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First occurrence of the orectolobiform shark *Akaimia* in the Oxford Clay Formation (Jurassic, Callovian) of England

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A B S T R A C T

The late Middle Jurassic (Callovian) Peterborough Member of the Oxford Clay Formation of eastern England yields a rich variety of marine vertebrate fossils, including a diverse assemblage of neoselachian elasmobranchs. Here we report the first record of the small Jurassic orectolobiform shark *Akaimia* Rees, 2010, otherwise known only from Poland and Germany, from the British Jurassic, together with an unusual, undetermined dermal denticle. The material comes from exposures in Cambridgeshire, eastern England. We refer the new specimens of *Akaimia* to the new taxon *A. myriacuspis* sp. nov., and provide a revised diagnosis for the genus.

1. Introduction

The Callovian Oxford Clay Formation of England, best regarded for its vertebrate fauna of large marine reptiles and diverse and sometimes gigantic bony fishes (Woodward, 1890; Andrews, 1910-13; Brown, 1981; Martill, 1991; Liston, 2008), has also produced a diverse assemblage of elasmobranchs since sampling began in the mid-19th century (Woodward, 1889; Thies, 1983; Martill and Hudson, 1991). At least 25 elasmobranch species have been described to date (Thies, 1983; Rees and Underwood, 2008). These taxa range from large active predators such as *Hybodus* and *Asteracanthus* (Hybodontidae) to likely benthic forms such as *Synechodus* (Palaeospinacidae), the Angel shark *Pseudorhina* (Pseudorhinidae) (Carvalho et al., 2008; Klug and Kriwet, 2013) and a Guitar fish, *Spathobatis* ("Rhinobatiformes") (Thies, 1983). The latter two taxa represent groups which are still extant in oceans today, appearing to differ little from their Jurassic relatives (Thies and Leidner, 2011). Similar elasmobranch assemblages to those of the Oxford Clay Formation have been reported from the Callovian and Oxfordian of Poland and Germany (Thies, 1983, 1989; Kriwet and Klug, 2004; Rees, 2010). Here we describe the first record of the genus *Akaimia* (Rees, 2010) outside of mainland Europe, a genus unrelated to, but with traits similar to the extant Wobbegongs or Carpet sharks (Orectolobidae) of the Indo-Pacific region (Rees, 2010).

2. Geological setting

The Middle Jurassic Oxford Clay Formation is a sequence of organic-rich clays and shales deposited in a shallow epeiric sea during the Callovian, a time when much of Europe was submerged due to a global rise in sea level (Hudson and Martill, 1994, Hallam, 2001) with water column temperatures in the 11–17 °C range (Mettam et al., 2014). The basal Peterborough Member crops out extensively to the East of Peterborough where since the late-18th century it has been dug commercially for brick manufacture. Today only Must Farm pit at Kings Dyke, Whittlesey, Cambridgeshire (National Grid reference TL237974) remains operational, although it still yields a plethora of fossils (Fig. 1).

Historically this clay pit is one of several very important sites around the Fenland Town and Whittlesey area for Oxford Clay fossils (Benton and Spencer, 1995). Commercial excavation of the Oxford Clay began in the late 1800's resulting in the discovery of hundreds if not thousands of vertebrate skeletons, many collected by Alfred Nicholson Leeds (1847–1917) and his elder brother Charles (born 1845) of Eyebury and Henry Keeping (1827–1924) at Cambridge University between *c.* 1867 and 1917 (Leeds, 1956; Araujo et al., 2008).

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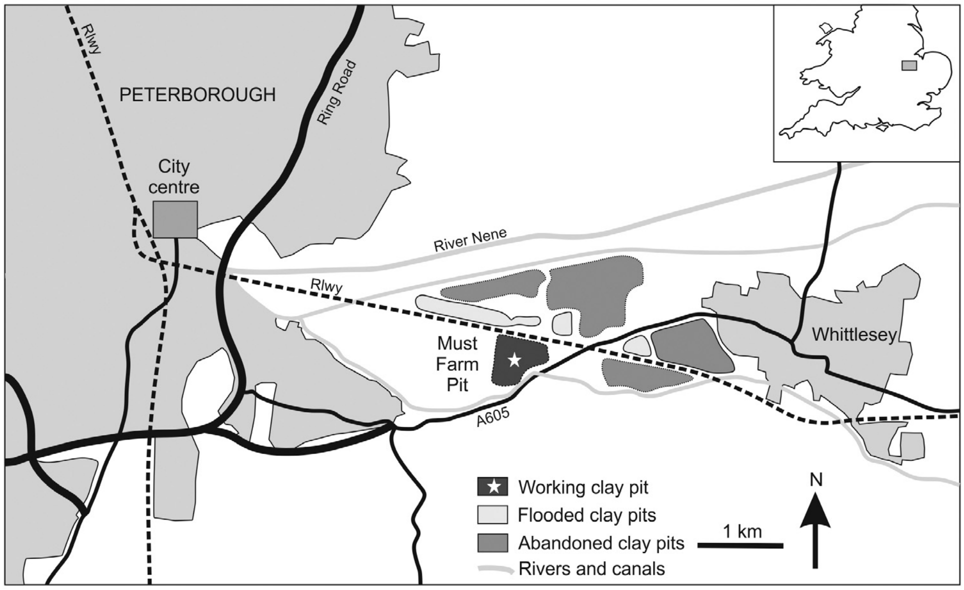

Fig. 1. Map showing location of Must Farm clay pit, near Whittlesey, Cambridgeshire. Currently this is the only working clay pit excavating the Peterborough Member of the Oxford Clay Formation.

The Oxford Clay Formation sequence exposed at Whittlesey is incomplete. The lower boundary of the Oxford Clay Formation is sometimes exposed in the pit base, with the underlying Kellaways Formation revealed in drainage ditches (Martill and Hudson, 1991) (Fig. 2). The main quarry face usually exposes the entire sequence of the Peterborough Member, and the overburden may consist of weathered parts of the Stewartby Member. However, the Stewartby Member is sometimes absent and replaced with Holocene Fen gravels and peat deposits. The Peterborough Member spans the later part of the Early Callovian and extends upwards into the base of the Late Callovian (Hudson and Martill, 1991).

2.1. Taphonomy

The teeth found in the Oxford Clay are well preserved, with little etching or abrasion noted. Many teeth are missing cusps or roots, although these breakages may have occurred post- fossilisation during collection and mechanical processing. Networks of micro-borings (Underwood et al., 1999) belonging to the ichnotaxon *Mycelites ossifragus* (Roux, 1887) are noted on the lingual face of the indeterminate denticle and roots of many of the *Akaimia* teeth (see section 5) as well as other teeth found during this study.

3. Late Jurassic neoselachian sharks

Neoselachians embrace those groups of living sharks and rays which are represented in modern seas, as well as their fossil relatives and some extinct families. As with all fossil chondrichthyans, they are mostly represented by isolated teeth in the fossil record because the high protein content of the cartilaginous skeleton is easily lost during decomposition, thereby reducing the preservation potential of the elements of the endoskeleton. The dental character that unites neoselachians is the presence of a triple-layered enameloid covering the surface of the crown.

Neoselachians seem to have had their origins in the Palaeozoic (Ginter et al., 2010), but do not become diverse until the Mesozoic (Cappetta, 2012). Many of the late Triassic forms are difficult to place with any certainty into higher taxonomic categories, other than identifying them as neoselachians, and it is only in the Jurassic that members of extant orders can be identified with any degree of confidence. A particularly important resource in this respect is the occurrence of several conservation Lagerstätten in the Jurassic of Europe; articulated whole-bodied chondrichthyan specimens are known, for example, from the Sinemurian of Lyme Regis (Dorset, UK) and Osteno in Italy, the Toarcian of Holzmaden in Germany, and the Kimmeridgian of Kimmeridge (Dorset, UK), plus the lithographic limestones of Nusplingen (Kimmeridgian) and Solnhofen (Tithonian) in southern Germany, and Cerin (Late Kimmeridgian) in eastern France. These spectacular deposits with their perfectly preserved faunas clearly indicate that the range of modern chondrichthyan body forms was fully established in or by Jurassic times. Our understanding of the intervening record of neoselachian orders necessarily depends on finds of isolated teeth. Since many of these are in the sub-millimetric size range, it is necessary to concentrate and isolate them from enclosing sediments using a variety of mechanical and chemical techniques. The Jurassic represents a particularly interesting time in the evolution of the Neoselachii, but the bulk sampling necessary to elucidate the development of a true picture of changing chondrichthyan faunal diversity throughout the Period is only in its early stages.

4. Methods

Samples for microvertebrate processing were taken from beds 6, 7, 11, 13, 17 and 19 (Bed numbers from Hudson and Martill, 1994) as part of a taphonomic study examining the relative abundances of otoliths and phosphatic skeletal fish remains. At least 2 kg of clay was collected from each bed, and air dried prior to disaggregation in 10% hydrogen peroxide. The resultant residues were wet sieved between 250 μm and 4 mm sieves to remove silt and clay, while coarser shelly material was removed manually. Microvertebrate remains were picked under a binocular microscope and mounted on aluminium SEM stubs for examination by JEOL JSM-6100 scanning electron microscope at 10kv. Images were digitally processed. The material described here has been accessioned into the collection of the Natural History Museum, London numbers NHMUK PV P 73690–P 73695.