Analyzing Fossil Records for Determining Timescales for Timetrees

Abiodun Musa*

Rua Antenor, Duque De Caxias, Rio de Janeiro, Brazil.

Corresponding Author*

Abiodun Musa
Rua Antenor, Duque De Caxias Rio de Janeiro, Brazil.
E-mail:natural.energy1234@gmail.com

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Abstract

The major information needed to establish absolute timescales for timetrees comes from the fossil and geologic records. The fossil record is used to bracket divergence periods for the paleontological assessment of proposed timetree timescales and for node-based approaches for building timetrees. By using well-dated fossils that may be confidently assigned to lineages based on favourable morphological evidence, minimal brackets (minimum ages) can be established. Maximum brackets are far more challenging to establish, partly because it is challenging to provide conclusive proof that a taxon's absence from the fossil record is genuine and not only the result of incomplete fossil and rock records. The difficulty of determining maximum age brackets is made more difficult by the fact that a group's potential for fossilisation often declines the closer one gets to its time of inception. There are additional challenges:

1 Because fossil data actually bracket the time of origin of the first relevant fossilizable morphology (apomorphy), not the divergence time itself.
2 Because fossil placement is phylogenetically uncertain.
3 Because of peculiar temporal and geographic gaps in the rock and fossil records
4 If a group's preservation potential changed significantly over time.

Keywords: Timetrees • Fossilizable • Coalescence

Introduction

It has been difficult to create accurate techniques for estimating divergence periods between lineages using paleontological and geological data. The development and evaluation of timetrees, trees whose relative branch lengths are mostly obtained from DNA sequence data but have been translated into units of absolute time, nevertheless, require these techniques. A topology, branch lengths according to time, and an absolute timescale make up timetrees. Here, we are especially concerned with the paleontological evaluation of the timelines, the estimations of lineage divergence times; that is, we want to concentrate on how palaeontologists estimate divergence times rather than how a particular timetree would have been produced.

Nevertheless, some of the topic is relevant to the creation of timetrees, particularly those obtained from node-dating techniques where priors on divergence times are provided by the fossil record, including the challenging maximum age limits. Even while these approaches do not require a priori maximum estimations of divergence times, some of the material is still applicable to non-node-dating methods for building timetrees since these methods still need to make assumptions about the rates of fossil recovery. These techniques include the Fossilized Birth Death (FBD) process, complete evidence methods, which estimate the phylogenetic positions of relevant fossils and extant taxa at the same time.

This entails determining the focus lineage's earliest fossil and its First Appearance Datum (FAD). The minimum age restriction relates to the age of the oldest appearance of the first fossilizable apomorphy of the focal lineage in the fossil record since palaeontologists are often only able to deal with morphological data. We need to estimate the extent of this temporal gap, i.e., establish a maximum age restriction, because a literal interpretation of the fossil record is skewed because the age of the FAD will post-date the divergence period due to the incompleteness of the fossil record. Now that we have turned our attention to the DNA component of timetrees, we should point out that DNA data, when calibrated appropriately, offer a measure of the divergence time (TDivergence) and the coalescence time for the loci being compared.

$$TDNA=TDivergence+TCoalescence$$

Conclusion

Depending on the group and the accessible fossil record, there is a wide range in the accuracy of temporal calibration. However, based on the group's age and its correlates, geographic distribution, and species richness, certain conclusions can be formed. Robust timetrees are well within our grasp for many taxa if caution is taken with the paleontological calibrations itself and with prudent examination of data using several techniques.

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