

The Divination of Dentitions in Evolution

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Abstract

Teeth are quintessential elements of evolutionary evidence imposed by ecological niches and determined by dietary demands. By virtue of their postmortem durability, teeth are often the only remaining remnants of long extinct species to provide presumption of their previous paleontological existence. That teeth are intimately associated with dietary intake provides unambiguous evidence of ancient ambient environments and extinct cultural practices. Spectroscopic analysis of enamel and attritional dental wear reveal archaic food composition. Genetic inheritance patterns contained in varying dental configurations reveal permutations of evolutionary trends. Analysis of the preserved mitochondrial DNA of archaic dental pulp tissue of long-deceased antecedents and historical figures of mankind is the current research focus of phylogenetics and evolutionary biology.

Keywords: Teeth; Evolution; Genetic inheritance

Introduction

Of all the organs of vertebrate bodies, teeth alone provide the most crucial evidence of evolutionary trends. The durability of the hard dental tissues, enamel and dentine, ensures their long-term survival post-mortem, often being the only remnants remaining for evolutionary identification. Moreover, their genetically endowed morphological characteristics provide evidence of inherited traits that link clades and generations over eons. The capability of direct comparisons of dental features preserved in fossilized teeth formed millions of years previously with extant dentitions provides unambiguous evidence of evolutionary links over eons.

Comparative Odontology

The evolutionary origin of teeth as derivatives of dermal placoidal scales of primitive fish appearing in the oral cavity over 400 million years ago is well established [1]. The development of the hardest and most durable biological tissues, dental enamel and dentine is one of the triumphs of adaptive evolution to the fundamental concept of survival: "Eat or be eaten". The serrated rows of frequently replaced escalating polyphyodont teeth in sharks is the foundation of the haplodont, homodont morphology of the most primitive teeth that have been modified over eons into the diphyodont heterodont dentitions of

mammals. These evolutionary dental changes were undoubtedly driven by altering dietary demands exemplified by the reversion of terrestrial ancestral cetaceans with heterodont teeth requiring masticatory capabilities to the extant marine cetaceans (whales, seals, dolphins and porpoises) with predatory piscivorous homodont dentitions [2]. The genetic basis of the reduction of multiple rows of teeth to the two-generation deciduous and permanent dentitions has been established [3,4].

The embryonic signaling of dental development and the potential for adaptive evolution is contained in the process of odontogenesis [5]. The suppression of the genetic endowment of teeth inherited in birds from their polyphyodont predecessor dinosaur dentitions is an evolutionary adaptation to granivorous seed-eating diets [6]. Most fossil birds had simple teeth, but the Cretaceous Period *Sulcavis georum* had large grooved teeth, being the first avian fossil to show specialized enamel [7].

The evolutionary loss of teeth occurred in turtles [8] and birds [9] approximately 100 million years ago, to be replaced by horny beaks as an evolutionary adaptation to changed diets. The extraordinary "lawn-mower" dental battery of *Nigersaurus* (Figure 1), adapted to an herbivorous diet is trumped for deviant dentitions by the bizarre spiral tooth whorl in the fossil *Helicoprion* [10] (Figure 2).

The mammalian radiation of tooth types reveals the dizzying array of tooth shapes and sizes seen in comparative odontology. Teeth are key to the identification of genera and species. "Montrez mois vos dents et je vous dirai qui vous êtes" [11]. "Nothing about mammals makes sense except in the light of their teeth" [12]. The adaptation of dentitions to prehensile capabilities and masticatory organs, as well as combing instruments and organs for aggressive displays or smiling pleasures and speech articulation appurtenances in humans have been identified by Ungar [13].

Hominid and Hominin Odontology

The teeth of the predecessors of mankind were transformed

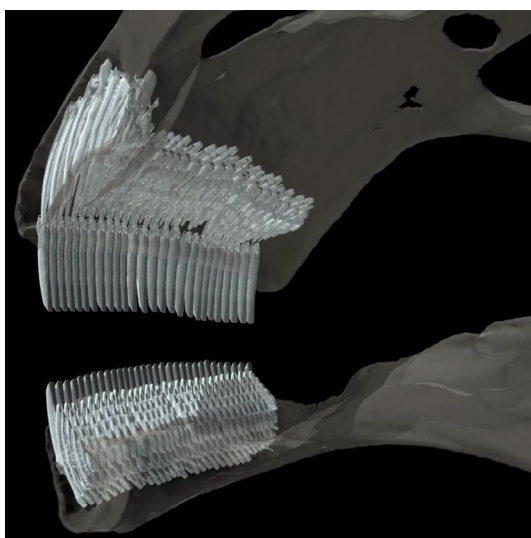


Figure 1: Dental "Battery" of *Nigersaurus*. (Downloaded from the Internet).

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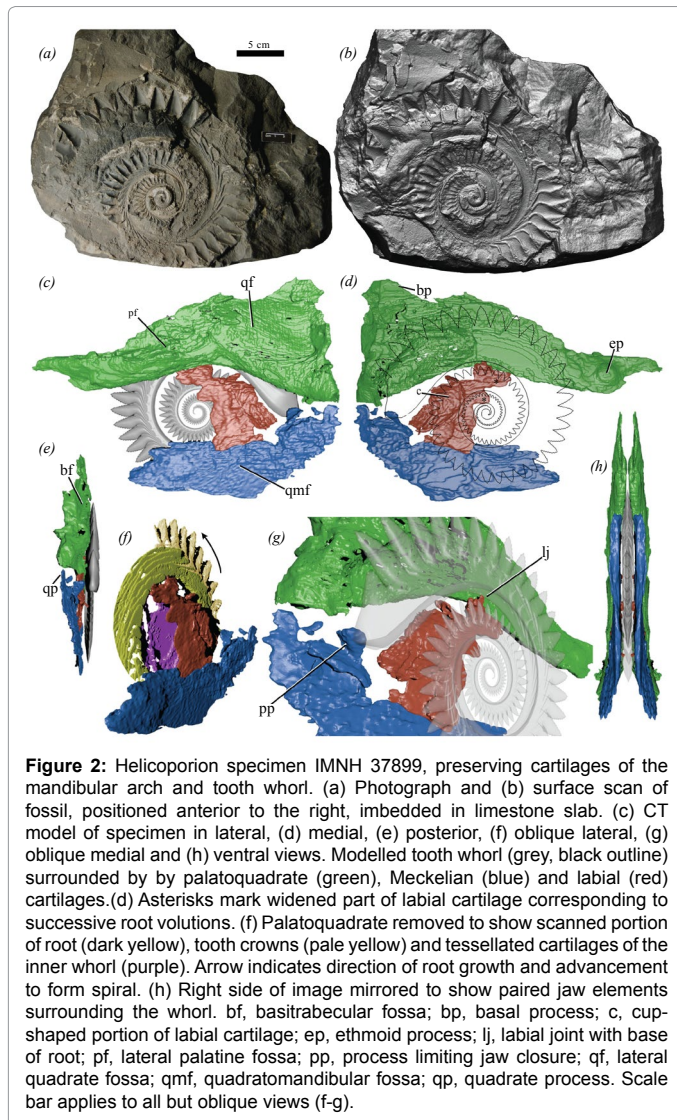


Figure 2: Helicoprorion specimen IMNH 37899, preserving cartilages of the mandibular arch and tooth whorl. (a) Photograph and (b) surface scan of fossil, positioned anterior to the right, imbedded in limestone slab. (c) CT model of specimen in lateral, (d) medial, (e) posterior, (f) oblique lateral, (g) oblique medial and (h) ventral views. Modelled tooth whorl (grey, black outline) surrounded by palatoquadrate (green), Meckelian (blue) and labial (red) cartilages. (d) Asterisks mark widened part of labial cartilage corresponding to successive root volutions. (f) Palatoquadrate removed to show scanned portion of root (dark yellow), tooth crowns (pale yellow) and tessellated cartilages of the inner whorl (purple). Arrow indicates direction of root growth and advancement to form spiral. (h) Right side of image mirrored to show paired jaw elements surrounding the whorl. bf, basitrabecular fossa; bp, basal process; c, cup-shaped portion of labial cartilage; ep, ethmoid process; lj, labial joint with base of root; pf, lateral palatine fossa; pp, process limiting jaw closure; qf, lateral quadrate fossa; qmf, quadratomandibular fossa; qp, quadrate process. Scale bar applies to all but oblique views (f-g).

from primate pongid dentitions with projecting canine teeth and diastemata set in a pattern of parallel or converging rows of cheek teeth to the parabolic arcades of contiguous teeth and reduced canines characteristic of the Australopithecinae. The identification of the Australopithecine Taung infant skull by Dart [14] as a new genus predecessor to modern mankind was based not only on its small cranial capacity but most significantly, on its hominin dentition, contrasting with that of the apes.

The subsequent explosion of australopithecine discoveries has led to re-creating the lifestyle of these 2.5 million year-old fossils by analysis of their diets based on their dentitions [15]. The techniques of analyzing attritional wear and scratch marks on the preserved pristine enamel by scanning electron microscopic analysis provide evidence of the dietary content ingested by these creatures [16,17]. Even more remarkable is the spectroscopic analysis of the varying ratios of isotopes of C^{12} and C^{13} in dental enamel to establish ambient dietary comestibles of 2.5 million years ago. Electron spin analysis of enamel provides dating of fossils beyond the limit of radiocarbon dating [18].

Advances in mitochondrial DNA (mtDNA) analyses of long preserved dental pulp tissues ensconced within teeth are being used to trace lineages and identification of Neanderthals [19] and skeletal

remnants of historical figures [20-22]. Dead men tell no tales, but their teeth live with tales long after them.

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