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### Short Communication

## First report of sea cucumbers (Echinodermata: Holothuroidea) from the latest Cretaceous of Bavaria, Germany

Mike Reich<sup>1,2,3</sup>

<sup>1</sup>SNSB - Bayerische Staatssammlung für Paläontologie und Geologie, Richard-Wagner-Straße 10, 80333 Munich, Germany

<sup>2</sup>Ludwig-Maximilians-Universität München, Department für Geo- und Umweltwissenschaften, Paläontologie und Geobiologie, Richard-Wagner-Straße 10, 80333 Munich, Germany

<sup>3</sup>GeoBio-Center der Ludwig-Maximilians-Universität München, Richard-Wagner-Straße 10, 80333 Munich, Germany

E-mail: m.reich@lrz.uni-muenchen.de

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**Schüsselwörter:** fossile Holothuroidea; Kreide; Maastrichtium; Bayern; Deutschland

The Bavarian Gerhardsreit Formation ("Gerhardsreiter Mergel" / "Gerhardsreiter Schichten"; cf. Böhm 1891; Hagn 1960; Wagreich et al. 2004), also known as Gerhartsreit Formation ("Gerhartsreiter Schichten"; Hagn et al. 1981, 1992; Schwarzhans 2010; Pollerspöck & Beaury 2014) or "Gerhardsreiter Schichten" (Egger 1899; Hagn & Hölzl 1952; de Klasz 1956; Herm 1979, 2000) is exposed in Upper Bavaria near Siegsdorf, southern Germany (cf. Hagn et al. 1981). The black to grey-black, fine sandy micaceous clayish marls were deposited on the northern Helvetic shelf (northwestern Tethyan realm; Herm 1979, 2000; Hagn et al. 1992), and are Maastrichtian in age.

The formation is well known for its diverse and well preserved assemblages of microfossils (e.g., Egger 1899; Ziegler 1959; Ohmert 1970; Hagn et al. 1981, 1992; Kirsch 1991), invertebrates, especially molluscs (Böhm 1891; de Klasz 1956; Hagn et al. 1992), and vertebrates (chondrichthyan and osteichthyan fishes; e.g., Schwarzhans 1996, 2010; Pollerspöck & Beaury 2014; Pollerspöck 2015). Collections have been made from the strata for over 150 years (Gümbel 1861: "Gosauschichten von Siegsdorf", Gümbel 1870: "Gosauergel von Götzreuth").

While examining micropalaeontological sieve residues of this formation, besides other microscopic echinoderm remains (Echinoidea, Ophiuroidea) a single holothurian calcareous ring element was found.

Whereas modern holothurians are common and ecologically important members inhabiting all marine environments, from the intertidal to the deepest oceanic trenches worldwide (e.g., Pawson 1982; Kerr & Kim 2001; Kerr 2003), fossil holothurians remain relatively rare (e.g., Frizzell & Exline 1956, 1966; Gilliland

1993; Smith 2004) due to different reasons (Reich 2013). There are nearly 1,700 valid extant sea cucumber species (Smiley 1994; Kerr 2003; Paulay pers. comm.) known worldwide. The fossil record (since the Middle Ordovician; Reich 1999, 2010), by contrast, is discontinuous in time and recorded ranges of species with around 1,000 reported forms (Reich 2013, 2014, 2015b) since the early 19th century.

Although well-preserved articulated material of holothurians are known from around a dozen fossil lagerstätten localities (Reich 2013) most of the fossil record of the group comprises isolated body-wall ossicles and elements of the calcareous ring (Pawson 1980; Smith et al. 2013; Reich 2015a).

The Cretaceous record of Holothuroidea was quite poor and understudied (Frizzell & Exline 1956; Müller 1969; Reich 1995, 1997) in comparison to Triassic and Jurassic holothurian faunas (Reich 2013). However, first gaps were filled by several papers published in the last 15 years (e.g., Al-Tamimi et al. 2001; Reich 2001a, 2001b, 2002a, 2002b, 2003a, 2003b, 2003c, 2003d; Reich & Wiese 2010; Reich & Ansorge 2014; Sadeddin & Al-Tamimi 2006; Al-Tamimi & Saqqa 2008).

The only known Cretaceous holothurian from Bavaria is represented by an isolated body-wall wheel ossicle ("*Calcarina rotula*", originally misinterpreted as a benthic foraminifer) from the Cenomanian of the "Einbachgraben" (Bavarian Alps), described by Joseph Georg Egger (1824–1913) in 1899 (cf. Reich 1997) which is in fact a member of the Apodida: Chiridotidae ("*Jumaraina rotula*"). Thus, unequivocal, identifiable holothurian fossils are important because this echinoderm group has largely been neglected by palaeontologists.

Images of the specimen figured here were captured with a Keyence VHX 5000 digital microscope with live depth composition (50–100 single stacked images). Figures were processed using Adobe Photoshop®.

Abbreviations: SNSB-BSPG – Bavarian State Collection of Palaeontology and Geology, Munich, Germany; CR – calcareous ring, R – radial element(s) of the calcareous ring, IR – interradial element(s) of the calcareous ring, RI to RV – Ludwig (1889) letters for designation of dorsal/ventral position of R: RI = mid-ventral, RII = left-ventral, RIII = right-ventral, RIV = left-dorsal, RV = right-dorsal.

### Systematic Palaeontology

The taxonomy, descriptive terminology and systematic scheme employed in this paper was adapted and modified from or is conform to those of Heding (1933), Gage & Billett (1986), Smirnov (2012), and Reich (2015a).

Phylum Echinodermata Bruguière, 1791  
[ex Klein, 1734]  
Subphylum Eleutherozoa Bell, 1891  
Class Holothuroidea de Blainville, 1834  
Subclass Holothuriacea Smirnov, 2012  
Order Molpadida Haeckel, 1896  
?(stem group) fam. nov.

gen. et sp. nov. A  
Fig. 1A-F

Type material: SNSB-BSPG 2016 VIII 151, radial CR element (?RI); isolated from the sieve residue of micropalaeontological sample #3857 (collected by Herbert Hagn in 1977).

Type locality: Gerhardsreiter (Gerhartsreiter) Graben, SE of Siegsdorf, Upper Bavaria, Germany.

Type stratum and age: Gerhardsreit (Gerhartsreit) Formation; Upper Cretaceous: Maastrichtian. – The precise biostratigraphy of this formation was the subject of debate during the last decades: (1) Lower Maastrichtian (e.g., de Klasz 1956; Ziegler 1959; Hagn 1961; Herm 1979), (2) Middle Maastrichtian (e.g., Hagn et al. 1981; Martini 1981; Hagn et al. 1992), or (3) upper Lower Maastrichtian to lower Upper Maastrichtian (Ohmert 1967), as well as (4) Upper Maastrichtian (e.g., Ohmert 1970; Herm 2000). However, the reported nanofossils (e.g., *Lithraphidites quadratus*; cf. Martini 1981; UC20 zone of Burnett 1998) and several foraminifera (e.g., *Bolivinoidea draco giganteus*, *Bolivinoidea draco draco*; cf. Koch 1977, Frenzel 2000) indicate an upper Lower Maastrichtian age (probably the fastigata belemnite zone).

Palaeoenvironment: Based on teleost fish oto-

liths described from the type stratum, Schwarzahns (2010) interpreted the environment as open or deeper shelf. This is in accordance to observations on the palaeoecology (cf. Frenzel 2000) of the recorded benthic foraminiferal fauna.

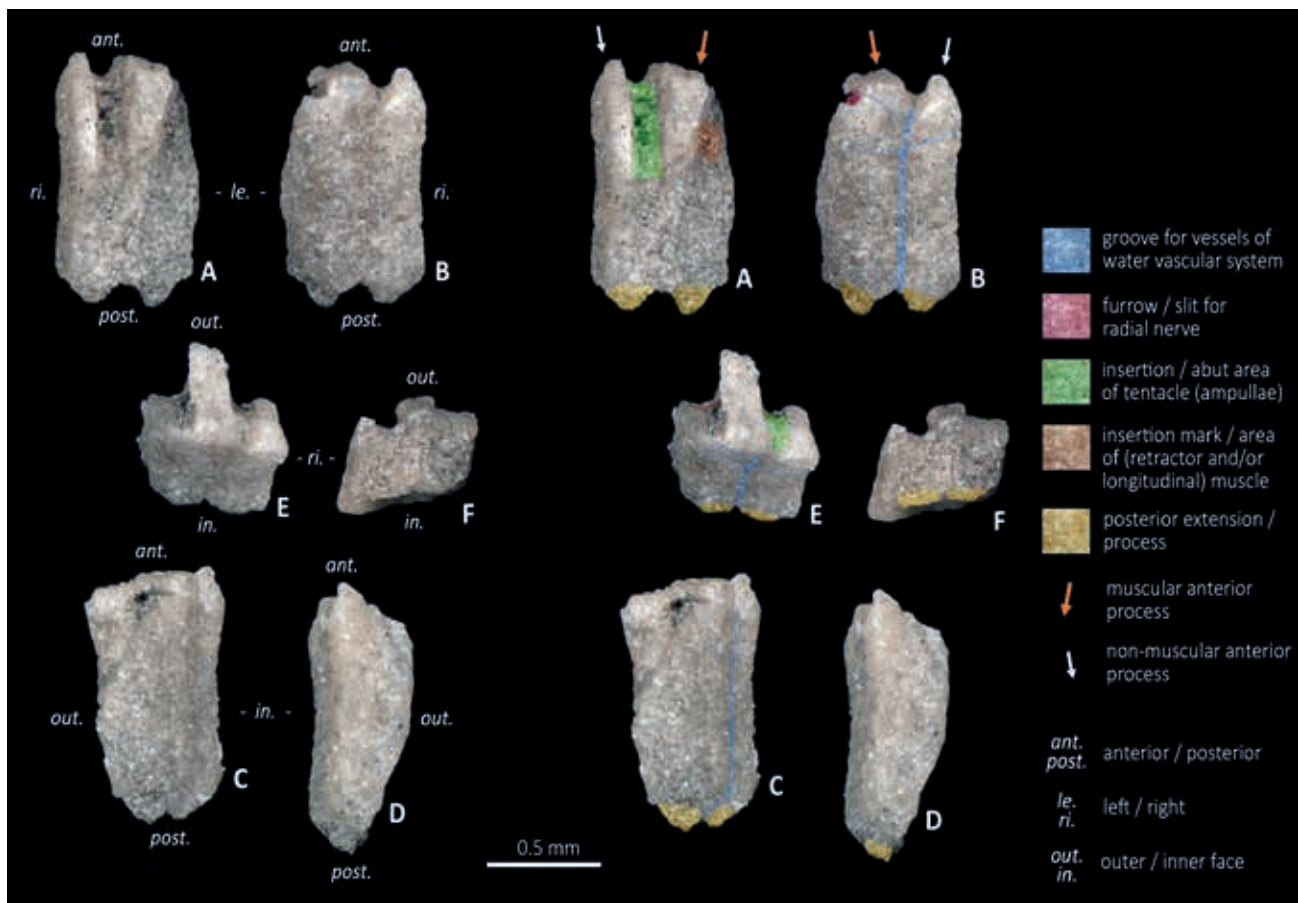
Description: The present specimen of an radial CR element is elongate and nearly subsquarish in outline; the whole element tends to be slightly curved with the inner face being concave and both lateral articulation faces inclined slightly inwards or being chamfered.

The muscular process bearing the notch for the passage of the radial nerve (Fig. 1B) is short, and facing somewhat outward (Fig. 1C, E) in part. The additional anterior process (non-muscular process; Fig. 1A-B) is slightly longer. On the external face (Fig. 1A) a medium-sized depression lies between the two anterior processes. On the inner face a posterior indent (encompassed by two short posterior extensions; Fig. 1A-F) extends into a furrow which divides anteriorly into three (?four) branches (Fig. 1B, C, E). Stereom structure is very dense.

Dimensions: Length of R: 1.19 mm; maximum width: 0.66 mm.

Discussion and remarks: Since only one specimen (of the diagnostic CR) of this taxon has been so far recorded I designated it as "gen. et sp. nov. A". The present R resembles the CR of molpadiid/caudinid holothurians but, by contrast, the typical posterior prolongations are short ("rudimentary") like in a few "non-typical" molpadids (e.g., *Eupyrgus*, *Cherbonniera*; Reich & Rössner 2016). However, by comparison with modern molpadid holothurian material (e.g., Hôzawa 1928; Heding 1933; Hatanaka 1939) it is possible to draw conclusions about some of the soft tissue components that were related to the CR (cf. Fig. 1A-F). Due to the size relationship of both anterior processes (shorter muscular process!) the position of the present CR element was probably mid-ventral (= RI). The central groove would have housed the anterior extension of the radial canal, leading to several tentacular canals (cf. also Hatanaka 1939). The insertion area of retractor/longitudinal muscles is located below the passage for the radial nerve (muscular process) (Fig. 1A-B). The new taxon is clearly different from modern molpadiid, caudinid and eupyrgid sea cucumbers that have a differing morphology and combination of anterior and posterior processes. It probably represents a stem group member (of our modern molpadids) rather than a representative of extant families.

Molpadid sea cucumbers are medium in size with a body which is often sausage-shaped, tapering posteriorly to form a conspicuous tail. These forms are deposit-feeders, usually burrowing into soft sediments or sand, often orientated with the anterior end downwards in the substrate and with the posterior end near the substrate surface for respiration (e.g.,



**Figure 1:** Radial CR element (probably RI) of an molpadid holothurian (gen. et sp. nov. A) from the Early Maastrichtian Gerhardsreit Formation of Bavaria (Gerhardsreiter Graben, near Siegsdorf), Germany (SNSB-BSPG 2016 VIII 151). **(A)** outer view; **(B)** inner view; **(C)** lateral (oblique) view (of left face); **(D)** lateral view (of right face); **(E)** anterior view; **(F)** posterior view. The left figure shows the overall morphology viewed from all directions, and the right figure with same configuration indicates interpretation of soft tissue anatomy related to the CR.

Pawson 1977, 1982). The group contains around 100 modern species in 9 genera and three families. Members of the Molpadida live in shallow or deep water with a bathymetric range of 0–5,250 m (e.g., Pawson 1977; Pawson & Liao 1992; Pawson et al. 2001; Pawson & Vance 2007; Davey & O’Loughlin 2013; Reich & Rössner 2016).

Late Cretaceous molpadid CR material was unknown so far. Hess (1975) and Gilliland (1992) reported on a few examples from the older Swiss and British Jurassic. Molpadid body-wall ossicles from Upper Cretaceous strata were recently described by Reich (2003d) and Reich & Ansorge (2014). The fossil record of Molpadida is poorly known, therefore each additional find can add significantly to our knowledge of extinct Holothuroidea or can help in identifying calibration points for phylogenies.

**Occurrence:** So far known only from the Lower Maastrichtian of the Bavarian Alps, Germany.

The newly discovered fossil constitutes the first reported occurrence of Holothuroidea from the Maastrichtian of Bavaria as well as of molpadid CR material from Late Cretaceous strata worldwide.

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