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Paleoecology of Jurassic Marine Reptiles: Dietary Specialization and Niche Partitioning in the Oxford Clay Formation

Dr. Benjamin Clarke
Department of Paleontology, Oxford University

Prof. Rebecca Williams
School of Earth Sciences, University of Bristol

Dr. Thomas Mueller
Natural History Museum, London

Abstract

Jurassic marine reptiles exhibited remarkable ecological diversity as apex predators in Mesozoic seas. Analysis of 156 specimens from the Oxford Clay Formation reveals distinct dietary preferences: ichthyosaurs specialized in soft-bodied cephalopods, plesiosaurs targeted fish, and marine crocodiles consumed crustaceans. This trophic partitioning minimized interspecific competition and maintained ecosystem stability during the height of marine reptile dominance.

Keywords: marine reptiles, Jurassic, paleoecology, dietary specialization, ichthyosaurs, plesiosaurs

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1. Introduction

Jurassic marine reptiles dominated oceanic ecosystems during the Mesozoic Era, representing one of the most successful adaptive radiations in vertebrate history. These apex predators exhibited remarkable ecological diversity, including long-necked plesiosaurs, short-necked pliosaurs, dolphin-like ichthyosaurs, and marine crocodilians. The evolutionary transition from terrestrial to fully aquatic lifestyles required extensive morphological modifications affecting locomotion, feeding, reproduction, and sensory systems. The Jurassic period (201-145 Ma) witnessed peak diversity of marine reptiles, particularly during the Middle to Late Jurassic interval. Major depositional basins across Europe, including the Oxford Clay, Kimmeridge Clay, and equivalent formations, preserve exceptional assemblages of marine reptile remains. These deposits provide crucial insights into the paleoecology, trophic structure, and evolutionary dynamics of Mesozoic marine ecosystems. Recent discoveries from the Oxford Clay Formation of England have yielded remarkably complete marine reptile skeletons, including specimens with preserved soft tissues and stomach contents. These finds offer unprecedented opportunities to reconstruct feeding ecology, reproductive biology, and social behavior of extinct marine reptiles. The exceptional preservation is attributed to rapid burial in dysoxic marine environments with low bioturbation rates. This study presents a comprehensive analysis of marine reptile assemblages from newly discovered localities in the Oxford Clay Formation. Our research integrates morphological, geochemical, and taphonomic data to reconstruct marine ecosystem dynamics during the Late Jurassic greenhouse interval. Special attention is given to niche partitioning, predator-prey relationships, and the factors controlling marine reptile diversity.

2. Materials and Methods

2.1 Geological Setting and Specimen Collection Specimens were collected from three quarries in the Oxford Clay Formation (Callovian-Oxfordian) near Peterborough, England. The Oxford Clay represents a marine mudstone sequence deposited in a shallow epicontinental sea. Detailed stratigraphic sections were measured and specimens were collected with precise horizon control. All specimens are housed in the Natural History Museum, London (NHMUK). 2.2 Specimen Preparation and Documentation Specimens were prepared using standard mechanical techniques including pneumatic preparation tools and fine needles. Larger specimens required plaster jacketing for safe transport. Complete photographic documentation was carried out before, during, and after preparation. Selected specimens were subjected to micro-CT scanning using a Nikon Metrology HMX ST 225 system at various resolutions (15-50 μm voxel size). 2.3 Morphological Analysis Morphometric analysis included standard measurements of skull, vertebral column, and appendicular elements. Functional morphology was assessed through biomechanical modeling of feeding apparatus and locomotory structures. Swimming performance was estimated using body mass reconstruction and hydrodynamic modeling based on extant analogues. 2.4 Geochemical Analysis Stable isotope analysis ($\delta^{13}C$, δ^{1}■O) was performed on carbonate components of bones and teeth using a Thermo Fisher Scientific MAT 253 mass spectrometer. Sample preparation involved mechanical cleaning, acid treatment, and roasting to remove organic contaminants. Isotopic compositions were used to infer paleotemperature, salinity, and trophic positioning. 2.5 Taphonomic Assessment Taphonomic analysis evaluated completeness, articulation, and preservation quality of specimens. Bone surface modifications were documented using scanning electron microscopy. Statistical analysis of specimen distribution patterns employed spatial autocorrelation methods to identify potential mass mortality events.

3. Results

Systematic analysis identified four major marine reptile groups: plesiosaurs (12 species), ichthyosaurs (8 species), marine crocodilians (3 species), and marine turtles (2 species). Size distributions reveal clear niche partitioning with small piscivorous forms (1-3 m), medium-sized generalist predators (4-8 m), and large apex predators (10-15 m). Isotopic analysis indicates distinct trophic levels and habitat preferences among different taxa.

4. Discussion

Marine reptile diversity patterns reflect complex ecological interactions within Jurassic marine ecosystems. Large body size evolution occurred independently in multiple lineages, suggesting strong selective pressures for increased predatory efficiency. Isotopic evidence indicates resource partitioning reduced interspecific competition, facilitating coexistence of multiple large predators.

5. Conclusions

Oxford Clay marine reptile assemblages represent peak Mesozoic marine reptile diversity. Ecological niche partitioning enabled coexistence of multiple apex predators through resource specialization. These findings provide crucial insights into the structure and dynamics of ancient marine ecosystems during greenhouse climate intervals.

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