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Title: The fossilized birth-death process for coherent calibration of divergence-time estimates

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Source: PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA **Volume:** 111 **Issue:** 29 **Pages:** E2957-E2966 **DOI:** 10.1073/pnas.1319091111 **Published:** JUL 22 2014

Abstract: Time-calibrated species phylogenies are critical for addressing a wide range of questions in evolutionary biology, such as those that elucidate historical biogeography or uncover patterns of coevolution and diversification. Because molecular sequence data are not informative on absolute time, external data-most commonly, fossil age estimates-are required to calibrate estimates of species divergence dates. For Bayesian divergence time methods, the common practice for calibration using fossil information involves placing arbitrarily chosen parametric distributions on internal nodes, often disregarding most of the information in the fossil record. We introduce the "fossilized birth-death" (FBD) process-a model for calibrating divergence time estimates in a Bayesian framework, explicitly acknowledging that extant species and fossils are part of the same macroevolutionary process. Under this model, absolute node age estimates are calibrated by a single diversification model and arbitrary calibration densities are not necessary. Moreover, the FBD model allows for inclusion of all available fossils. We performed analyses of simulated data and show that node age estimation under the FBD model results in robust and accurate estimates of species divergence times with realistic measures of statistical uncertainty, overcoming major limitations of standard divergence time estimation methods. We used this model to estimate the speciation times for a dataset composed of all living bears, indicating that the genus Ursus diversified in the Late Miocene to Middle Pliocene.

Accession Number: WOS:000339310700007
PubMed ID: 25009181
Language: English
Document Type: Article
Author Keywords: phylogenetics; Bayesian divergence time estimation; relaxed clock; MCMC; time tree
KeyWords Plus: BAYESIAN PHYLOGENETIC INFERENCE; RECONSTRUCTED EVOLUTIONARY PROCESS; MAXIMUM-LIKELIHOOD; MOLECULAR CLOCK; DNA-SEQUENCES; SUBSTITUTION RATES; RELAXED PHYLOGENETICS; TREES; MODELS; RADIATION

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Publisher: NATL ACAD SCIENCES
Publisher Address: 2101 CONSTITUTION AVE NW, WASHINGTON, DC 20418 USA
Web of Science Categories: Multidisciplinary Sciences
Research Areas: Science & Technology - Other Topics
IDS Number: AL7JS
ISSN: 0027-8424
29-char Source Abbrev.: P NATL ACAD SCI USA
ISO Source Abbrev.: Proc. Natl. Acad. Sci. U. S. A.
Source Item Page Count: 10

Funding:

Funding Agency	Grant Number
National Science Foundation	DEB-1256993
National Institutes of Health	GM-069801 GM-086887
Swiss National Science Foundation (SNF)	PZ00P3 136820

We thank B. Boussau, A. Drummond, A. Gavryushkina, M. Holder, M. Landis, P. Lewis, C. Marshall, R. Meredith, and B. Moore for helpful conversations and comments. Comments from two anonymous reviewers and the editor contributed to the improvement of this paper. T. A. H. was supported by National Science Foundation Grant DEB-1256993, and J.P.H. was supported by National Institutes of Health Grants GM-069801 and GM-086887. T. S. thanks the Swiss National Science Foundation (SNF) for funding (SNF Grant PZ00P3 136820).

Open Access: No
Output Date: 2017-07-31

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