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An Unusually Preserved Specimen of the Cretaceous Teleost *Dercetis elongatus*

By

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Abstract A specimen of the eel-shaped Cretaceous teleost fish *Dercetis elongatus* AGASSIZ from the Middle Chalk is described. The specimen consists of a nearly complete articulated cranium and some articulated post-cranial remains. It is preserved as an external mould within a frost-shattered flint nodule. This well preserved specimen is only the thirteenth known and extends the range of the species, previously only recorded from the Middle Chalk of eastern England, to south-west Britain. The taphonomy is unusual as vertebrate remains are rarely preserved in flint nodules.

Introduction

Recently Mr. James BURTONSHAW, an amateur collector, found a specimen of the Cretaceous teleost fish *Dercetis elongatus* AGASSIZ within a frost shattered flint nodule in Buller's Hill Quarry, Haldon Hills, Exeter, Devon (Figs. 1 and 2).

The geology of the Haldon Hills was investigated by HAMBLIN (1969, 1973a, 1973b, and 1974), EDWARDS (1973) and HAMBLIN and WOOD (1976). HAMBLIN (1973a) stated that the Haldon Hills are capped with Paleocene-Eocene gravels which contain derived Cretaceous flint nodules. These Haldon gravels can be subdivided into two distinct units:

1. The Tower Wood Gravel and,
2. The Buller's Hill Gravel.

The younger Buller's Hill Gravel rests upon the Tower Wood Gravel and consists of ten metres of abraded flints and subordinate clays and sands (HAMBLIN, 1973a).

The gravels consist mainly of pale brown to pale gray flints that show abrasion and chatter-marks but they also contain a large amount of exotic pebbles such as Carboniferous shale, vein quartz, schorl etc. which show there to have been a sediment input from the westerly high ground of Dartmoor.

HAMBLIN (1973a) noted that all the primary sedimentary structures in the gravels had been destroyed and that the gravels contain lenticular bodies of disordered 'ball-clay' kaolinite. These factors led Hamblin to postulate that the

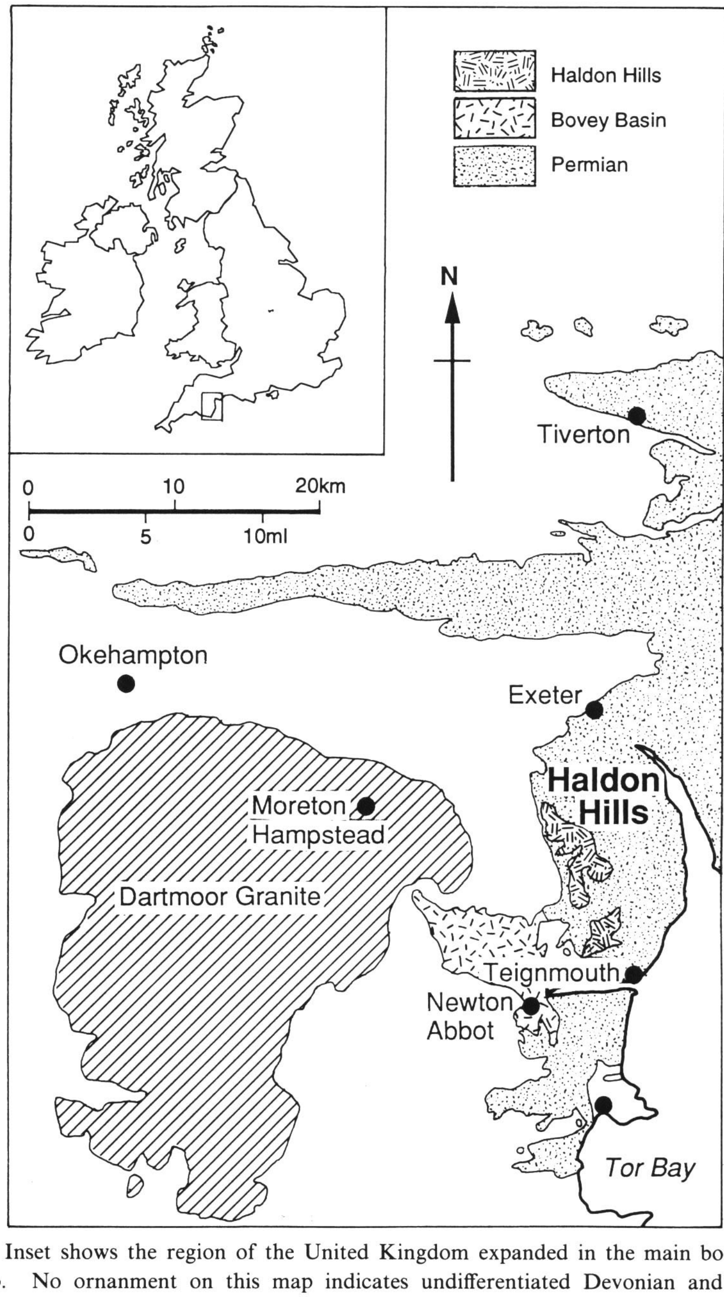

Fig. 1. Inset shows the region of the United Kingdom expanded in the main body of the map. No ornament on this map indicates undifferentiated Devonian and Carboniferous sediments. The Haldon Hills sediments are Paleocene-Eocene in age. The Bovey Basin sediments are Oligocene in age.

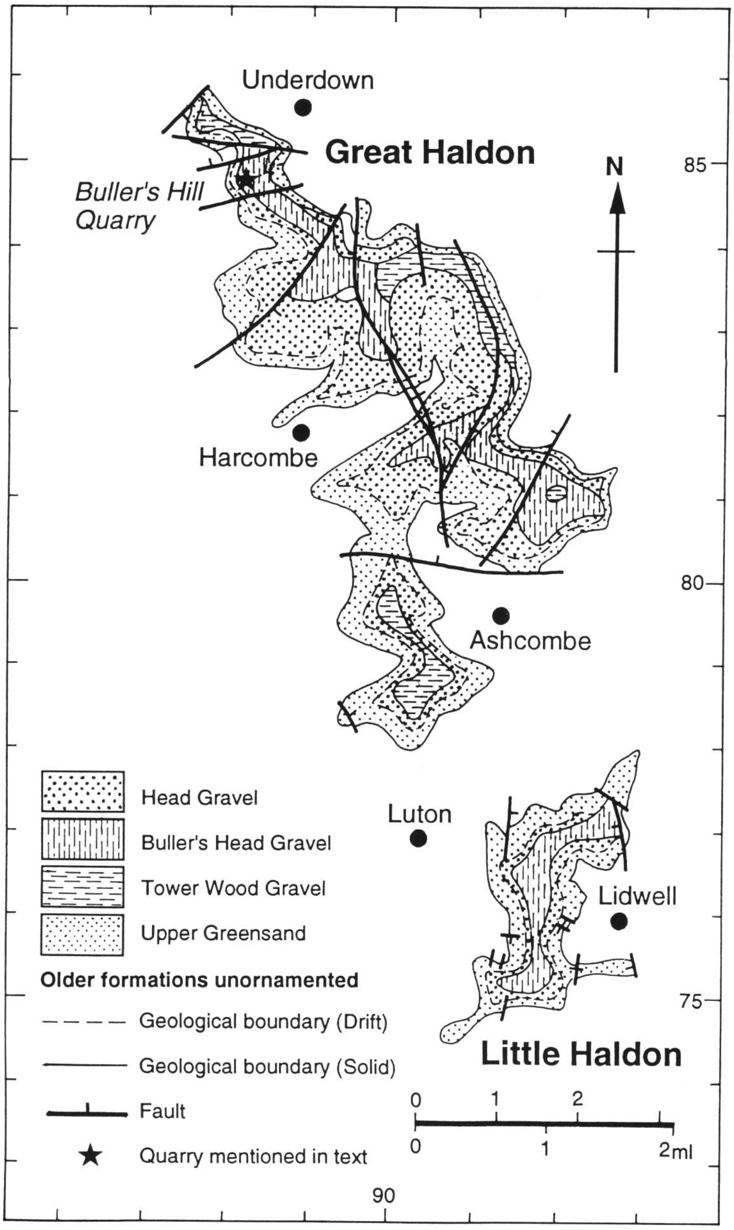

Fig. 2. Detailed geological map of the Haldon Hills area, Devon, England. Numbers around edge of map are Ordanance Survey Grid Reference numbers. Map adapted from EDWARDS and FRESHNEY (1982).

Buller's Hill Gravels were highly effected by periglacial processes during the Pleistocene, including frost shattering of the gravels.

The age of the flints within the Haldon Gravels are determined using characteristic fossils such as echinoids. EDWARDS and FRESHNEY (1982) using this technique stated that the earliest possible age for all the units is the Senonian stage of the Upper Chalk and therefore a good limiting age for the specimen can be assumed.

Systematic Palaeontology

Class Actinopterygii COPE 1871
Subclass Teleostei MULLER 1846
Subdivision Neoteleostei NELSON 1969
Order Alepisauriformes REGAN 1911
Suborder Ichthyotringoidei GOODY 1969
Family Dercetidae PICTET 1850
Genus *Dercetis* AGASSIZ, 1834
Dercetis elongatus AGASSIZ 1834
Fig. 3.

1834. *Dercetis elongatus* AGASSIZ; p. 55, p. 258, figs. 1, 2, 5–8.
1863. *Leptotrachelus elongatus*: VON DER MARCK, p. 59.
1878. *Triaenaspis elongatus*: COPE, p. 67.
1879. *Dercetis elongatus*: DAVIES, p. 145.
1888. *Dercetis elongatus*: WOODWARD, p. 318, fig. 7.
1901. *Leptotrachelus elongatus*: WOODWARD, p. 184, fig. 4.
1903. *Leptotrachelus elongatus*: WOODWARD, p. 68, pl. 16.
1940. *Benthesikyme elongatus*: WHITE and MOY-THOMAS, p. 102.
1969. *Dercetis scutatus* GOODY, p. 51.

Types: Holotype: Mantell collection, Natural History Museum, London (BMNH P4132-33). Probably from one of the Turonian zones, near Lewes, Sussex. Paratype: Capron collection, Natural History Museum, London (BMNH P49793). Probably from one of the Turonian zones, near Lewes, Sussex.

Material: Figs. 3–5. A single, half-nodule of flint, containing the external mould of a cranium of *Dercetis elongatus* in palatal view (housed in the private collection of Mr J. BURTONSHAW) plus a latex cast (obtained by the direct transfer method) of the above nodule (housed in the University of Bristol Geology Museum, BRSUG 24215).

Description: The specimen consists of an articulated almost complete cranium and some articulated post-cranial remains. The specimen, due to the preservation in a flint nodule, is three dimensional and the bones remain in natural articulation with little diagenetic compaction.

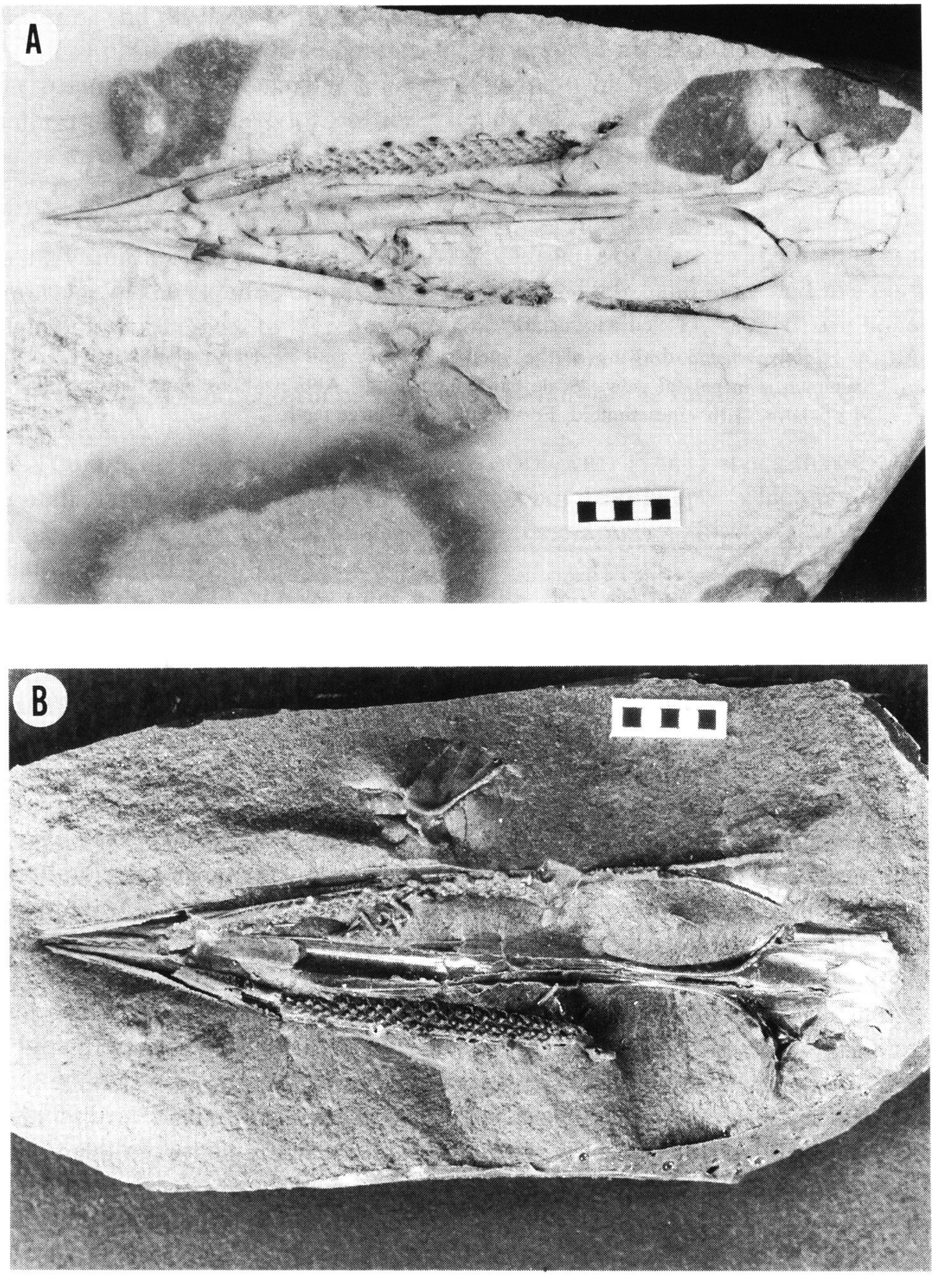

Fig. 3. A, photograph of the flint nodule containing the specimen of *Dercetis elongatus* in the private collection of Mr J. Burtonshaw; B, photograph of the latex peel of the above specimen (BRSUG 24215). Both specimens show a palatal view. Scale bar in both photographs is 1 cm.

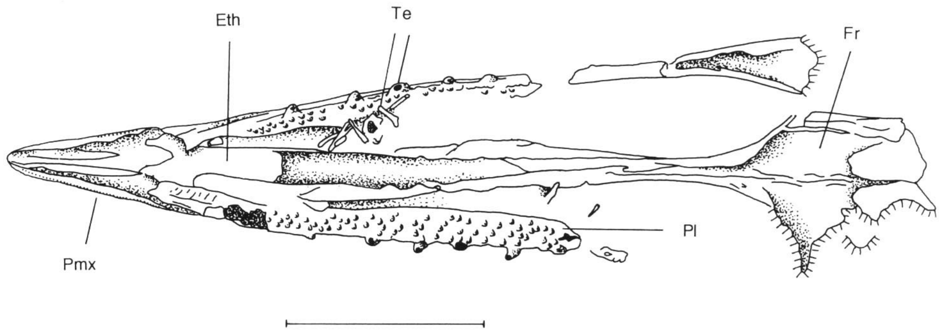

Fig. 4. *Camera lucida* drawing of the latex peel of *Dercetis elongatus* (BRSUG 24215). Specimen is in palatal view. Scale bar is 1 cm long. Abbreviations: Pmx = premaxilla; Pl = palatine; Eth = mesethmoid; Fr = frontal; Te = large teeth.

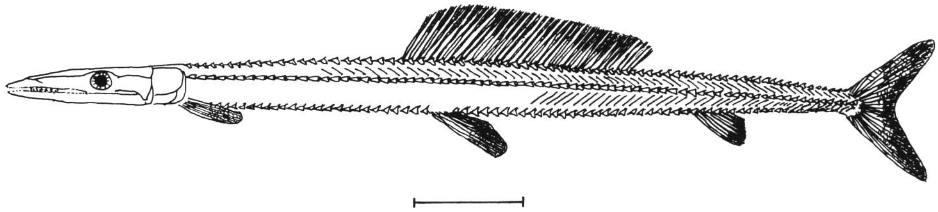

Fig. 5. Reconstruction of *Dercetis elongatus* based on Fig. 15 of WOODWARD (1903). Scale bar is 5 cm long.

Neurocranium: The rear portion of the neurocranium is not preserved. The interior aspect of the frontals form all of the visible skull roof. They have a small flange after the narrow interorbital region, and then taper anteriorally to meet the mesethmoid towards the front of the skull. They are ornamented with fine striations running posteriorally, radiating out from the medial anterior end of the bones.

The mesethmoid is composed posteriorally of two strips of bone which join anteriorally and which flank the anterior edge of the frontals. The mesethmoid is long, narrow and also tubular in cross-section. Some fine striations can be seen along the median part of this bone. The front portion of the mesethmoid is expanded into two small "wings" with a median indentation between them.

Palatal bones: The palatine is well preserved, and shows a large quantity of teeth. The bone is long and narrow, with a slight degree of anterior-posterior curvature. It seems to be almost tubular in cross-section. There is a narrowing towards the anterior end. Due to the nature of the preservation, it is not possible to see how the palatine articulates.

The ectopterygoid/maxilla is represented by an disarticulated fragment. It is present as a narrow rod of bone which is thickened at the posterior end. The posterior end diverges to form a flange of bone.

The posterior end of the premaxilla is wrapped around the anterior edge of the palatine. The premaxilla is a slender bone, which comes to a narrow point anteriorally. The posterior portion extends as a shallow lamina of bone which bears a row of small teeth.

Dentition: Three distinct rows of small teeth are present on the inner face of the palatine. Each tooth has approximately the same basal area, with space being visible around each tooth. On the outside edge of these rows, situated at the top ridge of the palatine are six large teeth on the left hand side, and five on the right. Both sets seem to increase with size posteriorally. These teeth are hollow, with a large pulp cavity, and oval in cross-section. They are forward curving, with wear facets in the form of striations. Details of the smaller teeth rows were not visible.

Comments on other descriptions: Woodward (1888) states that the jaws contain 'powerful recurved teeth, though it is not definite upon which bones these are fixed'. Due to the three dimensional preservation of this specimen we note that these teeth are attached to the top ridge of the palatine. Woodward (1903) describes the teeth as belonging mainly on the palatine, but again makes no mention of differentiation into two size classes. Goody (1969) states that there are three tooth rows on the palatine, but that some shorter, stouter and more recurved teeth are situated on the ectopterygoid (=larger teeth of above?).

Descriptions have also varied as to the extent of the frontals with respect to the parietals and the rest of the skull roof. Woodward (1903) states that the frontals occupy just over half of the skull roof, with the parietals composing the remaining space, while the more recent review of Goody (1969) states that the frontals occupy a much larger proportion of the neurocranium. We feel that the frontals occupy the greatest part of the skull roof, and that in the examined specimen they are overlain with other bony material.

Taphonomy

The formation of flints and cherts in chalks has long been a mystery. It is only recently (Bromley *et al.*, 1975; Clayton, 1986; Toynto & Parsons, 1990) that plausible explanations have been reached.

The formation of flint depends upon the reduction of sulphate to hydrogen sulphide by the action of organic matter within the chalk [1 and 2]. The hydrogen sulphide migrates through the sediment and mixes with dissolved oxygen at the oxic-anoxic interface [3]. The ensuing reaction between the two releases protons which in turn react with the calcium carbonate in the chalk in an acid-base type reaction [4]. This reaction produces the soluble bicarbonate ion which "seeds" the metastable pore waters which are undersaturated with respect to amorphous silica but highly supersaturated with respect to crystalline silica (e.g. Opal-CT) and hence there would be a rapid precipitation of silica [5]. This can be summarised to the following equations (after CLAYTON, 1986).

[1] Organic matter $+ SO_4 \rightarrow$ smaller organic particles $+ CO_2 + S^{2-}$

The CO_2 and S^{2-} reach equilibrium with the environment.

[2] $S^{2-} + CO_2 + H_2O \leftrightarrow HS^- + HCO_3^- \leftrightarrow H_2S + CO_3^{2-}$

In the oxidising condition.

[3] $H_2S + 2O_2 \rightarrow SO_4^{2-} + 2H^+$

The protons react with the calcite of the chalk.

[4] $H^+ + CaCO_3 \leftrightarrow Ca^+ + HCO_3^-$

The bicarbonate ions then seed the pore waters.

[5] $HCO^-_{3(aq)} + SiO_{4(aq)} \rightarrow HCO^-_{3(aq)} + SiO_{4(ppt)} \downarrow$

As evidenced by the previous equations flint must be an early diagenetic precipitate and forms at depths of 5–10 m below the sediment surface (at the oxic-anoxic boundary) and because of this any organism (e.g. echinoid, burrow, sponge etc.) which is preserved in flint will retain it's three dimentional shape as compaction has not yet had chance to distort the organism. It also has the potential to preserve organisms in their entirety i.e. before decay and disarticulation have any effect.

Fish, however, are very rarely preserved in flint. There are only three specimens known, all of which have been recovered from the Cretaceous Chalk of southern and eastern England. It may be a coincidence that one of these specimens is also a *Dercetis* species (Natural History Museum, London, BMNH P9100).

From the observation of this new specimen and the other known specimens the following general points about the taphonomy of fish in flint can be recorded:

1. Whole fish are never found totally enclosed within a flint nodule-usually only part of the fish is encapsulated. This may be due to the actual place of formation of the flints (which form in high permeability and porosity chalk) rather than a taphonomic effect i.e. disarticulation.
2. When preserved in flint, fish retain a three dimentional structure (which is concurrent with the fossilisation of other organisms preserved in flint).
3. The bones of fish are always preserved as external moulds. This is due to the dissolution of the bone which must occur after the formation of the flint, but before the flint becomes sealed to the percolation of pore waters (it is assumed that the pore water chemistry is responsible for the dissolution of the bone).

The taphonomy of this individual specimen shows all of these general features. This, therefore, presents the first ideas on the taphonomy of fish in flint and obviously shows the need for further future study of the taphonomy of flint organisms.

Conclusions

The redescription of the cranium of this species has been facilitated by this well preserved specimen.

The specimen has also allowed the extension of the species range from the Middle Chalk of Norfolk, Sussex and Kent to the Middle Chalk remainée flints of Devon.

The first theories on the preservation of bone in flint have been presented here.

Acknowledgments

We wish to thank Mr Jim BURTONSHAW for finding this specimen and allowing us to describe it, Prof. Brian GARDINER and Dr Colin PATTERSON for their endless help with references, specimens and advice. We would also like to thank Dr Patrick SPENCER for making the latex cast, Mr. Simon POWELL for producing the photographs and Ms. Pam BALDERO for producing the maps.

References

AGASSIZ, L., 1833–44. Recherches sur les poissons fossiles. Neuchatel. 5 vols, 1420 pp., 396 pls, with supplement.

BROMLEY, R. G., M. G. SCHULZ & N. B. PEAKE, 1975. Paramoudras: giant flints, long burrows and the early diagenesis of chalks. *K. dansk. vidensk. Selsk. Geol. Skr.* 20(10): 3–31.

CLAYTON, C. J., 1986. The chemical environment of flint formation in Upper Cretaceous chalks, p. 43–54. *In* SIEVEKING, G. de C. & M. B. HART, (eds.): The Scientific Study of Flint and Chert. Cambridge University Press.

COPE, E. D., 1878. Description of fishes from the Cretaceous and Tertiary deposits West of the Mississippi River. *Bull. U.S. Geol. Geogr. Survey Territories*, 4(1): 67–77.

DAVIES, W., 1879. On some fish exuviae from the chalk, generally referred to as *Dercetis elongatus*, AG., and on a new species of fossil Annelidae *Terebella lewensiensis*. *Geol. Mag.* 6: 145–148.

EDWARDS, R. A., 1973. The Aller Gravels: Lower Tertiary braided river deposits in south Devon. *Proc. Ussher Soc.*, 2: 608–616.

——— & E. C. FRESHNEY, 1982. The Tertiary Sedimentary Rocks, p. 204–237. *In* DURRANCE, E. M. & D. J. C. LAMING (eds.): The Geology of Devon. University of Exeter Press.

GOODY, P. C., 1969. The relationships of certain Upper Cretaceous teleosts with special reference to the Myctophoids. *Bull. Brit. Mus. (Nat. Hist.) Geol. Suppl.*, 7: 1–255.

HAMBLIN, R. J. O., 1969. The geology of the Haldon Hills. Unpublished Ph.D. Thesis, University of Exeter.

———, 1973a. The Haldon Gravels of south Devon. *Proc. Geologists' Assoc.*, 84: 459–476.
———, 1973b. The clay mineralogy of the Haldon Gravels. *Clay Minerals*, 10: 87–97.
———, 1974. On the correlation of the Haldon and Aller Gravels. *Proc. Ussher Soc.*, 3: 103–110.
——— & C. J. WOOD, 1976. The Cretaceous (Albian-Cenomanian) stratigraphy of the Haldon Hills, south Devon. *Newsletters on Stratigraphy*, 4: 135–149.
PICTET, F. J., 1850. Description de quelques poissons fossiles du Mont Liban. 59 pp. J-G Fick, Genevè.
REGAN, C. T., 1911. The anatomy and classification of the teleostean fishes of the order Inoimi. *Ann. Mag. Nat. Hist.*, 8: 120–133.
TOYNTON, R. & D. W. PARSONS, 1990. The compaction history of a composite flint. *Proc. Geologists' Assoc.*, 101(4): 315–334.
VON DER MARCK, W., 1863. Fossile Fische, Krebse und Pflanzen aus dem Plattenkalk der Jungsten Kreide in Westphalen. *Palaeontographica*, 11: 1–83.
WHITE, E. I. & J. A. MOY-THOMAS, 1940. Notes on the nomenclature of fossil fishes—Part II, Homonyms D-L. *Ann. Mag. Nat. Hist.*, 6: 98–103.
WOODWARD, A. S., 1888. A synopsis of the Vertebrate fossils of the English Chalk. *Proc. Geologists' Assoc.*, 10: 273–338.
———, 1901. Catalogue of the fossil fishes in the British Museum (Natural History). 636 pp. British Museum (Natural History) London.
———, 1903. The fossil fishes of the English Chalk—Part 2. *Palaeontographical Soc.* (*Monograph*): 57–96, pls 14–20.