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**First evidence of vampyromorph cephalopod jaw structures from the Sinemurian,  
Lower Jurassic of Dorset**

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A new specimen of the Coleoidea from the Charmouth Mudstone Formation of the Dorset Coast has been identified as *Loligosepia bucklandi* (Voltz, 1840). The specimen includes the gladius and jaw fragments, which represent one of few records of its kind, but the head area, arms, hooks and suckers are not discernible. It can be favourably compared to other *L. bucklandi* fossils in the Natural History Museum in London and the J.F. Jackson Collection in the National Museum Wales in Cardiff. The range of *L. bucklandi* is determined to be from the Turneri Zone, Brooki Subzone to the Obtusum Zone, Stellare Subzone of the lower Sinemurian, with the new specimen stratigraphically a little older than the precisely located specimens in the J.F. Jackson Collection.

Key words: Jurassic, Sinemurian, Dorset, Coleoidea, *Loligosepia*

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## INTRODUCTION

Loligosepiina Jeletzky, 1965, a group of fossil coleoid cephalopods, play a central role in the evolution of the Coleoidea (e.g., Fuchs and Weis, 2008; Fuchs et al., 2013; Marroquín et

al., 2018; Fuchs, 2020). The original specimen of *Loligosepia bucklandi* was collected by Mary Anning from the Lias of Lyme Regis (Dorset, UK). It was recorded as 'fossil *Loligo*' by William Buckland (1836, p. 306). This specimen which, by this time, was in the Oxford University Museum (OUM J3530), was named by Voltz (1840) only on the basis of Buckland's illustration (1836, pl. 30). This specimen (Fig. 1), is therefore, the holotype (see Donovan and von Boletzky 2014). Since that time further specimens have been recorded (e.g., Fraas, 1889) and some are in the collections of The Natural History Museum in London and the National Museum Wales in Cardiff. An early description of "*Loliginites zitteli*" provided by Fraas (1889), re-drawn by Naef (1922) and more recently figured and described by Fuchs et al. (2013) shows arm stumps, a lower mandible; eye, cephalic cartilage; funnel and mantle. In recent years there have been further descriptions of *Loligosepia* by Fuchs and Weis (2008), Donovan and von Boletzky (2014) and Rowe et al., (2023) examining both soft tissue preservation and the place of *Loligosepia* in coleoid phylogeny.

Nevertheless, apart from representatives of the Belemnoidea, fossil remains of the Coleoidea are rare (e.g. Rowe et al., 2023) and well preserved coleoid beaks are exceedingly rare (Dzik 1986; Klug et al. 2005). Klug et al. (2005) do show upper and lower 'beaks' of coleoids, from the Kimmeridgian and Klug and Fuchs (2009) also note beaks for a specimen from the Hettangian of Somerset Coast, but it is not shown in detail (or convincing). Rarity may, in part, be related to the chitin of the beak requiring a moderately early mineralization and a low rate of decay to become fossilized (Allison, 1988).

## GEOLOGICAL SETTING

Exposed along the Dorset coast (Fig. 2) between Lyme Regis and Seatown (Dorset, UK) are marine sediments of the Charmouth Mudstone Formation of Sinemurian and

Pliensbachian age that have been investigated extensively in terms of their biostratigraphy (e.g., Lang and Spath, 1926; Cope et al., 1980; Simms, 2004), lithostratigraphy and sedimentology (e.g., Sellwood, 1972; Hesselbo and Jenkyns, 1995; Cox et al., 1999) and fossil content (e.g., Bennett et al., 2012; Donovan and von Boletzky, 2014; Hart et al., 2020). The sediments of the Charmouth Mudstone Formation are divided into five members (Fig. 3). The lowermost Shales-with-Beef Member (from which the specimen was derived, see below) consists of finely laminated and organic-rich dark-grey mudstone beds with a few bands of limestone nodules (e.g., the Birchi Nodules) and thin beds of fibrous calcite, or 'beef', which give the member its name (Hesselbo and Jenkyns, 1995; Simms, 2004; Cope, 2016). The Shales-with-Beef Member was deposited in a fully marine environment and represents part of the fill of a half-graben system that constitutes a segment of the Wessex Basin (Chadwick, 1986; Hesselbo and Jenkyns, 1995).

With respect to the holotype (Buckland, 1836, p. 304) there was, however, no locality or other geological information attached to it other than it was from Lyme Regis. Many of the other specimens listed by Donovan and von Boletzky (2014, appendix 1) also lack stratigraphical information, although they appear to come from the Shales-with-Beef and Black Ven Marls members of the Charmouth Mudstone Formation (Figs. 2, 3). The most precisely located specimens are those in the J.F. Jackson Collection (National Museum Wales) which are recorded as coming from the Flatstones and the Stellare Nodules of the Sinemurian Black Ven Marls of Lyme Regis. The bed numbers used by Lang and Spath (1926, p. 160) were reported by Donovan and von Boletzky (2014) based on Cope (2012, p. 56). Specimen NMW G250 is recorded as being associated with the Lower Flatstones (bed 83d) while specimen NMW G3528a is from the Upper Flatstones (bed 83h). The new specimen, representing part and counterpart (Figs. 4, 5), is within a loose nodule that was found in Chippel Bay (Lyme Regis) ~200 m east of Seven Rock Point: see Cope (2016, fig.

9) for a locality map. This would place it from within the Shales-with-Beef Member (which underly Black Ven Marls) of the of the Charmouth Mudstone Formation (Turneri Zone, Microderoceras birchi Subzone, lower Sinemurian) near to the Birchi Tabular or Birchi Nodules (Lang and Spath, 1926, beds 76–83; Palmer, 1984).

Chippel Bay lies within the Pinhay Bay to Fault Corner Geological Conservation Review Site (GCR) that was described by Simms (2004, pp. 60–82). This account illustrates the succession in three important logs of the Liassic sequence (Simms, 2004, figs 2.6a, b, 2.8 and 2.11), three of which were also reproduced by Cope (2016, figs 13, 16 and 18). The specimen NMW G.3658, which is a near-complete gladius (though missing some shelly material) from the Stellare Nodules, is nearly identical to the specimen in our Figure 5. The gladius is a chitinous structure in the dorsal mantle of living Vampyromorpha (Octobrachia) that provides support during the contractions involved in swimming by ‘jet propulsion’ (Fuchs and Iba, 2015). Jurassic species appear to have had a gladius preserved in apatite (Fuchs and Weis, 2008), although this has not been confirmed in the new specimen. The form of the gladius has been described in detail by both Fuchs and Weis (2008) and Donovan and von Boletzky (2014, fig. 4). Two other specimens in the Jackson Collection (NMW G3528 and NMW G250) are more fragmentary with only a partial gladius (again with shell material missing). If all the specimens in the Jackson Collection and the NHM (see Donovan and von Boletzky 2014) are conspecific with the new specimen, then the range of *L. bucklandi* is from the Turneri to the Obtusum zones, Brooki to the Stellare subzone of the lower Sinemurian. This would date the new specimen as a little older than the specimens in the Jackson Collection of the National Museum Wales.

*Institutional abbreviations.* NMW – National Museum Wales, Cardiff; NHM – Natural History Museum, London

## **Systematic palaeontology**

Class Cephalopoda Cuvier, 1797

Superorder Octobranchia Haeckel, 1866

Order Vampyromorpha Robson, 1929

Genus *Loligosepia* Quenstedt, 1839

*Type species: Loligo aalensis* Schübler in v. Zieten (1832, p. 24) by subsequent designation by van Regteren Altena (1949, p. 57); ICZN Opinion 1914, 1999. Type species from the Lower Toarcian of Southern Germany.

*Loligosepia bucklandi* (Voltz, 1840)

**Material.** The new specimen (Figs. 4a, 5) shows the gladius, some jaw fragments and an area surrounding the jaw fragments that may have been part of the head and the arms. No details of the latter are apparent. Owing to the similarities in the gladius shape and the parameters listed by Fuchs (2020) the gladius is considered to belong to a vampyromorph coleoid, *Loligosepia*.

**Current status and depository.** The specimen described in this paper is currently being cleaned into a final condition, with further investigations planned. Discussions are on-going about its final location in a suitable collection within the area of the Dorset Coast. The status of some of the fossils from this area *vis-à-vis* the proposed on-line ‘Jurassic Coast Collection’ of the Dorset and East Devon World Heritage Site is also being considered.

**Description.** Similar to the earlier records mentioned above, this specimen includes an almost unfragmented and three dimensionally preserved gladius (length = 16 cm), head and arm crowns (Fig. 4). The jaw fragments include the ‘rostrum’ of the upper jaw together

with part of the lower jaw. Figure 5 shows the median field in a central position between the paired lateral fields (*sensu* Jeletzky, 1966). The slightly sinusoidal character of the growth lines in the hyperbolar zone is quite distinct. In comparison, the general appearance of this specimen closely resembles that illustrated by Fuchs and Weis (2008, fig. 3) and the specimens figured by both Fuchs and Weis (2008, fig. 4A) and Donovan and von Boletzky (2014, fig. 1A, C and fig. 2A): see also Fuchs (2016).

*Remarks.* The jaw fragments (Fig. 4a, b) are up 17 mm in length. They show the ‘rostrum’ (sharp tip) of the upper jaw and a part of the lower jaw, following Tanabe et al. (2017). The position of the jaw fragments and preservation has not permitted the rostral, hood, crest and wing length, as well as the width of outer lamella to be determined (cf. Clarke, 1962, Clarke, 1986 and Clarke and Maddock, 1988; Tanabe et al. 2017). Indeed, as this rostrum is in a cementstone nodule it cannot be extracted further without damage. Hence further comparisons with Tanabe et al. (2017) for example are not possible. Nevertheless, this specimen represents one of the few records of the jaw in *Loligosepia* (family Loligosepiidae). There are some undetermined ‘black features’ posterior of the jaw fragments and the area anterior of the jaw fragments should contain evidence of the arms, though this is unclear in both normal and UV light.

A specimen in the University Museum in Florence, recorded as *Geoteuthis bollensis* Münster 1843 would probably be placed in *Loligosepia* following Fuchs and Weis (2008). This specimen may be the first record of the jaw in *Loligosepia* (family Loligosepiidae) from Jurassic strata, although there are other occurrences described by Tanabe (2012) and Keupp and Mitta (2013). Triassic ‘beaks’ have been described by Doguzhaeva et al. (2022).

A full discussion of cephalopod 'beaks' is provided by Clarke (1962, 1986); Clarke and Maddock (1988); and Klug et al. (2010, 2020). There are some undetermined 'black features' posterior of the jaw fragments and the area anterior of the jaw fragments should contain evidence of the arms, though this is unclear in both normal and UV light. It must be noted that none of the *L. bucklandi* specimens in the NMW and NHM collections preserve evidence of the head area, arms, hooks or suckers. In all these specimens, the gladius is less well-preserved than the new specimen.

It may only be a 'coincidence' but Clarke (2003, fig. 15) described a statolith (Jurassic sp. B) from this part of the Dorset coast succession. Clarke's material was provided by amateur fossil collectors Mr and Mrs Hiscock, who were based in Somerset. They collected and prepared the samples which were used to demonstrate that Jurassic sp. B (see Hart et al., 2015, fig. 2C, D) is widespread across Dorset and Somerset, including their location XII (see Hart et al., 2015, fig. 1) near Lyme Regis. This statolith probably came from near, or within, Bed 88f in the upper part of the *Asteroceras stellare* Subzone. This is the same stratigraphical level as specimen NMW G3658 in the Jackson Collection of the National Museum Wales. It is possible, therefore, that statolith Jurassic sp. B may come from *L. bucklandi* although other coleoids (belemnites and phragmoteuthids) are known from the same bed, and such an interpretation is therefore speculative. The statolith Jurassic sp. B coming from *L. bucklandi* cannot be confirmed without a macrofossil specimen that has the statolith *in-situ*. Other examples of Jurassic sp. B have been recorded in the adjacent strata.

*Stratigraphic and geographic range.* This specimen and those in the collections of the National Museum Wales and the Natural History Museum indicate a stratigraphical range



from the *Microderoceras birchi* Subzone to the *Asteroceras stellare* Subzone of the Lower Sinemurian and a distribution that is currently that of the Lyme Regis area of West Dorset.

## CONCLUSIONS

A new specimen of *Loligosepia bucklandi* (Volz, 1840) from Chippel Bay, west of The Cobb in Lyme Regis, UK, has been cleaned and prepared. It reveals many of the diagnostic features of both the genus and species, especially in the shape and structure of the gladius. The jaw fragments include a clear view of the rostrum, although the details of the head, arms and any suckers are missing. Apart from representatives of the Belemnnoidea, fossil remains of the Coleoidea are rare and such well-preserved coleoid jaw fragments are exceedingly rare (Dzik 1986; Klug et al. 2005). If all the specimens in the Jackson Collection and the NHM are conspecific with the new specimen described here, then the range of *L. bucklandi* is likely to be from the Turneri to the Obtusum zones, Brooki to the Stellare subzones of the Lower Sinemurian. This would place the new specimen stratigraphically a little older than the precisely located specimens in the Jackson Collection of the National Museum Wales.

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providing the photo of the holotype of *Loligosepia bucklandi* (Voltz). James Quinn is thanked for his assistance with the final versions of the figures used in this paper.

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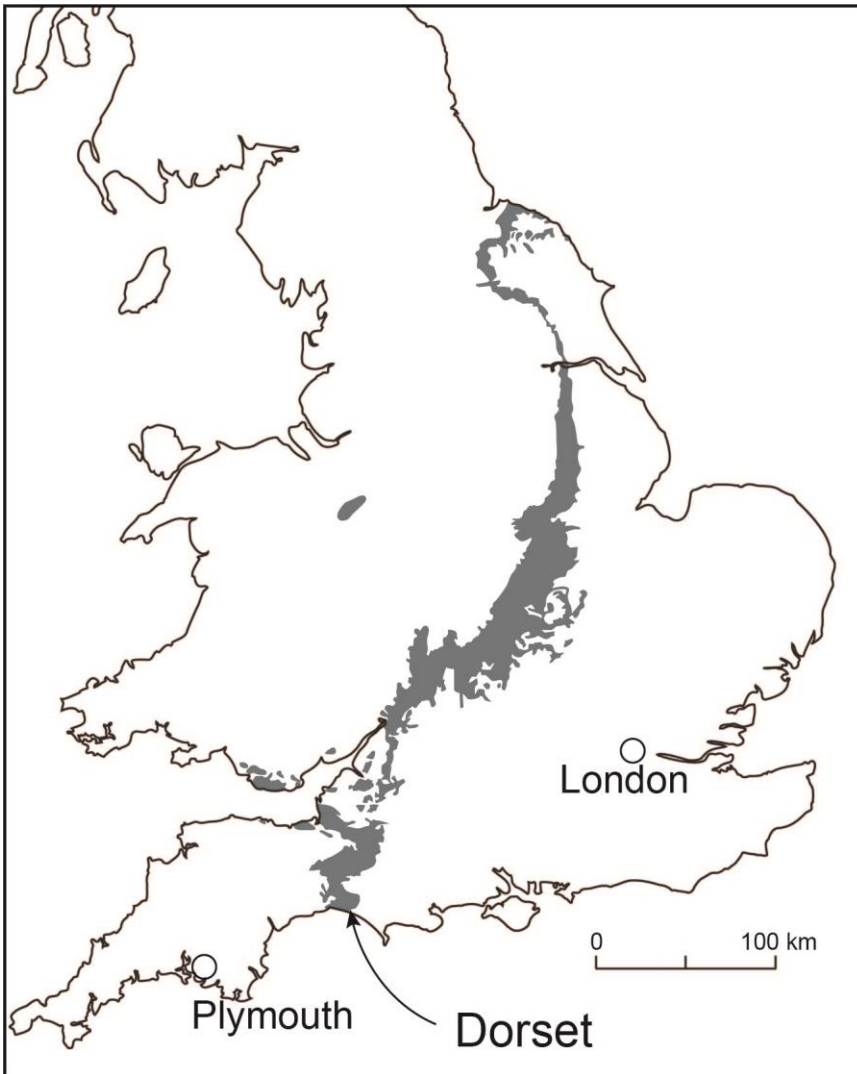
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**Figure 1.** *Lorigosepia bucklandi* (Voltz), the holotype, OUM J3530, gladius, anterior to left. Scale bar 5 cm. Oxford University Museum digital image, PAL-J3530.



**Figure 2.** Outcrop map for the Lias Group in England and Wales and showing the location of Dorset, UK (after Cox et al., 1999). The new specimen is within a loose nodule that was found in Chippel Bay (Lyme Regis) approximately 200 m east of Seven Rock Point: see Cope (2016, fig. 9) for a more detailed locality map.



| Stage/<br>substage     | Ammonite<br>zone | Lithostratigraphy                  |  |
|------------------------|------------------|------------------------------------|--|
| Toarcian               | Aalensis         | Bridport Sand Formation            |  |
|                        | Pseudoradiosa    |                                    | Down Cliff Clay Member   |
|                        | Dispansum        | Beacon<br>Limestone<br>Member      | Eype Mouth<br>Limestone<br>Member                                    |
|                        | Thouarsense      |                                    |  |
|                        | Variabilis       |                                    |  |
|                        | Bifrons          |                                    |  |
|                        | Serpentinum      |                                    |  |
|                        | Tenuicostatum    |                                    |  |
| Upper<br>Pliensbachian | Spinatum         |                                    | Marlstone Rock Member  |
|                        | Margaritatus     | Dyrham Fm.                         | Thorncombe Sand Member<br>Down Cliff Sand Member<br>Eype Clay Member |
| Lower<br>Pliensbachian | Davoei           | Charmouth<br>Mudstone<br>Formation | Green Ammonite<br>Mudstone Member                                    |
|                        | Ibex             |                                    | Belemnite Marl Member  |
|                        | Jamesoni         |                                    |  |
| Sinemurian             | Raricostatum     |                                    | <i>non-sequence</i>  |
|                        | Oxynotum         |                                    | Stonebarrow Pyritic Member   |
|                        | Obtusum          |                                    | <i>non-sequence</i>  |
|                        | Turneri          |                                    | Black Ven Marl Member  |
|                        | Semicostatum     |                                    | Shales-with-Beef Member  |
|                        | Bucklandi        |                                    |  |
| Hettangian             | Angulata         | Blue Lias Formation                |  |
|                        | Liasicus         |                                    |  |
|                        | Planorbis        |                                    |  |
| Rhaetian               |                  | Penarth Group Lillstock Formation  |  |

Pinhay Bay

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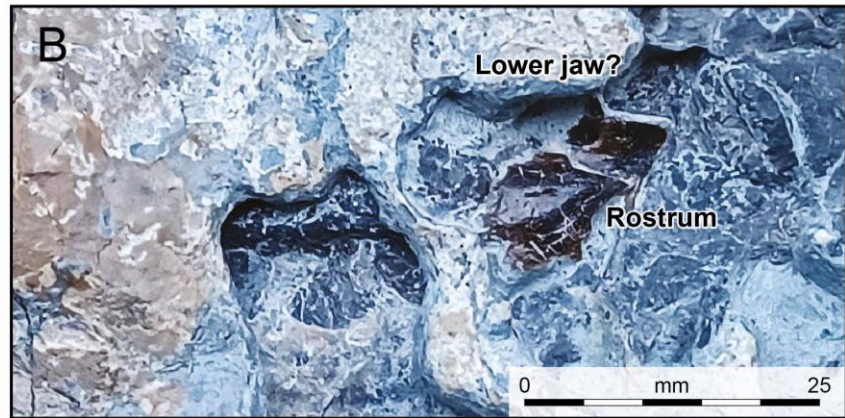
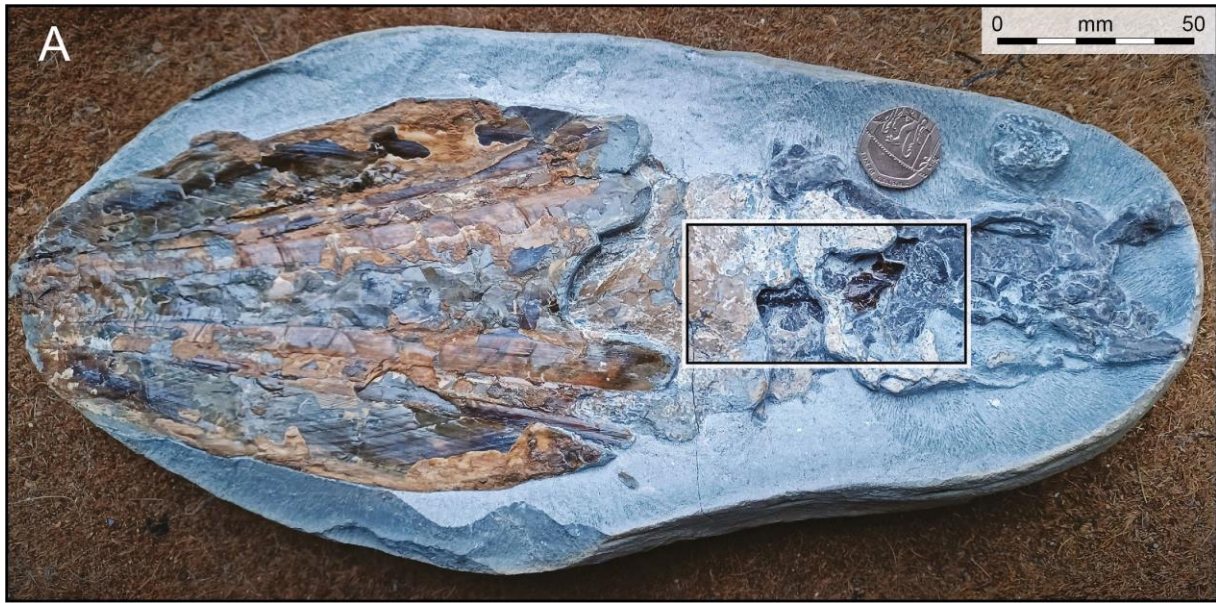
Church Cliffs and Black Ven

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Stonebarrow and Westhay

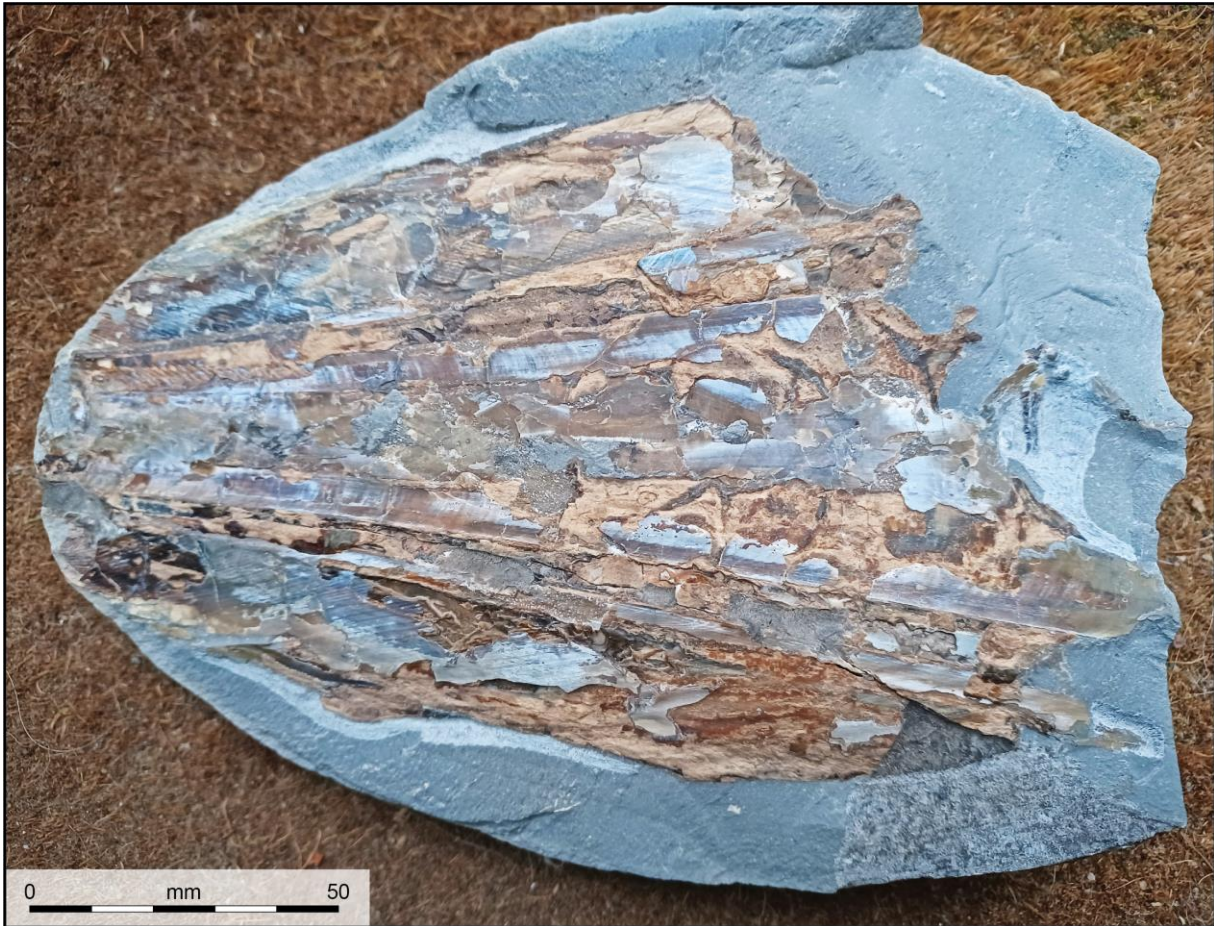
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**Figure 3.** Stratigraphical succession of the Jurassic strata exposed on the Dorset Coast, West Dorset (modified from Simms, 2004).



Figur

**Figure 4.** Vampyromorph cephalopod *Loligosepia bucklandi* (Volz, 1840) from a loose nodule that may have come from the Turneri Zone (*Microderoceras birchi* Subzone), Shales-with-Beef, Charmouth Mudstone Formation (Sinemurian) of Monmouth Beach, Lyme Regis. The gladius (A) and jaw fragments (B) (black in colour) and an area which may represent the disturbed remains of the head and arms. The jaw fragments include the 'rostrum' of the upper jaw together with part of the lower jaw. Within the gladius, the median field and the paired lateral fields are visible.



**Figure 5.** Vampyromorph cephalopod *Lorigosepia bucklandi* (Volz, 1840) counterpart, the gladius of the specimen shown in Figure 4A. The median field is visible as well as the paired lateral fields (with growth lines at a distinct angle to the edge of the median field).