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Published in:

Proceedings of the Geologists' Association

DOI:

[10.1016/j.pgeola.2018.02.008](https://doi.org/10.1016/j.pgeola.2018.02.008)

Publication date:

2018

Link:

[Link to publication in PEARL](#)

Citation for published version (APA):

Hart, M. B., Hughes, Z., Page, K. N., Price, G. D., & Smart, C. W. (2018). Arm hooks of coleoid cephalopods from the Jurassic succession of the Wessex Basin, Southern England. *Proceedings of the Geologists' Association*, 0(0). Advance online publication. <https://doi.org/10.1016/j.pgeola.2018.02.008>

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1 **Jurassic onychites (hooks from squid-like cephalopods) from the**
2 **Wessex Basin, southern England.**

3

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7

8 ABSTRACT

9 *Keywords:* Squid-like cephalopods, onychites, Jurassic, lagerstätte

10

11 **1. Introduction**

12 Modern squid have few easily preservable components. These include the crystalline
13 lens of the eye (Clarke, 1993), the gladii or chitinous backbone (La Roe, 1971),
14 mandibles or chitinous jaws (Clarke, 1965), onychites (squid arm and tentacle
15 hooks) and statoliths (Clarke, 1966). As statoliths are calcareous (aragonite), and
16 grow in size during ontogeny, they have the potential to record the development and
17 age of the parent animal (Clarke, 1966; Jackson, 1994; Arkhipkin, 2005) but, as
18 demonstrated by Kear et al. (1995, p. 117) in experimental work, they are often
19 destroyed by the decay of the dead animal. Kear et al. (1995, p. 124) also indicated
20 that while statoliths have a fossil record, none had been reported within a body fossil.
21 Wilby et al (2004,), however, indicated that some specimens of *Belemnotheutis*
22 *antiquus* may have statoliths present in the area of the head.

23 Modern coleoid (squid-like) cephalopods have arms that carry arrays of both
24 suckers and hardened, organic hooks. Fossil arm hooks have been known since
25 their description by Sternberg in 1823, although he identified them as plant remains.
26 During the twentieth century there were a number of brief descriptions of hooks but it
27 was Kulicki & Szaniawski (1972) who described 22 morphotypes from the Jurassic of
28 Poland. These authors gave these 'forms' names using a binomial classification
29 though, with many lacking defined (and figured) holotypes and , in some cases, only
30 one recorded specimen, some of their designations should probably be regarded as

31 invalid. Some of their morphotypes have, however, been reported from DSDP sites
32 on the Falkland Plateau (Wind et al., 1977) as well as New Zealand (xxxxxxx),
33 Germany, Poland and the United Kingdom (Hart et al., 2016). Arm hooks are
34 reported from the mid-Carboniferous to the Cretaceous/Paleogene boundary (Young
35 et al., 1998, fig. 2) and these records appear to be different to the arms of modern
36 squids that have suckers that can vary in size, with some containing a chitinous ring
37 (Roper et al., 1984; Hanlon and Messenger, 1996, fig. 4.3). Other squid-like
38 cephalopods are also known to bear hooks on the end of their club-like tentacles
39 (Roper et al., 1984; Hanlon and Messenger, 1996, fig. 4.3c).

40 In the fossil record it is clear that the hooks belong to widely distributed members
41 of the Belemnitida and Phragmoteuthida, and occur in three different situations:

- 42 • Discrete hooks that are found in either samples processed for other
43 microfossils (e.g., Hart et al., 2016) or in acid reductions of limestones
44 (e.g., Kulicki & Szaniawski, 1972);
- 45 • Assemblages of hooks associated with soft-bodied preservation of the
46 arms of squid-like cephalopods (e.g., the specimen of *Belemnotheutis*
47 *antiquus* illustrated by Clements et al., 2016, fig. 1D); or
- 48 • Occasional hooks that are either present in the preserved stomach
49 contents of vertebrate fossils (e.g.,.....) or in coprolites (e.g.,.....)

50 Using the abundance of material available to us from the Wessex Basin, we are
51 attempting to identify, where possible, the host animals. If this can be established
52 then it should be possible, using micropalaeontological samples, to determine the
53 stratigraphical and palaeoecological ranges of some of the host macro-fossils, many
54 of which are otherwise rarely preserved. There are some important questions to
55 answer before tackling this issue:

- 56 • Are all the hooks in any specimen identical or is there a variation along the
57 length of the arms?
- 58 • Do the hooks present in any taxon remain the same throughout the total
59 stratigraphical range or do they change through time?

- 60 • Is it possible to use the occasional hooks found in preserved stomach
61 contents or coprolites to identify the species that have fallen victim to
62 predation?

63 In attempting to answer these questions we have studied a range of specimens from
64 a number of key locations in the Wessex Basin of Jurassic age.

65

66 **2. Christian Malford**

67 Exceptional soft-bodied preservation of species such as *Belemnotherutis antiquus*
68 Pearce 1847 from the Callovian–Oxfordian of the United Kingdom has allowed the
69 identification of the host animal of some hook morphotypes, though the majority
70 remain un-attributable. In the Christian Malford lagerstätte (Upper Callovian) of
71 Wiltshire large numbers of hooks (including forms described as *Acanthuncus*, *Arites*,
72 *Deinuncus*, *Falcuncus*, *Longuncus* and *Paraglycerites*) are found associated with an
73 abundance of statoliths (cephalopod ‘ear bones’) and macrofossil evidence of both
74 belemnites and other squid-like cephalopods, some of which includes exceptional
75 soft-bodied preservation (see Wilby et al., 2004, 2008; Hart et al., 2016).

76 The Christian Malford ‘squid bed’ (Page and Doyle, 1991) and associated strata
77 have yielded *B. antiquus*, occasional *Mastigophora brevipinnis*, and unique
78 specimens of *Romaniteuthis* sp. and *Trachyteuthis* sp.. The history of *B. antiquus*
79 has been fully documented by Donovan and Crane (1992), who illustrated their
80 account with a number of photographs of specimens housed in the Pearce Collection
81 of the City of Bristol Museums and Art Gallery (BRSMG). All of Pearce’s material
82 came from the Oxford Clay Formation of Christian Malford during construction of the
83 Great Western Railway in 1840. The associated ammonites are characteristic of the
84 Phaeinum Subzone (Athleta Zone) of the Callovian Stage (Donovan, 1983, pp. 486–
85 487; Page in Martill and Hudson, 1991, p. 156; Wilby et al., 2008; Hart et al., 2016).
86 Preservation is exceptional (Allison, 1988; Wilby et al., 2004) and includes
87 permineralized soft tissues, ink sacs, aragonitic phragmacones, statoliths (ear
88 bones) and onychites (hooks). In disaggregated samples of the clays, Hart et al.

89 (2016) record the presence of abundant benthic foraminifera (including aragonitic
90 taxa), ostracods, otoliths (fish 'ear bones'), statoliths and hooks.

91 The specimens described by Donovan and Crane (1992, pls. 1–5, text-figs 2,
92 3) show a range of structures, though no statoliths are mentioned. In particular they
93 illustrate (Donovan and Crane, 1992, pls 2, 4(1), text-figs 2, 3) the characteristic
94 hooks of *B. antiquus*. In all these illustrations the hooks appear to be almost identical
95 and are characterized by a smooth outline, simple curved uncinus and no sign of a
96 spur (Fig. 1). There is evidence of slight variability in the form of the hooks along the
97 arms although, as noted by Donovan and Crane (1992, p. 291) this may be an
98 artefact of preparation. The specimen from Christian Malford (NHMUK 25966)
99 illustrated by Clements et al. (2016, fig. 1D) shows a series of paired hooks in the
100 arms that appear remarkably constant in appearance. Donovan and Crane (1992, p.
101 282) record the earliest *Belemnotheutis* from the Kellways Rock (Calloviense Zone,
102 Lower Callovian) in Wiltshire, while the youngest appears to be Kimmeridgian in age.
103 Riegraf (1987) reported a crushed phragmacone from the Kimmeridge Clay
104 Formation of Kimmeridge Bay (Dorset), though no precise position is known.
105 Donovan and Crane (1992, p. 282) suggest a position in the Pseudomutabilis Zone
106 or Gigas Zone. The youngest recorded specimen is given as Upper Kimmeridgian
107 (?Pallasiodes Zone).

108 The 'Etches Collection', part of which is now on display in the village of
109 Kimmeridge (Dorset), contains numerous examples of *Belemnotheutis*, including
110 several specimens (www.theetchescollection.com) that show the characteristic
111 layout of the arms and – in places – the paired hooks that are almost identical to
112 those illustrated by Donovan and Crane (1992). These specimens are all from the
113 Kimmeridge Clay Formation of Dorset and confirm the range of the species from
114 Lower Callovian to Upper Kimmeridgian.

115 Doyle (1991, p. 172) records a (?) *Belemnotheutis* phragmacone from the
116 Nordenskjöld Formation of the Antarctic Peninsula, which is probably late
117 Kimmeridgian in age. In DSDP cores on the Falkland Plateau, Wind et al. (1977) pl.
118 2(7)) record a smooth *Belemnotheutis*-like hook from the Oxfordian. Wind et al.
119 (1977, pls 1–6) also illustrate a range of hook morphotypes that are mostly

120 characterized by the presence of spurs. These are attributable to the ‘taxa’ described
 121 by Kulicki & Szaniawski (1972), and record them as *Paraglycerites*, *Urbanekuncus*
 122 and *Longuncus*. Wind et al. (1977, pl. 4, p. 830) also describe a new morphotype
 123 (*Accoluncus*) with a spur much further along the shaft towards the uncinus (Fig. 1C).
 124 The variety of morphotypes, though not identical, is reminiscent of the range of forms
 125 seen in samples from Christian Malford (Hart et al., 2016, fig. 3).

126

127 **3. Lower to Middle Jurassic hooks**

128 The range of hook morphotypes present in the samples from Christian Malford
 129 (Hart et al., 2016) is suggestive of a much greater range of taxa being present than
 130 is currently known from soft-bodied material and phragmacones. Hart et al. (2016)
 131 also only reported two types of statolith being present: described as Jurassic sp. A
 132 and Jurassic sp. C by Clarke (2003). Most of the non- hooks fall into two main
 133 groups:

- 134 • Elongate forms included in *Longuncus* by Kulicki & Szaniawski (1972); and
- 135 • Forms with a distinctive spur that were mainly included in *Parglycerites* by
 136 Kulicki & Szaniawski (1972).

137 Donovan (2006), in a review of the Phragmoteuthida from the Lower Jurassic of
 138 Dorset, has indicated that they are rare in the Charmouth Mudstone Formation
 139 (Sinemurian, Jurassic). Two species – *Phragmoteuthis huxleyi* Donovan (1966) and
 140 *P. montefiorei* J. Buckman (1880) – are described, each reflecting a different style of
 141 preservation. Donovan (2006, text-fig. 1) illustrates the holotype of *P. montefiorei*
 142 (specimen BMNH C5026), which shows the presence of slightly curved hooklets and
 143 these are also visible in Donovan’s (2006, text-fig. 2) illustration of another specimen
 144 from Lyme Regis. Donovan (2006, p. 677) goes on to note that the hooks associated
 145 with *P. montefiorei* are similar to those of *P. bisinuata* (Bronn, 1859) from the Upper
 146 Triassic and *P. conocauda* Quenstedt, 1849 from the Lower Jurassic of southern
 147 Germany (Riegraf, 1996, fig. 4c; Riegraf et al., 1984, pl. 10, fig. 11, text-fig. 43c).
 148 Donovan (2006, p. 677) also indicates that the specimens of *P. huxleyi* are (mainly)

149 from the Black Ven Marls Member of the Charmouth Mudstone Formation (Obtusum
150 Chronozone), with one specimen labelled as 'Monmouth Beach' , west of Lyme
151 Regis. The specimens of *P. huxleyi* and *P. montefiorei* illustrated by Donovan (2006)
152 show no evidence of statoliths but are clearly potential hosts of Jurassic sp. B
153 (Clarke, 2003; Hart *et al.*, 2015). *P. conocauda* (from the Toarcian) could be the host
154 of another statolith, which has been recorded in SW Germany from the uppermost
155 Toarcian (Aalensis Chronozone) and lowermost Aalenian (Opalinum Chronozone):
156 *fide* Dr Wolfgang Riegraf (Münster, Germany).

157 Hyde (2012) has described two specimens of phragmoteuthid cephalopods
158 that are in the collections of Manchester Museum: specimen numbers L6809 and
159 L.6923). These are recorded as being from 'Lyme Regis' and attributed to the Lower
160 Lias "somewhere near the top of the *A. bucklandi* Zone". Hyde (2012, fig. 1)
161 illustrates specimen L6923, which includes part of the pro-ostracum and
162 phragmacone and hooks. Hyde (2012, p. 443) notes that the hooks appear to be
163 paired with one being long and gently curved with a "bifurcated base" and the other
164 being shorter, more robust and triangular in shape. Hyde (2012, p. 444, fig. 2) also
165 indicates that specimen L6809 has paired hooks which can be used to define the
166 arms. It seems clear, therefore, that these early Jurassic forms have paired hooks, of
167 different appearance, with the larger, curved hooks having a distinctive 'base'. No
168 spur, *sensu* Kulicki and Szaniawski (1972), is described or illustrated in these
169 individuals.

170

171 In the Paleontological Museum of the University of Florence (via Giorgio La Pira
172 4, Firenze) is Specimen Igf 10966 which is listed as *Geoteuthis bollensis*, and which
173 is attributed to the Upper Lias of Boll, Württemberg, Germany. It is a two-sided
174 specimen, one of which preserves an elongated ink sac. There is no visible sign of
175 any arms and no hooks are visible in the surrounding matrix. It is quite difficult to
176 determine the details of the head area and there is, therefore, no location in which to
177 search for statoliths. There are no details of who described this specimen or the
178 geology of the site from which it was collected.

179 In Leeds City Museum and Art Gallery is another specimen attributed to *G.*
180 *bollensis*, and this is labelled as being from Lyme Regis. There are no further details
181 as to the stratigraphical location of the specimen, though many squid-like
182 cephalopods come from bed 88f (in the Lang, 1914, 1917, 1924, 1932, 1936
183 nomenclature). This specimen was recently described by Robert Chandler.....

184 **Summary**

185 **Acknowledgements**

186 **References**

187 Allison, P.A., 1988. Phosphatised soft bodied squid from the Jurassic Oxford Clay
188 Lethaia 21, 403–410.

189 Clarke, M.R., 1965. “Growth rings” in the beaks of the squid *Moroteuthis ingens*
190 (Oegopsina, Onychoteuthidae). Malacologia 3, 297–307.

191 Clarke, M.R., 1966. A review of the systematic and ecology of oceanic squids.
192 Advances in Marine Biology 4, 91–300.

193 Clarke, M.R., 1978. The cephalopod statolith – An introduction to its form. Journal of
194 the Marine Biological Association of the United Kingdom 58, 701–712.

195 Clarke, M.R., 1993. Age determination and common sense – a free discussion on
196 difficulties encountered by the author, *in* Okutuni, T., O’Dor, R.K., Kubodera, T.,
197 eds., Recent advances in cephalopod fisheries biology, Tokai University Press,
198 Tokyo, 670–678.

199 Clarke, M.R., 2003. Potential of statoliths for interpreting coleoid evolution: A brief
200 review. Berliner Paläobiol. Abhandlungen 3, 37–47.

201 Clements, T., Colleary, C., De Baets, K., Vinther, J., 2016. Buoyancy mechanisms
202 limit preservation of coleoid cephalopod soft tissues in Mesozoic lagerstätten.
203 Palaeontology, doi: 10.1111/pala.12267

204 Hanlon, R.T., Messenger, J.B., 1996. Cephalopod Behaviour. Cambridge, Cambridge
205 University Press, 232 pp.

- 206 Hart, M.B., De Jonghe, A., Page, K.N., Price, G.D., Smart, C.W., 2016. Exceptional
207 accumulations of statoliths in association with the Christian Malford lagerstätte
208 (Callovian, Jurassic) in Wiltshire, United Kingdom. *Palaios* 31, 203–220.
- 209 Hyde, B.G. 2012. A description of two phragmoteuthid coleoid cephalopods from the
210 Lower Jurassic of Lyme Regis, Dorset and the importance of well intended
211 forgeries. *The Geological Curator* 9(8), 441–446.
- 212 Kear, A.J., Briggs, D.E.G., Donovan, D.T., 1995. Decay and fossilization of non-
213 mineralized tissues in coleoid cephalopods. *Palaeontology* 38, 105–131.
- 214 Kulicki, C., Szaniawski, H., 1972. Cephalopod arm hooks from the Jurassic of
215 Poland. *Acta Palaeontologica Polonica* 17, 379–419.
- 216 Lang, W.D., 1914. The geology of the Charmouth cliffs beach and foreshore.
217 *Proceedings of the Geologists' Association, London* 25, 293–360.
- 218 Lang, W.D., 1917. The *ibex* Zone at Charmouth and its relation to the zones near it.
219 *Proceedings of the Geologists' Association, London* 28, 31–36.
- 220 Lang, W.D., 1924. The Blue Lias of the Devon and Dorset coasts. *Proceedings of*
221 *the Geologists' Association, London* 35, 169–185.
- 222 Lang, W.D., 1932. The Lower Lias of Charmouth and the Vale of Marshwood.
223 *Proceedings of the Geologists' Association, London* 43, 97–126.
- 224 Lang, W.D., 1936. The Green Ammonite Beds of the Dorset Lias. *Quarterly Journal*
225 *of the Geological Society, London* 92, 423–437, 485–487.
- 226 La Roe, E.T., 1971. The culture and maintenance of the loliginid squids, *Sepioteuthis*
227 *sepioidea* and *Doryteuthis plei*. *Marine Biology* 9, 9–25.
- 228 Mantell, G.A., 1848. Observations on some belemnites and other fossil remains of
229 Cephalopoda, discovered by Mr Reginald Neville Mantell in the Oxford Clay
230 near Trowbridge, in Wiltshire. *Philosophical Transactions of the Royal Society*
231 138, 171–182.

- 232 Martill, D.M., Hudson, J.D. (eds), 1991. Fossils of the Oxford Clay, Palaeontological
233 Association, Field Guide to Fossils No.4, The Palaeontological Association,
234 London, 286pp.
- 235 Pearce, J.C., 1841. On the mouths of ammonites and on fossils contained in
236 laminated beds of the Oxford Clay, discovered in cutting the Great Western
237 Railway, near Christian Malford in Wiltshire. Proceedings of the Geological
238 Society, London 3, 592–594.
- 239 Roper, C.F.E., Sweeney, M.J., Nauen, C.E., 1984. FAO Species Catalogue.
240 Cephalopods of the World. An annotated and illustrated catalogue of species of
241 interest to fisheries. *FAO Fisheries Synopsis* 3, 1–277.
- 242 Wilby, P.R., Hudson, J.D., Clements, R.G., Hollingworth, N.T.J., 2004. Taphonomy
243 and origin of an accumulate of soft-bodied cephalopods in the Oxford Clay
244 Formation (Jurassic, England). *Palaeontology* 47, 1159–1180.
- 245 Wilby, P.R., Duff, K., Page, K., Martin, S., 2008. Preserving the unpreservable: a lost
246 world discovered at Christian Malford, UK. *Geology Today* 24(3), 95–98.
- 247 Young, R.E., Vecchione, M., Donovan, D.T., 1998. The evolution of coleoid
248 cephalopods and their present biodiversity and ecology. In: Payne, A.I.L.,
249 Lipiński, M.R., Clarke, M.R., Roeleveld, M.A.C. (eds), *Cephalopod biodiversity,*
250 *ecology and evolution*, South African Journal of Marine Science 20, 393–420.

251

252 **Figure Captions**

253 Figure 1. Terminology applied to the hooks of squid-like cephalopods. A; typical hook
254 of *Belemnotheutis antiquus*: B; typical appearance of a hook identified as
255 *Paraglycerites* by Kulicki and Szaniawski (1972): C; the species identified as
256 *Accoluncus falklandensis* Wind et al. (1977), showing the small spur near the
257 uncinus: D; the elongate form described as *Longuncus* by Kulicki and
258 Szaniawski (1972)

259 Figure 2.

1st November 2016

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