

A HYBODONT SHARK FROM THE REDWATER SHALE MEMBER, SUNDANCE FORMATION (JURASSIC), NATRONA COUNTY, WYOMING

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ABSTRACT

Remains of a shark specimen were found in the gastric contents of a small-bodied plesiosaur. The fossil material was identified as a member of the Hybodontiformes based on the teeth and dorsal spine denticles. The specimen is the first hybodont shark to be identified from the Upper Sundance Formation of Wyoming. Hybodont shark material previously described was limited to the Lower Sundance and not associated with marine reptile remains. The hybodont specimen described here may indicate a different type of predation on the marine vertebrate and invertebrate environment of the Sundance Formation biota.

INTRODUCTION

The discovery of a hybodont shark specimen during the preparation of an articulated small-bodied plesiosaur, found in the Upper Redwater Shale of the Late Jurassic Sundance Formation, was a unique bonus. The plesiosaur, *Tatenecktes laramiensis* (UW 24215) is part of the Vertebrate Paleontology Collections at the University of Wyoming and was found near the town of Armento, Natrona County, Wyoming. (O'Keefe and Wahl, 2003; Drake and Wahl, 1994). The hybodont shark fossil material was found as gastric contents situated within the articulated remains of the plesiosaur, and as such the shark material is designated UW 24218.

The Redwater Shale of the Sundance Formation (Oxfordian) has yielded many vertebrate specimens. The majority of these vertebrates are marine reptiles, represented by both isolated skeletal elements and articulated specimens. The marine reptiles include a plesiosaur, at least two types of plesiosaurs, and large number of ichthyosaur specimens. Juvenile specimens of some of these marine reptiles have also been identified. Fossil fish material has been described from the Hulett member of the Lower Sundance Formation (Schaeffer and Patterson, 1984). So far, the only scattered fish material found in the Upper Sundance Formation has been identified as gill plates, unidentified teeth and enameloid scales.

The vertebrate material of the Sundance Formation has been compared to fossils from the

Peterborough Member of the Oxford Clay of England (Callovian, Middle Jurassic). Oxford Clay material represents the only well studied Jurassic marine environment supporting a wide variety of vertebrate species that is comparable to that of the biotic environment of the Sundance Formation (Wahl, 1997). Chondrichthyan fish form an important part of the biota of the Oxford Clay environment and include *Pachymylus*, *Ischyodus*, *Brachymylus* and *Leptacanthus* (Chimaeriformes); *Hybodus* and *Asteracanthus* (Hybodontiformes); "*Notidanus*" (Hexanchiformes); *Protospinax* (Squaliformes); as well as types of various Heterodontiformes. (Martill, 1989). This is an impressive list but most of the identifications are based on incomplete or inadequate material, although *Hybodus* and *Asteracanthus* are represented by a variety of skeletal remains (Martill, 1989).

In comparison, chondrichthyan fish of the North American Jurassic include *Hybodus* and *Ischyodus* from the Stockade Beaver Member of the Lower Sundance Formation. They are represented only by scattered, limited remains now in the collections of the American Museum of Natural History (Schaeffer and Patterson, 1984). This paper documents the first record of a possible hybodont species from the Upper Sundance Formation.

DESCRIPTION OF MATERIAL

The shark material (UW 24218) consists of two teeth, a dorsal spine denticle, and a large number of

possible dermal denticles. The remains were found surrounding the bones of the plesiosaur (UW 24215) both in the encompassing matrix and lying on the bones themselves. The denticle material was concreted to the bones. A small amount of grain size change occurs in the sediment surrounding the bones. This suggests that the bones may have acted as an obstruction to the current action, causing small objects such as teeth or dermal denticles to drop out of suspension. However, the matrix surrounding the bones does not contain larger than normal amounts of pelecypod shell debris and belemnite guards of less than 3 mm. This debris is relatively common in the sandy-shale of the Upper Redwater Shale. Thus, it is doubtful that the material washed into the bone foramen by wave action or movement in the sediment. The matrix surrounding the plesiosaur also contained thousands of coleoid tentacle hooklets (Wahl, 1998). The lighter hooklet material appears to have floated further away from the bones whereas the heavier, dermal denticle material sank into the matrix. The delicate hooklets are also believed to have been gastric contents from plesiosaur UW 24215. Also, the bones were not encrusted by any invertebrate fauna, indicating the fossils were not exposed for very long. The shark remains are of uniform size and found in close enough association to suggest coming from a single animal.

The teeth are conical, slightly flattened anteriorly-posteriorly, and multicusped, with the large central cusp well separated from the smaller cusplets (Figure 1). The larger and smaller cusps are both striated with uniform longitudinal ridges running to the top of the crown face. The larger cusp has a distinct cutting edge running laterally. One tooth with a broken central cusp allows a cross-sectional view. The tooth appears to be osteodont without a central pulp cavity. The root of the whole specimen appears to be anaulacororhizous and very porous.

The external skeleton material is represented by two dorsal fin spine denticles (Figure 2) and a large number of dermal denticles (Figure 3). The former were found under a thoracic rib of the plesiosaur specimen as well as concreted to bone surface. The dorsal spine denticles could belong to chimaeroid. As the material was found associated with the teeth, however, it is likely from the same hybodont shark specimen. Both dorsal spine denticles are dense in appearance with a large channeled growth suture running up the posterior side and are the same color as both the tooth enamel and the enamel dermal denticles (Maisey, 1978). The posterior bases of both spine denticles are missing and the remaining material shows some signs of having been broken off prior to deposition in the sediment. Hence, the broken spine

denticle may indicate predation on the shark by the plesiosaur.

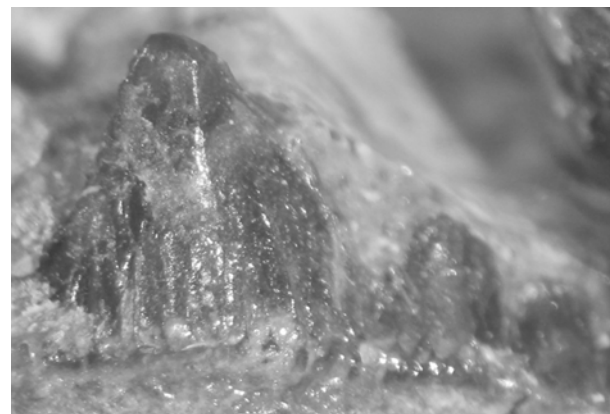
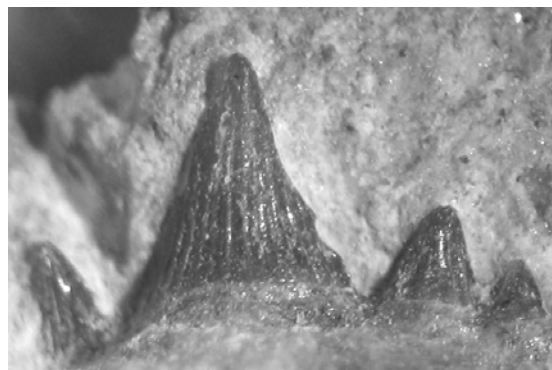


FIGURE 1. Top: Hybodont shark tooth (UW24218). The highest cusp of this tooth is 3 mm by 2 mm. Bottom: A second, more worn tooth fragment from the same material.

A large portion of dermal denticle material or scales was found close to the plesiosaur (UW 24215). A layer of these was found against the cervical portion of the skeleton, noticeably becoming more thinly scattered further in the matrix away from the bone material. These denticles are 1 mm to 0.5 mm in length and display a range of shapes but are mostly blunt-headed, smooth and shiny flat plates. Some of the scales have parallel canals that run the entire length of the scale (Figure 3). Other dermal denticles are flatter with distinct cusps on the edge. The range of shapes suggests that the denticles came from different parts of the body. They are roughly the same size and are comprised of the same material. The scale is covered by a dense coating of buff to brown material with central rugose canals (Reif, 1980). The hybodont sharks are known from their decorative dorsal spines as well as cephalic spines and separate multicusped teeth. Unfortunately, the genus and species of the shark

cannot be determined by any of these factors alone (Maisey, 1978).

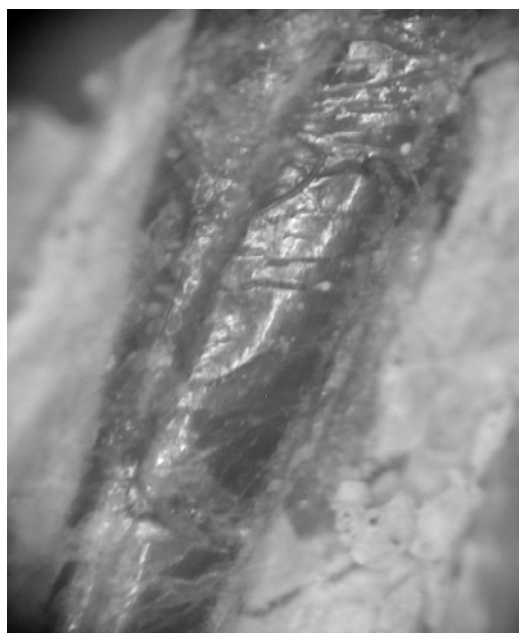
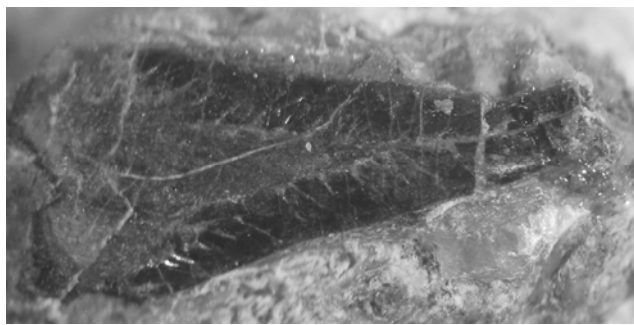


FIGURE 2. Top: Dorsal spine denticle, 4 mm in length and 2 mm wide at the base. Bottom: Another dorsal spine denticle showing the groove that runs down the middle. Both specimens UW 24218.

DISCUSSION

The scattering of phalanges from the plesiosaur UW 24215 and missing limb material indicate some scavenging by sharks might have occurred. The carcass may have initially floated, then sank, attracting scavengers such as hybodont sharks. Originally, these specimens were thought to be an isolated tooth that resulted from the scavenging of the plesiosaur by a hybodont shark while the carcass lay on the seafloor. The hybodontid sharks of the Oxford Clay are thought to have scavenged on carcasses and their isolated teeth are very common (Martill, Taylor, and Duff, 1994). Occasional scavenging by the sharks may have

reflected an opportunistic life style. However, the additional discovery of dorsal spine denticles and many dermal denticles suggest that the Sundance shark might have been the prey of the plesiosaur before the plesiosaur met its own demise.



FIGURE 3: Rugose skin denticles (UW 24218).

Hybodont shark material is quite common in the Oxford Clay, where there is a rich diversity of marine reptiles (Martill and Hudson, 1991). Conversely, the shark material here described is the first to be found in the upper Redwater environment and is considered not to have been common to the Upper Sundance Formation. The Sundance fauna includes a smaller variety but larger numbers of some marine reptiles, in contrast to the Oxford Clay. Ichthyosaurs make up a larger proportion of the fauna than plesiosaurs (Wahl, 1997). The presence of medium size predators in large numbers (small bodied plesiosaurs and ichthyosaurs) in the Sundance Formation could have kept the numbers of fish-eating, non-reptilian vertebrates, such as sharks, to a minimum.

Hybodont specimens found in the Cretaceous of Texas are described as having been found in brackish, fresh water influenced, and shallow coastal marine

deposits, yet are uncommon or missing in the deeper marine deposits (Welton and Farish 1993). Martill (1989) suggested that the Oxford Clay specimen of *Hybodus dawni* was possibly associated with brackish water. However, the Oxford Clay sediments were organically rich and estuarine derived and have been known to contain terrestrial fossils from nearby landmasses (Martill and Hudson, 1991). This material would have been an important food source for scavenging sharks. In contrast, the Upper Sundance Formation sediments were not estuarine influenced and the only terrestrially derived fossil material found is in the form of plants and woody debris. However, an abundance of juvenile marine reptile fossils found in the area could indicate a breeding or nursery environment. Such an environment could have been associated with a near shore estuary. Further work on the shark specimen and its environment will be required before this can be confirmed.

CONCLUSION

Asteracanthus and *Hybodus* are the two most common hybodont shark types in the Jurassic marine environments such as the Oxford Clay. However, whether the hybodont shark specimen is either *Asteracanthus* or *Hybodus* depends on the shape of the tooth. The teeth of *Asteracanthus* are broad, dorso-ventrally compressed shapes useful for crushing. Schaeffer and Patterson (1984) based his identification of *Hybodus* from the Stockade Beaver Member of the Lower Sundance Formation on isolated teeth. The teeth have a principle cusp with a broad base well separated from the lateral cusplets. The large central cusp has close packed striae or ridges. The tooth shape of UW 24218 appears to be this type. Such a caniniform, multicuspate tooth would be useful for grasping and may indicate an opportunistic feeding style that was not necessarily restricted to fish. This could place the shark specimen into a nekto-benthic lifestyle, i.e. living in a variety of depths in the water column (Martill, Taylor and Duff 1994).

Based on the size of the teeth and dorsal spine denticles, the shark was relatively small (< 40 cm). This agrees within the prey size range indicated by the cephalopod coleoid hooklets, which were also associated with UW 24215. As thousands of hooklets were found in the plesiosaur, it is apparent that the plesiosaur had fed on coleoid individuals for some time. The size of the Sundance hooklets have been compared to the sizes of the well-preserved hooklets associated with the Oxford Clay belemnite specimen *Belemnoteuthis antiquus* as well as the belemnite *Passaloteuthis* (Wahl, 1998). Assuming the

same proportions, hooklets of the Sundance specimens belonged to an animal between 250 mm and 300 mm. It is unlikely that the coleoids of that size could have been preyed upon by the small hybodont shark also represented in the gastric contents of the larger plesiosaur. However, a 250-300 mm coleoid was large enough prey for a >3 m plesiosaur. Coleoids were certainly large enough to be a major part of the diet of marine reptiles that lived in the Sundance Sea. The hybodont sharks may have been small-bodied scavengers or invertebrate shell crushers. Larger species may have been excluded by the prevalence of the larger marine reptiles. Several isolated shark teeth have also been collected from harvester ant mounds situated on Sundance outcrops. These do not appear to be hybodontid as they are slender, slightly curved, and may have a central pulp cavity.

ACKNOWLEDGMENTS

I thank the people of the Bureau of Land Management for their cooperation and patience in the collection and preparation of this specimen. The Casper College Library staff was invaluable in their help as well. I had useful discussions with Dr. D. Martill of the Portsmouth University Geology Department, Portsmouth, England and Dr. J. Maisey of the American Museum of Natural History, New York. I also thank Dr. J. Massare of SUNY Brockport and A. Hunter of Casper College for reviewing earlier versions of this work.

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