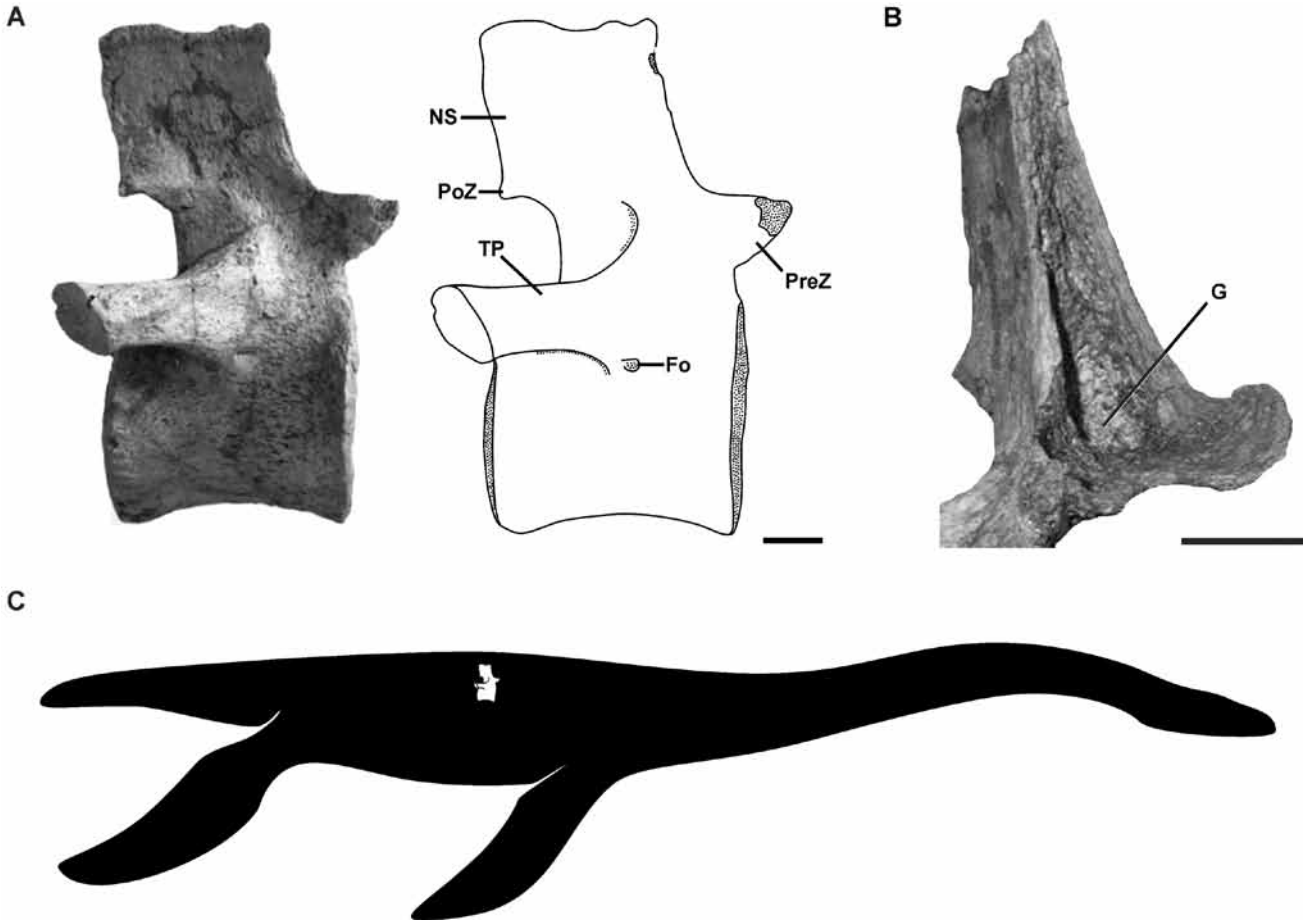

Figure 2: Photographs and sketches of the vertebra from Wismar. **(A)** Vertebra in lateral view. (**B)** Neural arch in anterior view with deep oblong groove. **(C)** Sketch of a plesiosaur with the proposed position of the vertebra. *Fo* fossa, *Gro* groove, *NS* neural spine, *PoZ* postzygapophysis, *PreZ* prezygapophysis, *TP* transverse process. *Scale bars* 2 cm.

less well-preserved planktonic foraminifera, triaxone sponge spiculae and fragments of osteichthyian bones and chondrichthyian teeth.

Table 1: Proportions of dorsal centra in different Cretaceous plesiosaur taxa (see Fig. 3). *H* high, *L* lengt.

Taxon	H: L max	H: L min	H: L mean
Wismar plesiosaur			1,067
Scanisaurus	1,163	0,942	1,007
Elasmosauridae	1,645	0,902	1,131
Plesiosauria indet.	1,473	1,036	1,278
Pliosauridae	1,829	1,455	1,550
Polycotylidae	1,837	0,917	1,441

Lithological studies reveal that the geschiebe can be correlated with the "Köpinge" sandstone from the Ystad-Vomb area of southern Sweden (Hadding 1929). This area is a sedimentary basin 80 km long by 7–11 km wide, situated in the tectonically active Fennoscandian marginal zone (Fig. 1). The basin was formed by vertical movements along NW-SE striking faults occurring since the late Palaeozoic or early Mesozoic (Norling 1982; Chatziemmanouil 1982). The oldest Mesozoic sediments within the basin are Late Triassic in age, and are covered by a nearly complete sequence of Jurassic and Lower Cretaceous strata in the centre of the basin. The Upper Cretaceous sediments within the trough have a thickness of a little less than 800 m and are mainly composed of calcareous and silty mudstones (Chatziemmanouil 1982; Kennedy & Christensen 1993). The Campanian sediments reach a maximum thickness of 159 m (Chatziemmanouil 1982; Fig. 1) and consist primarily of greyish to light greenish, carbonatic and glauconitic fine-grained sand- and siltstones generally called „Köpinge-Sandstone" (Hadding 1929, 1932). On basis of foraminifera and belemnites, these sandstones are referred to the upper Lower Campanian and the lower parts of the Upper Campanian (Chatziemmanouil 1982; Christensen 1986, 1990; Gravesen 1993). The geschiebe cannot be referred to a particular stratigraphic level within this sequence because of glacial transport and the absence of further biostratigraphically informative fauna, but correlation to Campanian sediments of southern Sweden or the adjacent Baltic Sea area is probable.

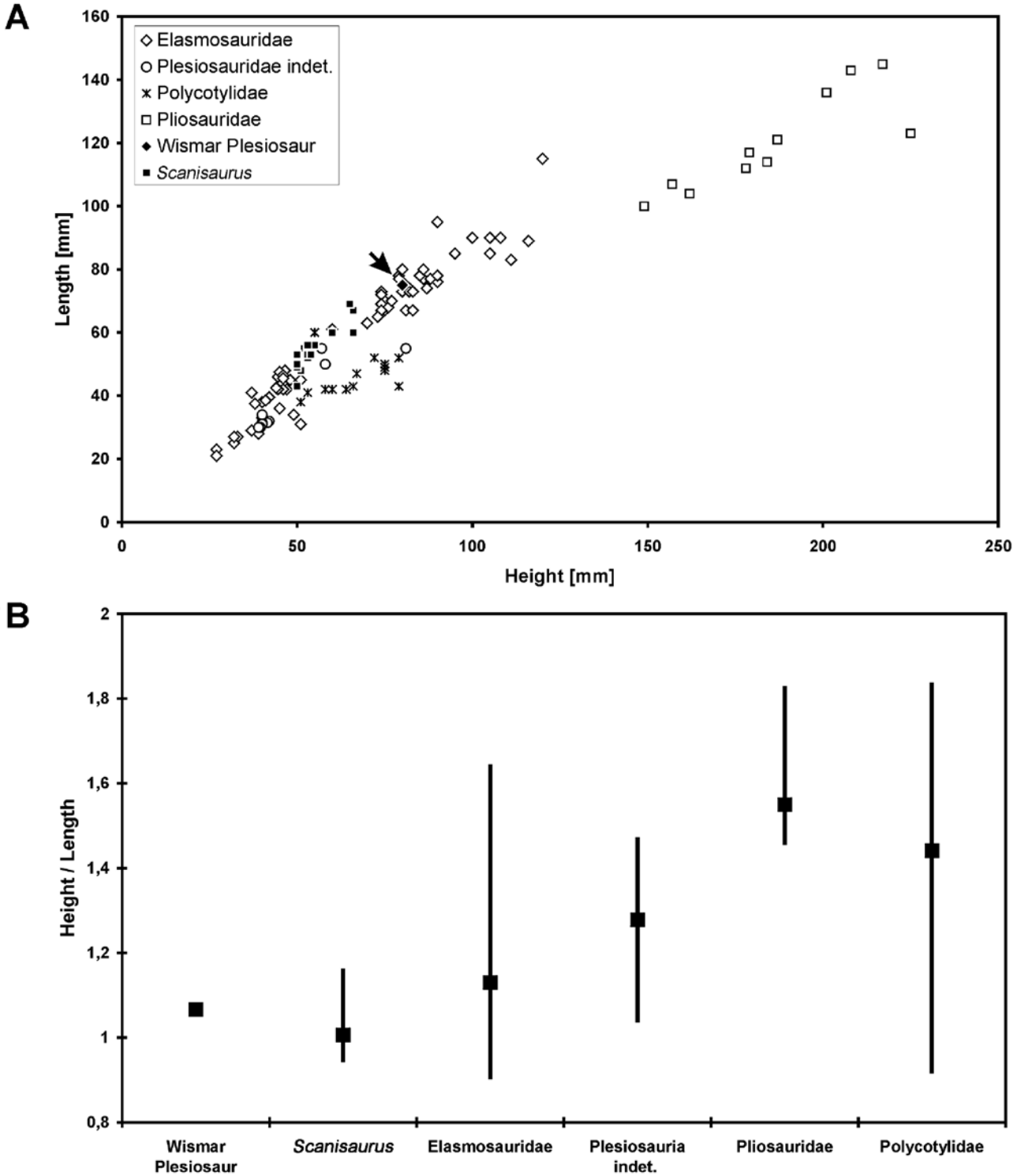

Figure 3: (A) Ratio of length to height for vertebral centra in different plesiosaur taxa. Note that the vertebra from Wismar (arrow) plots within Elasmosauridae. (**B)** Height: length ratio for vertebral centra in different plesiosaur taxa. The proportions of the vertebra from Wismar conform to the values for Elasmosauridae.

4. Systematic palaeontology

Diapsida Osborn, 1903
Sauropterygia Owen, 1860
Plesiosauria de Blainville, 1835
Plesiosauroidea Welles, 1943
Euplesiosauria O'Keefe, 2001
Elasmosauridae Cope, 1869

Description and Discussion: The vertebra from Wismar is almost completely preserved (Fig. 2 A). The centrum is 75 mm long and 80 mm high. The ventral and lateral surfaces as well as the articular facets of the centrum are slightly concave. In the middle of the anterior articular facet is a small unremarkable notochord pit. Because over half of the vertebra centrum

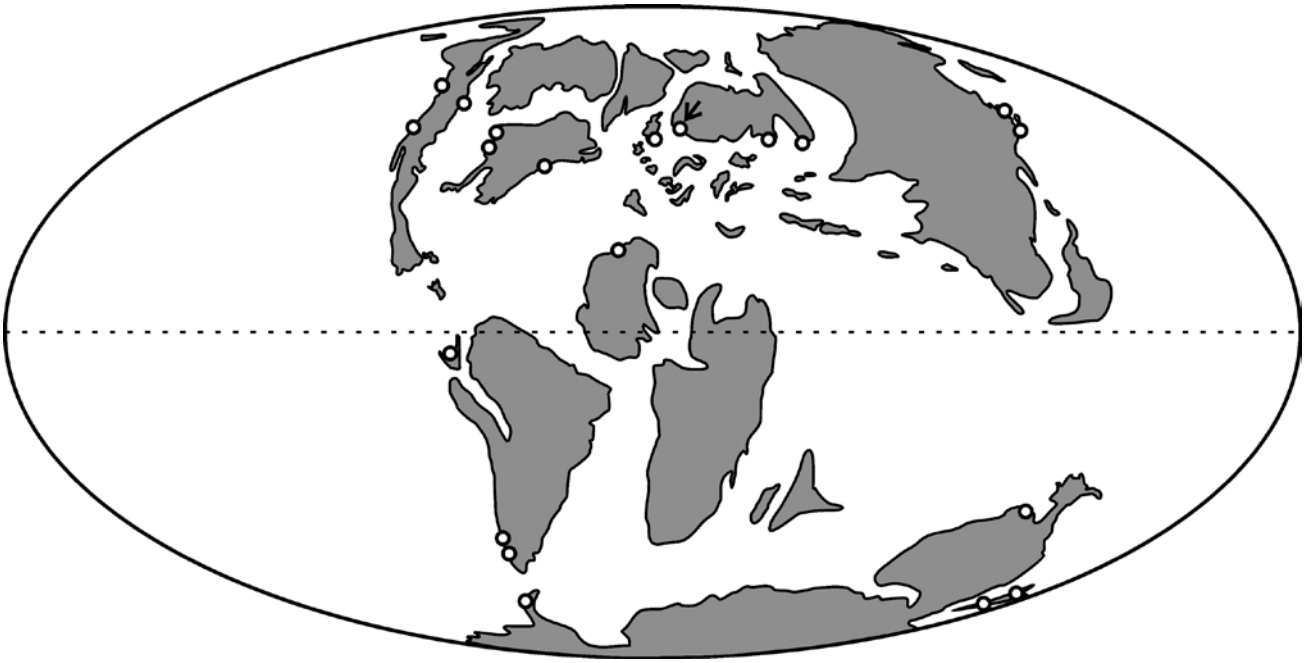

Figure 4: Biogeographic distribution of Upper Cretaceous Elasmosauridae. The Upper Campanian locality of southern Sweden is shown by an arrow.

is still embedded in rock, the ventral foramina for nutritive vessels are not visible. The neural arch is 85 mm high and 57 mm long. The neural spine is rectangular, but broken at the distal end. On the anterior surface of the spine a deep oblong groove is present (Fig. 2 B). The short postzygapophyses lie dorsal to the prezygapophyses, the latter being prominently developed. The neural channel is almost circular and has a diameter of 28 mm. The transverse processes are 55 mm long and directed posteriorly and the articular facets for the ribs are flat and circular. A small fossa is visible anterior to the transverse processes.

Elongated transverse processes, rib facets positioned above the centrum and flat to slightly concave articular facets on the anterior and posterior surfaces of the centrum are typical features of the dorsal vertebrae of plesiosaurs (e.g. Koken 1905; Brown 1913; Sachs 2005). Therefore, this vertebra can be identified as from the dorsal region of a member of this clade (Fig. 2 C). Because the taxonomy of plesiosaurs is mainly based on the morphology of the pectoral girdle (Lucas & Reynolds 1993), and the skull and cervical vertebrae (O'Keefe 2001), the referral of the dorsal vertebra to any known taxon is difficult. Nevertheless, the lateral compression of the neural spine is characteristic of cervical and dorsal vertebrae of Plesiosauroidea (*Plesiosaurus* + Aristonectidae + Cryptoclididae + Elasmosauridae + Polycotylidae; Sander et al. 1997; O'Keefe 2001; O'Keefe & Street 2009).

Comparisons of the proportions of the centrum (height: length ratio) with other plesiosaur taxa, allows a Pliosauridae or Polycotylidae identification to be ruled out, because their dorsal vertebrae are relatively short. In contrast, the proportions of the centrum are similar to that of Elasmosauridae (Tab. 1, Fig. 3). Furthermore, the high neural spine with a deep, oblong groove on the anterior surface of the spine (Fig. 2 B) is also typical for some Elasmosauridae (Hiller et al. 2005; Sato et al. 2006), suggesting that the vertebra probably belongs to this clade.

Several plesiosaur specimens are known from the Upper Cretaceous of Sweden and Europe, e.g. Elasmosauridae and Polycotylidae (Persson 1954, 1959, 1963). Most of these specimens consist of isolated teeth or vertebrae (Persson 1963). The most complete remains come from *Scanisaurus* cf. *nazarowi* which was first described as a relative of Elasmosauridae (Persson 1959), but later reinterpreted as a member of Cimoliasauridae (Persson 1960). The latter were placed as sister group to Polycotylidae (O'Keefe 2001). However, a recent revision of the type material of *Cimoliasaurus magnus* Leidy, 1851 has shown that this genus belongs to Elasmosauridae (O'Keefe & Street 2009). Examination of the cervical vertebrae of *Scanisaurus* suggests that a relationship to Elasmosauridae is plausible. The centra of *Scanisaurus* are relatively short and have well-defined ossified articular margins and binocular-shaped articular faces which are characteristics of Elasmosauridae (see O'Keefe & Street 2009). Multiple dorsal vertebra centra with two prominent foramina for nutrient vessels on the ventral surface are known from *Scanisaurus*. The proportions of the centra are in the range of Elasmosauridae (Fig. 3 B). Compared to the dorsal vertebra from Wismar, the proportions are similar, but the centra are slightly smaller in overall size. The lack of neural arches in *Scanisaurus* vertebrae, as well as the general absence of diagnostic characters in plesiosaur dorsal

vertebrae (Sachs 2005), makes the attribution of the vertebra to any genus or species impossible. Therefore, we refer the new vertebra from Wismar to Elasmosauridae genus et species indeterminate.

Up until the end of the Upper Cretaceous, Elasmosauridae were a very successful reptile group with a global distribution (Persson 1963, Sato et al. 2006). Major elasmosaurid localities are in Japan, Australia, New Zealand, California, Argentina, Antarctica (Sato et al. 2006) and in the middle and east of North America (Persson 1963). In contrast, such findings are rare in Europe and usually incomplete. Isolated vertebrae, bones or teeth come from southern England, Russia and southern Sweden (Persson 1963). The new vertebra from Wismar differs from previous finds due to its almost complete preservation.

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