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Introduction

Lanternsharks (Etmopteridae) are a highly diverse family of poorly known, bioluminescent deep-sea elasmobranchs with 42 species in five genera (Compagno et al. 2005). We compiled an extensive DNA dataset to (1) identify the sistergroup of Etmopteridae among Squaliformes, (2) test for the monophyly of Etmopteridae, (3) test for the independent development of bioluminescence within Squaliformes, (4) test for the monophyly of the two polytypic etmopterid genera, (5) test for a Lower Eocene origin of Etmopteridae as indicated by the fossil record, and (6) to analyse sequential versus rapid speciation in the course of the speciose etmopterid radiation.

Material & Methods

- 26 of 43 described species analysed plus ten preliminary or unidentified samples
- *Chimaera*, *Odontaspis*, and *Apristurus* as distantly related nested outgroups
- Phylogenetic analyses were conducted on a multigene alignment of 4665 bp
- loci: RAG1 (nuclear), COI (mt), 12S rRNA (mt), valine tRNA (mt), and 16S rRNA (mt)
- Analysing approaches: MP (PAUP*), ML (RAXML), and Bayesian inferences (MrBayes)
- node time estimation: relaxed molecular clock approach using Penalized Likelihood (r8s) and Bayesian inferences (BEAST)

Results & Discussion

- (1) Identifying sister-group relationships of Etmopteridae failed.
- (2) The monophyly of Etmopteridae is strongly supported, four major intrafamilial lineages corresponding largely to four morphologically well diagnosable genera, and four intraspecific species groupings among *Etmopterus* are identified (Fig.1).
- (3) Results support the multiple independent evolution of bioluminescence among Squaliformes (Reif 1985).
- (4) Three of five genera display well-supported monophyly, i.e. *Aculeola*, *Centroscyllium*, and *Trigonognathus*. *Etmopterus* renders paraphyletic with respect to *Miroscyllium* contradicting Shirai & Nakaya (1990) and Shirai (1992) placing *M. sheikoi* in between *Centroscyllium* and *Etmopterus*.
- (5) Age estimates of Etmopteridae falls at the end of the Cretaceous / beginning of the Paleocene and is substantially earlier than the first unambiguous etmopterid fossil from deepwater Eocene sediments. The basal etmopterid radiation into four lineages that differ mostly in highly specific dentition characters indicates that trophic specialization played an important role for the early radiation of the group in the Eocene (Fig. 2).
- (6) Splitting and evolution of extant genera of Etmopteridae occurred in between 45 and 15 mya (middle Eocene to early Miocene) displaying rather fast radiation of *Etmopterus* species groups (Fig. 1) at the Oligocene/ Miocene transition.

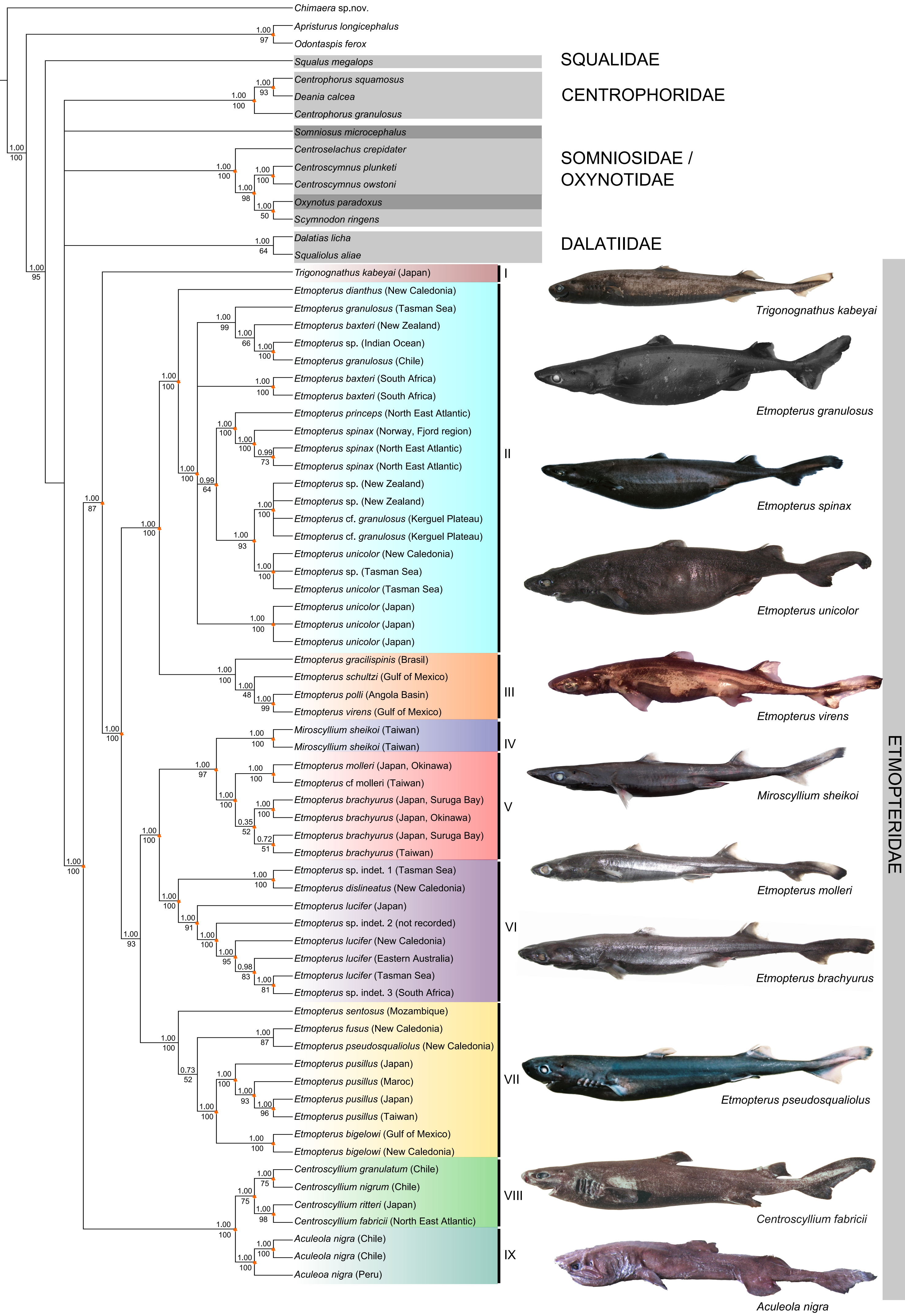


Figure 1: dendrogram displaying phylogenetic relationships of Etmopteridae, reconstructed with Bayesian inference. Widely congruent topologies were attained with ML and MP analyses. Numbers above internal nodes indicate posterior probabilities (PPs) from Bayesian analyses, numbers below branches bootstrap scores attained from ML search strategies. Orange asterisks refer to nodes found in MP analysis with a bootstrap support > 50%. Nodes displaying PPs and bootstrap scores < 0.95 (PP) and < 50% (bootstrap support) were collapsed. Roman numerals refer to nine major clades resulting from phylogenetic analyses.

Among the speciose genus *Etmopterus*, four species groups can be identified, partially morphologically characterizable: *E. spinax* species group (clade II), *E.gracilispinis* species group (clade III), *E. lucifer* species group (clades V & VI), and *E.pusillus* species group (clade VII). *Etmopterus* sp. indet. 1: preliminary identified as *E. cf molleri*; *E. sp. indet. 2*: preliminary identified as *E. lucifer*; *E. sp. indet. 3*: preliminary identified as *E. cf brachyurus*. Dark grey colors mark taxa differing from traditional Squaliform families (light gray).

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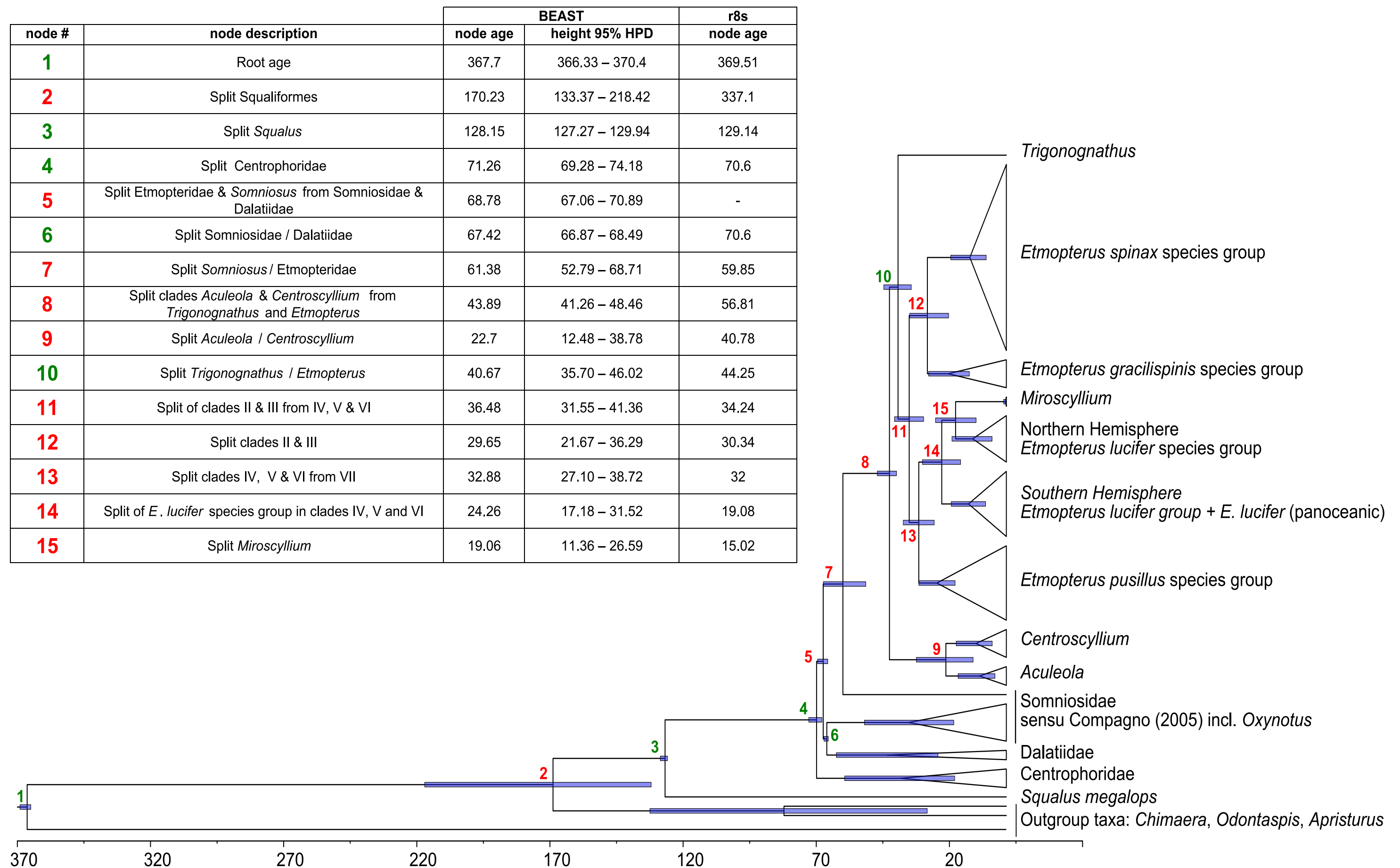


Figure 2: estimated divergence times (in Ma). Red numbers refer to node numbers given in the table including mean node ages of both analysing approaches and confidence intervals. Green numbers indicate applied calibration points attained from fossils.