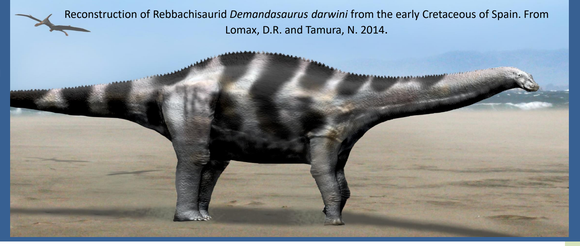
Making a complete record of early Cretaceous (late Barremian – early Aptian) rebbachisaur (Sauropoda, Rebbachisauridae) remains found on the Isle of Wight, UK, including unpublished material

Skeletal reconstruction of Rebbachisaurid *Nigersaurus taqueti* from the early Cretaceous of Niger. © Scott Hartman From Lomax, D.R. and Tamura, N. 2014

Nigel R. Larkin[1], Mick Green[2], Dean R. Lomax[3], Andrew Cocks[4] Keith Simmonds[5] and Remmert Schouten[6]

[1]Cambridge University Museum of Zoology, UK; [2]Brighstone, Isle of Wight; [3]School of Earth and Environmental Sciences, The University of Manchester, Manchester, UK; [4]Newport, Isle of Wight; [5]Brighstone, Isle of Wight; [6]Sociedade Historia Natural Travessa Florêncio Augusto Chagas no 8 R/C Apartado 25-2564-909 Torres Vedras, Portugal.



Introduction

The Rebbachisauridae is a widespread family of Cretaceous (Hauterivian-Coniacian) basal diplodocid sauropods known from South America, Africa and Europe, but their remains are rare. In the UK, only three specimens have formally been described, recorded from the Early Cretaceous (late Barremian – early Aptian) Wessex Formation on the Isle of Wight. These include some of the oldest rebbachisaurid remains known in the world and the only postcranial material of the clade so far identified in the British Isles (Naish and Martill, 2001 (pl.36), assigned to the Rebbachisauridae by Sereno and Wilson (2005), Mannion (2009) and Lomax and Tamura, (2014). However, many additional rebbachisaur specimens have been found by various collectors over the last 40 years including cervical, dorsal and caudal vertebrae, pectoral or pelvic material, forelimbs and ribs. Some of the bones show signs of tooth damage and most exhibit traces of invertebrate burrowing. The material has been found in at least four distinctly separate sites in the Wessex Formation but these appear to all be of a similar geological age, with similar preservation. Although two described and published bones are in the Dinosaur Isle Museum the rest are scattered throughout several private collections. Recently, the authors have been assessing and recording all of the known Isle of Wight rebbachisaur remains, including 3D scanning all the bones to create a virtual collection of the material in one place to facilitate research, in order to resolve which species the bones may represent. Here, the additional hitherto unpublished bones and the sites where they were found are described for the first time.

Site 1

The oldest of the four sites is found within the grey conglomerate at the base of the Sudmoor Point sandstone, between Sudmoor Point and Chilton Chine (closer to Sudmoor). Mick Green has found one dorsal vertebral centrum and a separate block with some very fine bones, yet to be identified. One vertebral process without a centrum was found by James Dolby (Fig 1).

***Fig 1**. James Dolby's vertebral spine from Site 1.*

Site 2

The Sudmoor Point Sandstone unit in the Wessex Formation between west of Chilton Chine and east of Sudmoor Point (closer to chilton). Between 1984 to 2012 Mick Green and David Cooper discovered three sacral vertebrae, three anterior caudal vertebrae, a caudal vertebra, a proximal end of an ulna and three bones thought to be part of the pectoral girdle. Other material found at this site include a cervical vertebra found by Shaun Smith (donated to Mick Green's collection), a caudal vertebra found by Mr Jacob and as recently as July 2019 a bone tentatively identified as a small scapula was found by Kai Bailey (donated to Mick Green's collection). See Figs 2A to 2G.

***Fig. 2. (above) A**. Dorsal vertebra (Mick Green's collection) from site 2 (scale 10cm); **B**. Caudal vertebra (Mick Green's collection) from site 2; **C.** ?Scapula found at site 2 in July 2019 by Kai Bailey (Mick Green's collection) (max length 34cm).*

***Fig. 2 continued (above) D**. Cervical vertebra (Mick Green's collection) from site 2, found by Shaun Smith (scale 10cm); **E**. Caudal vertebra (Mick Green's collection) from site 2, found by David Cooper in 1984 (scale 10cm); **F.** Anterior caudal vertebra (Mick Green's collection) from site 2 (scale 10cm); G. Sacrum (Mick Green's collection) from site 2 (scale bar 30cm).*

Site 3

The conglomerate band at the base of the Brighstone sandstone in the Wessex Formation in Brighstone Bay. Between 1997 and 2003 Mick Green found a partial femur, a possible illium fragment and a cervical vertebra, and Andrew Cocks found a dorsal vertebra centrum - see Fig3 below for the dorsal vertebra (scale bar15cm).

Site 4

'Pink bed' in the foreshore, stratigraphically above the Brighstone Sandstone in Brighstone Bay. Between 1988 and 2019 Keith Simmonds recovered the remains of four forelimbs from two different rebbachisaurids from this bed, and this appears to be the youngest rebbachisaurid material known to have been found on the Isle of Wight. The finds consist of: 2 complete radii, 2 complete ulnae (Fig 4A); 2 radii and ulnae partially eroded by the sea; 1 humerus; 2 complete feet; and one partial foot (Fig 4B).

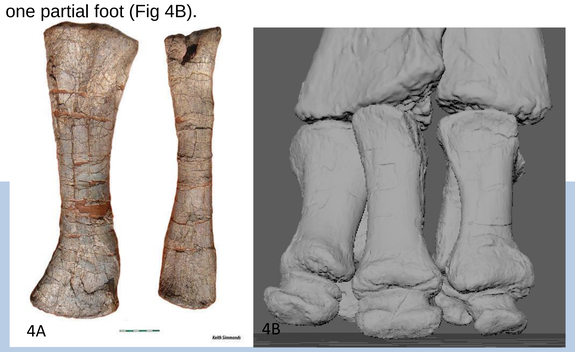


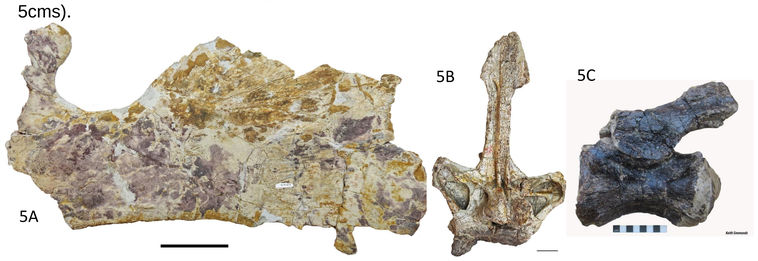
***Fig 4** (above) **A.** Complete radius and ulna from Site 4 found and prepared by Keith Simmonds (scale bar = 6 cm); **B.** Digital model of one of the feet reconstructed by Keith Simmonds (work in progress).*

Specimens from uncertain stratigraphy

Nick Chase found a partial left scapula in situ within the foreshore at Grange Chine above the Brighstone sandstone unit in a purple red bed (Mannion, 2009). Fig 5A *(in Dinosaur Isle Museum, no.MIWG.6544; Scale bar 5cm. Photograph from Lomax &Tamura, 2014).*

Steve Hutt found a partial anterior caudal vertebra in the conglomerates of the Brighstone Wessex Formation of Brighstone bay (Mannion et al, 2011). Fig 5B (*in Dinosaur Isle Museum, no. MIWG.5384; Scale bar 5cm. Photograph from Lomax &Tamura, 2014*).

Keith Simmonds found a caudal vertebra (tentatively attributed to Rebbachisauridae) collected from the black band (debris bed on the east side of Brighstone Bay) in March 1988. This is possibly the youngest of the IOW rebbachisaur material. Fig 5C (scale bar 5cms).



Preservation

All of the material found on the Isle of Wight that has been identified as rebbachisaurid has a similar preservation including the texture and colour of the bone and the matrix and the fact that the bones were partially encased in many concretions, some extremely hard. In places the bone could be quite soft and fragile and in other places quite hard. In all cases the bones have been damaged by burrowing invertebrates that have left sub-circular tunnels up to 15 to 20mm in diameter (Fig 6). These burrows are naturally infilled and frequently contain fragments of the damaged bone. It is most likely that the burrowers were ossiphagous beetles, perhaps Dermestidae, suggesting a climate including at least seasonally extended dry periods (Lockwood et al, 2016). The geology and palaeoenvironment is being investigated by Bill Webb.

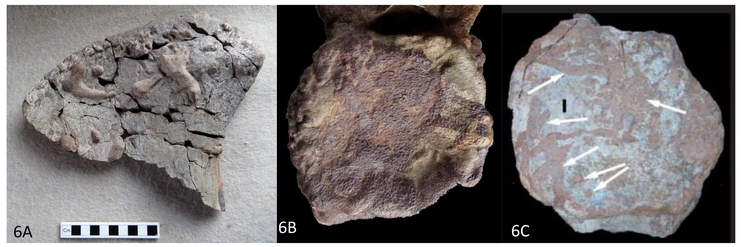


***Fig 6 (above) A**. Possible sternum or pectoral girdle fragment (Mick Green's collection) from site 2, with infilled burrows left in situ during preparation; **B**. Posterior end of caudal vertebra (Mick Green's collection) from site 2, with burrow marks (purple) within the bone (grey); **C**. Anterior articular face of a ebbachisaurid caudal vertebra from La Revilla, northern Spain. The white arrows indicate burrows in the bone surface (scale bar = 1cm). From Fernandez-Baldor, 2012.*

Preparation & Recording

Preparation: Mick Green mostly removed the matrix from his bones using a pneumatic reciprocating needle airpen, and where needed a Swamblater airbrasive unit utilising sodium bicarbonate. In some places the bone was soft enough to require consolidation (Paraloid B72 in acetone) to allow the handling required for further preparation and study. Some bones were prepared by the late David Cooper and one cervical vertebra (donated by Sean Smith) was prepared by Gary Blackwell of the Dinosaur Isle Museum.

Recording: Andrew Cocks is creating 3D digital models of all the rebbachisaur bones (Fig 7), using a Shining 3D scanner SP Pro white light structured light scanner. The models can currently be seen on Andrew Cocks Facebook page but will soon be made more widely available.

***Fig 7** (left) Images from the digital 3D model of a dorsal vertebra (Mick Green's collection) from Site 2.*

Discussion & Conclusion

All of the rebbachisaurid bones were found in situ. The material appears to be scattered as the bones are found very infrequently and are usually not articulated but some do appear to be associated (particularly the forelimbs). Many of the bones have clearly experienced weathering before burial and one rib fragment has multiple scratches indicating possible scavenging and one vertebra has clear tooth marks (Fig 8). Invertebrate burrows are found within the matrix – including the concretions – and through the bones and sometimes along the surfaces of the bones.

The preservation of these bones as well as the colour and appearance of the matrix and, importantly, the presence of burrows in the matrix and in bones are identical to rebbachisaur material of a similar age (upper Barremian) found in La Revilla northern Spain, approximately 520 miles south from the Isle of Wight, comprising some of the best rebbachisaur material in Europe. The startling similarity of preservation in both of these locations may indicate rebbachisaurids were conservative in their habits, exploiting a narrow environmental niche.

Rebbachisaurid bones in the UK are rare but are amongst the oldest known material of this group. Compared with the various described rebbachisaur species the bones found on the Isle of Wight appear to possess some slight anatomical differences - for instance in the orientation of the neural spines. Previous work on a limited range of the material has suggested that the Isle of Wight rebbachisaur remains are most closely related to the Spanish *Demandasaurus* and the African *Nigersaurus.* This project aims to further resolve the identification of rebbachisaur material found on the island.

***Fig 8 A.** Possible tooth marks on a rib (Mick Green's collection) from site 2; **B**. Possible tooth marks on the rim of and anterior caudal vertebra centrum (Mick Green's collection) from site 2.*

Acknowledgements

David Cooper donated material to Mick Green and prepared some of his own material and prepared some of Mick's material. Shaun Smith and Kai Bailey donated bones to Mick Green's collection. James Dolby and Mr Jacob have allowed material to be assessed and recorded. Gary Blackwell of Dinosaur Isle Museum prepared one of the bones. Jeremy Lockwood is thanked for continuous support. Many people are thanked for helping to identify material over the years, including Denver Fowler.

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