Histological Analysis of *Ischyrhiza mira* Rostral Spines

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**Introduction**

An elongated rostrum lined with enlarged rostral spines possessed by the pristiophorids (extant sawsharks), pristids (extant sawfishes), and sclerorhynchoids (extinct sawfishes) likely served as a foraging, predation, and/or self-defense adaptation (Wüeringer et al., 2009). Based on external morphology and location along the rostrum, it is believed that rostral denticles are derived from dermal denticles (Cappetta, 2012). Both teeth and dermal denticles are composed of a crystallite bundled enameloid layer overlying a dentine region that surrounds a pulp cavity (Reif, 1982). However, unlike the highly organized arrangement of crystallite bundles observed in tooth enameloid, denticle enameloid has only a limited degree of crystallite organization (Manzanares et al., 2014; Feichtinger et al., 2020). The histology of the enameloid layer in rostral spines has been completely overlooked. Here we describe the enameloid microstructure of rostral spines in *Ischyrhiza mira*, an extinct sawfish that inhabited the marine waters of North America during the Late Cretaceous (100–66 Ma = Million years ago).

**Research Hypothesis**

The objective of this study is to examine the enameloid layer of rostral spines using *Ischyrhiza mira* specimens. Given that rostral spines are believed to be modified dermal denticles, it is hypothesized that the enameloid will only show a limited degree of crystallite organization, like that of denticles found elsewhere on the body.

**Methodology**

*Ischyrhiza mira* rostral spines were recovered from the Early Maastrichtian Navesink Formation of New Jersey, USA. The specimens were transversely and longitudinally sectioned using 800, 1000, 1500, and 2000-grit, carborundum paper. The samples were then etched and diluted in 10% HCl for either 5, 10, or 30 seconds. An FEI Quanta 650 Scanning Electron Microscope was used to examine and image the various histological layers. Gross structure imaging utilized ammonium chloride coating and digital photography.

**Major Outcomes, Results and Conclusion**

We determined that the enameloid microstructure of *Ischyrhiza mira* rostral spines are considerably more complex than that of previously described dermal denticles. The enameloid layer consists of an outer single crystallite enameloid (SCE) and an inner bundled crystallite enameloid (BCE) containing distinct parallel bundled enameloid (PBE), tangled bundled enameloid (TBE), radial bundled enameloid (RBE), and ridges/cutting edge layer (RCEL) components. The highly organized enameloid observed in the rostral spines of this species resembles the complex microstructure observed in teeth. This demonstrates that dermal denticles have the capacity to act as a coevolutionary origin, evolving histologically similar complex tooth-like structures both inside and outside the oropharynx.