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A PATHOLOGIC AND DEFORMED *SQUALICORAX PRISTODONTUS* TOOTH FROM THE LATEST MAASTRICHTIAN BASAL HORNERSTOWN FORMATION, GLOUCESTER COUNTY, NEW JERSEY, U.S.A.

NEW JERSEY STATE MUSEUM NATURAL HISTORY

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ABSTRACT

A *Squalicorax pristodontus* tooth (NJSM 22369) from the latest Maastrichtian basal Hornerstown Formation in Gloucester County, New Jersey exhibits atypical, pathologic features. Located centrally on the crown's lingual surface, a patch of thickened enamel features a series of sub-vertically oriented (in the final occlusal position), sub-parallel, enamel ridges. Additionally, the distal carina is deformed, exhibiting a small protrusion which does not affect the serrations. Considering the rarity of pathologic features on modern shark teeth, it can be assumed that both the enameloid protuberance and the deformed carina resulted from the same mechanism.

Abnormal dentition among modern chondrichthyans is generally attributed to feeding-related injury to the jaw cartilage and/or gum tissues. Batoid tail spines and teleost fin spines, as well as fishing hooks, are known to puncture tooth-forming tissues in sharks, resulting in pathologic teeth. Typically, these pathologies take the form of twisted or bent crowns and roots, abnormal tooth growths, or deformed tooth files. Although it is nearly impossible to determine the cause of dental abnormalities in fossil shark dentition, ancient pathologic teeth typically exhibit very similar features, suggesting that the causative mechanisms are similar.

Pathologic shark teeth are unusual, generally accounting for far less than 1% of both modern and fossil specimens. However, this proportion is highly variable among species, which is likely the result of different prey preferences, predation strategies, and jaw anatomy.

DESCRIPTION

Squalicorax pristodontus is a large (up to 5m), extinct genus of shark that was similar in form to modern tiger sharks (**Fig. 2**). They likely were aggressive predators and opportunistic scavengers (Schwimmer et al., 1997). Fossilized teeth from *S. pristodontus* are very common fossils in Late Cretaceous nearshore marine units in Europe, North Africa, and especially North America.

NJSM 22369, a single tooth crown identified as *S. pristodontus*, is distinguished from others in exhibiting a deformity as well as an atypical pathologic feature.

Deformity (Fig. 3A): Located near the midpoint of the distal carina

- Small protrusion

Pathologies (Fig. 3B): Located centrally on the lingual surface of the crown

- Protuberance, or a patch of thickened enamel
- Sub-vertically oriented (in the final occlusal position), asymmetrical sub-parallel enamel ridges

Figure 2. Artist rendering of *S. pristodontus* scavenging on a dinosaur carcass.

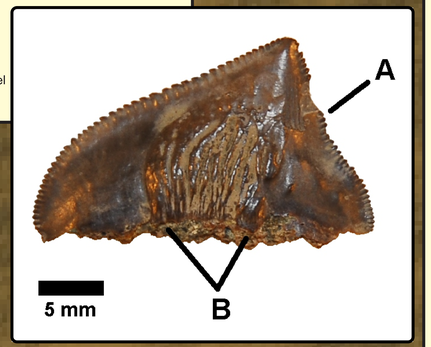

Figure 3. *Squalicorax pristodontus* tooth crown (NJSM 22369) with a deformity (**A**) and pathologies (**B**).

SELACHIAN DENTAL PATHOLOGIES

In general, pathologic shark teeth are dental abnormalities that developed prior to the completion of tooth formation (Welton and Farish, 1993; Shimada, 1997). These abnormalities can be extremely varied in their form. Some of the more common malformations among both modern and fossil dentition include:

- Asymmetrical, or wrinkled enamel ridges (Gottfried, 1993; Hubbel, 1996; Becker et al., 2000b)
- Twisted crowns (Gudger, 1937; Gottfried, 1993; Hubbel, 1996; Becker et al., 2000a, b)
- Split, divided, or conjoined teeth (Gudger, 1937; Hubbel, 1996; Balbino and Antunes, 2007)

Shimada (1997) noticed six types of dental pathologies among numerous *Cretoxyrhina mantelli* teeth:

- Notches along the carina
- Cracked enamel
- Excess growth of dentine
- Formation of a fossa
- Protuberance on the crown surface
- Disturbance near the crown-root contact

Several causative mechanisms have been proposed for these malformations. Disease has been suggested (Johnson, 1987), and of course genetic mutation is likely to cause some abnormalities (Johnson, 1987; Welton and Farish, 1993), though neither has been definitively linked to the phenomenon as yet (Becker et al., 2000a). However, physical trauma and/or injury to the tooth-forming tissues have been shown definitively to be directly related to pathologic dentition. Numerous investigations of modern sharks have observed dental malformations immediately adjacent to, and certainly related to, injured gum tissue (Gudger, 1937; Johnson, 1987; Becker et al., 2000b; Masahiko and Masatoshi, 2001). Most often, these injuries are associated with embedded batoid tail spines and teleost fin spines, and are therefore feeding-related injuries (Gudger, 1937; Hubbel, 1996; Becker et al., 2000b; Balbino and Antunes, 2007).

It is impossible to determine the cause of dental pathologies in fossil shark teeth in almost all cases (Shimada, 1997). However, since feeding strategies and prey preferences among extinct species are believed to be similar to those of modern sharks, and since the types of dental malformations seen in fossil sharks are very similar to those observed in their modern equivalents, it can be assumed that feeding-related injuries among ancient species were the results of similar causes (Becker et al., 2000b).

RARITY OF DENTAL PATHOLOGIES

Shark teeth are the most common vertebrate body fossils, but pathologic shark teeth are extremely rare. Studies of both fossil and modern specimens show that far less than 1% of teeth exhibit malformations. For example:

- Johnson (1987) found 0.06% of approximately 51,400 Permian xenacanthodiid teeth were deformed.
- Hubbel (1996) reported 0.25% of *Carcharodon carcharias* (Great White Shark) teeth exhibit pathologic features.
- Becker et al. (2000b) observed malformations in only ≤0.017% of modern shark teeth.
- Becker et al. (2000b) stated that 0.09% of the approximately 10,000 fossil teeth they observed had pathologic abnormalities.

There appears to be a high degree of interspecific variation in the frequency of pathologic teeth, which is likely to be related to prey preference, predation strategies, and jaw anatomy. Species that prefer prey with substantial spines are likely to exhibit dental malformations more often (Becker et al., 2000b).

CONCLUSIONS

- The thickened patch of assymetrical, wrinkled enamel ridges on a single *Squalicorax pristodontus* tooth crown (NJSM 22369) resembles pathologic features described by numerous previous investigators (Gottfried, 1993; Hubbel, 1996; Shimada, 1997; Becker et al., 2000b).
- Considering the rarity of pathologic features on modern shark teeth, it can be assumed that both the pathologies (enameloid wrinkles) and the malformation (deformed carina) exhibited on NJSM 22369 resulted from the same mechanism.
- It may be possible to infer the prey preferences of extinct chondrichthyan species based on the commonality of pathologic teeth.

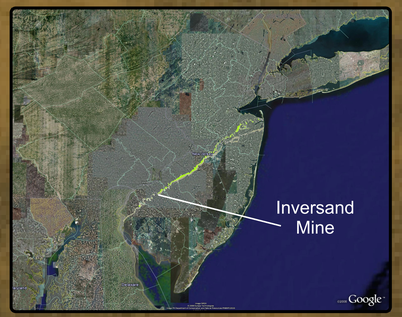

Figure 1. Outcrop area of the Maastrichtian Navesink Formation (green) and the latest Maastrichtian-Danian Hornerstown Formation (gray).

GEOLOGIC SETTING & LOCALITY

(Fig. 1)

NJSM 22369 was recovered from the Main Fossil Layer (MFL) which lies stratigraphically near the base of the Hornerstown Formation. The MFL has long been a source of contention over both its age and the nature of its deposition. Some researchers believe it is an earliest Danian transgressive lag, while more recent investigations suggest that it was deposited very slowly (a "condensed section") during the latest Maastrichtian. Definitive evidence elevating either theory has yet to be described. Furthermore, these debates are beyond the scope of the present project and are summarized at length elsewhere (e.g., Gallagher and Parris, 1996; Egerton et al., 2008; Schein et al., 2008).

Geographically, the tooth was collected from the Inversand Mine, a well-known, recently decommissioned open pit glauconite mine in Gloucester County, New Jersey, U.S.A.

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