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Evolution of the sabertooth mandible: A deadly ecomorphological specialization

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ABSTRACT

Saber-toothed cats were armed with formidable weapons. They evolved a number of highly derived morphological features, most notably a pair of extremely long upper canines, which makes them unique within the felid family. Although the sabertooth character evolved several times among carnivorous mammals, sabertooth clades mostly had disjunctive occurrences both in space and time, and no sabertooth is alive today. We studied the rates of phenotypic and taxonomic diversification in the mandible of sabertooths, as compared to the rates calculated for both extinct and extant conical toothed cats. We found that the mandible's shape and physical properties in sabertooth clades evolved at distinctly higher rates than the rest of the felid tree. In addition, sabertooths had similar speciation rate to conical toothed cats, but statistically higher extinction rate. The wealth of morphological specializations required to be a sabertooth, and their tendency to focus on large-sized species as prey, was likely responsible for such high extinction rate, and for the peculiar, disjunctive patterns of sabertooth clade occurrence in the fossil record.

1. Introduction

Felids (Mammalia, Carnivora) form a morphologically homogenous, monophyletic clade, including strictly carnivorous species. In contrast to other meat-eating mammals, felids only retain the anterior, slicing portion in their lower molars, while the crushing part (the talonid) is lost (Meloro et al., 2007; Van Valkenburgh, 2007). Felids (Felidae plus Barbourofelidae families) can be ecomorphologically subdivided into two categories: conical-toothed cats and sabertooths (Van Valkenburgh, 2007). The former borrow their name from the shape of their canines in cross section (Martin et al., 2000). They include the modern cat genera such as *Felis*, *Panthera*, and *Acinonyx*. Sabertooth cats were characterized by laterally-compressed, extremely long upper canines, procumbent incisors, reduced coronoid process, and low glenoid fossa (Christiansen, 2008a, 2008b, 2006; Slater and Van Valkenburgh, 2008). All of these features conferred on sabertooths a unique killing behavior. The success of the sabertooth morphology is testified by its iterative evolution among meat eating mammals (Van Valkenburgh, 2007). Sabertooths are known among Thylacosmilidae, an extinct clade of South American marsupials of the Miocene and Pliocene (Antón, 2013), and Creodonta, which lived in North America in the Paleocene and Eocene (Antón, 2013). Within Carnivora, the sabertooth morphology appeared in the Nimravidae family, which emerged in late Eocene (Bryant, 1991), the Barbourofelidae family (known from the early Miocene, Morlo et al., 2004), and in the true cat subfamily Machairodontinae, which radiated between Miocene and Late Pleistocene (Hunt Jr., 1996; Werdelin et al., 2010).

Sabertooths' highly derived cranial morphology (Christiansen,

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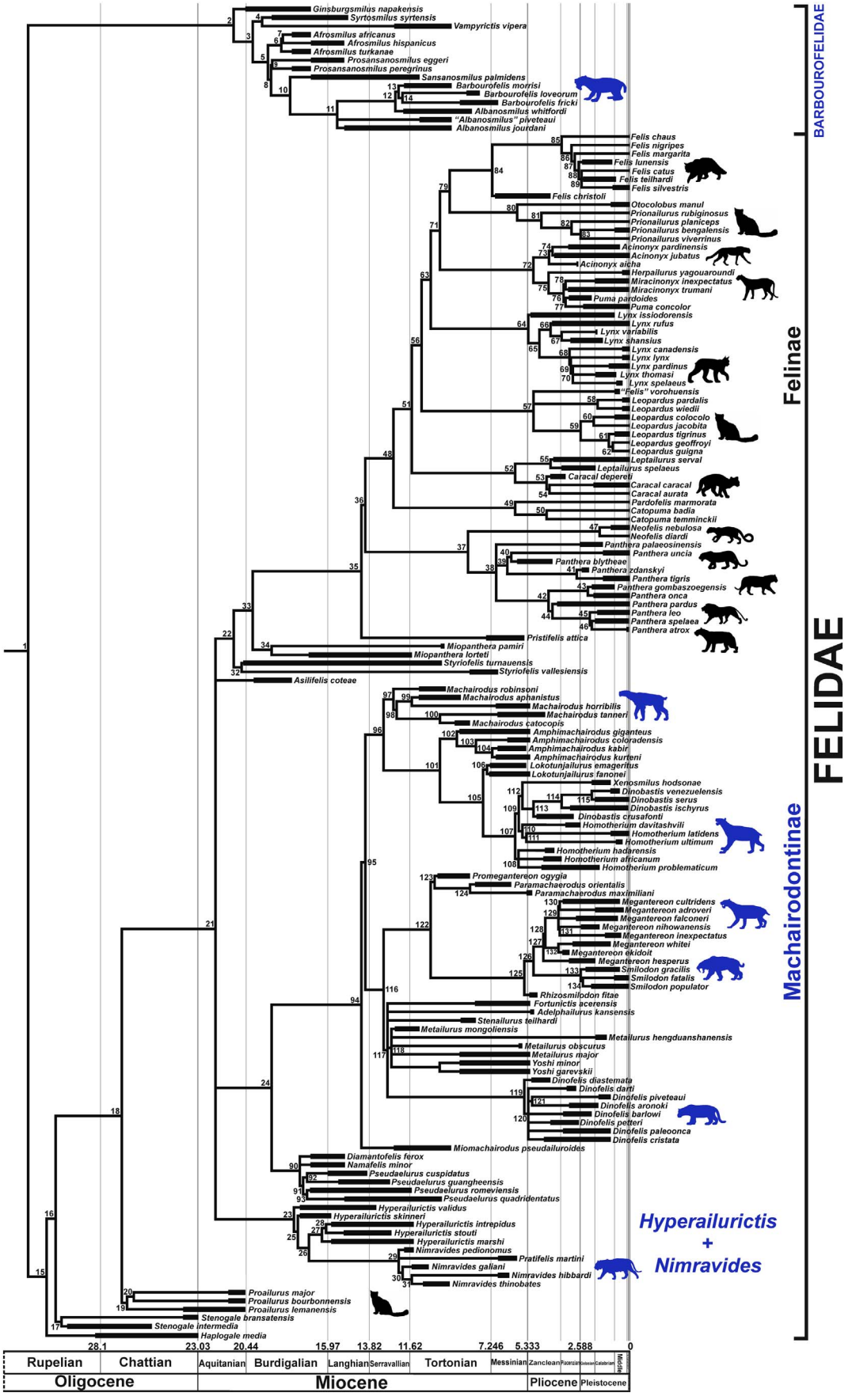

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