Digging into the temporal diversification of the fossorial snake family Uropeltidae

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Introduction

Environmental factors play a key role in mediating diversification by triggering shifts in range size and creating the ecological setting for lineages to diversify.

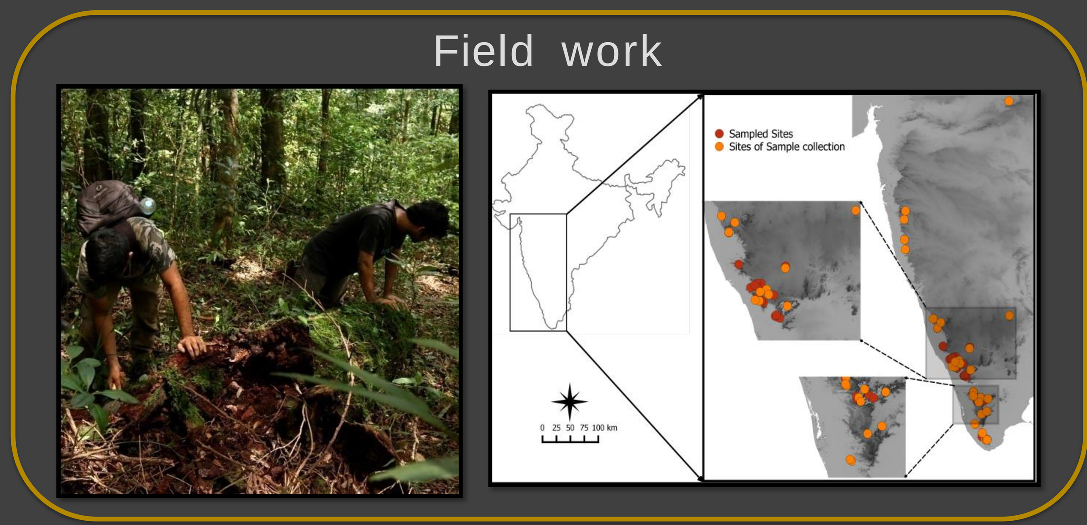
Several studies have shown that paleoclimate have had a pronounced effect on diversification (e.g. Birds – Claramunt and Cracraft, 2015; Insects – Condamineet al., 2016; Spiny-rayed fish – Near et al., 2012; Amphibians – Roelantset al., 2007; Mammals – Stadler, 2011).

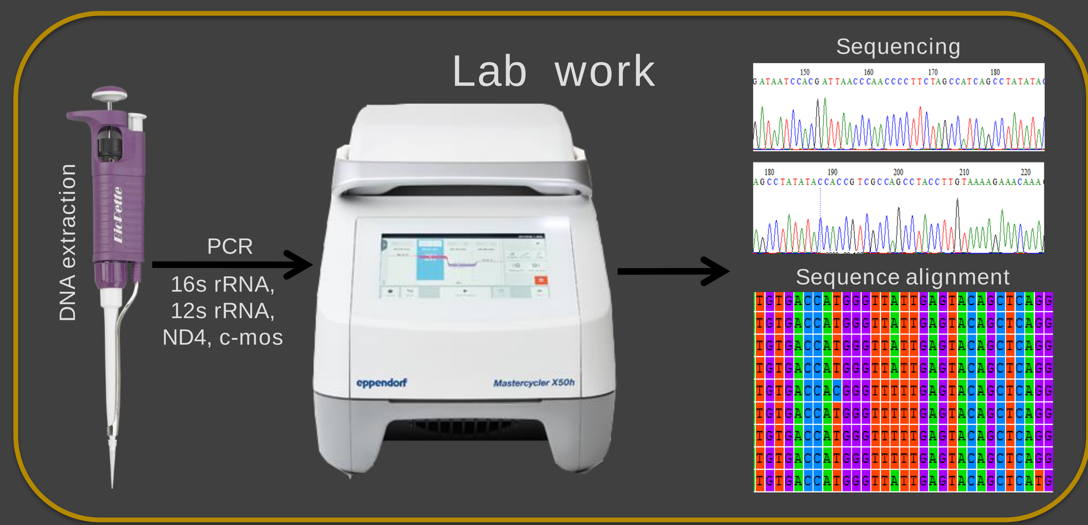
Fossorial environments are structurally simple and relatively stable compared to above ground environmental fluctuations (Nevo, 1979; Kinlaw, 1999; Scheffers *et al.*, 2014).

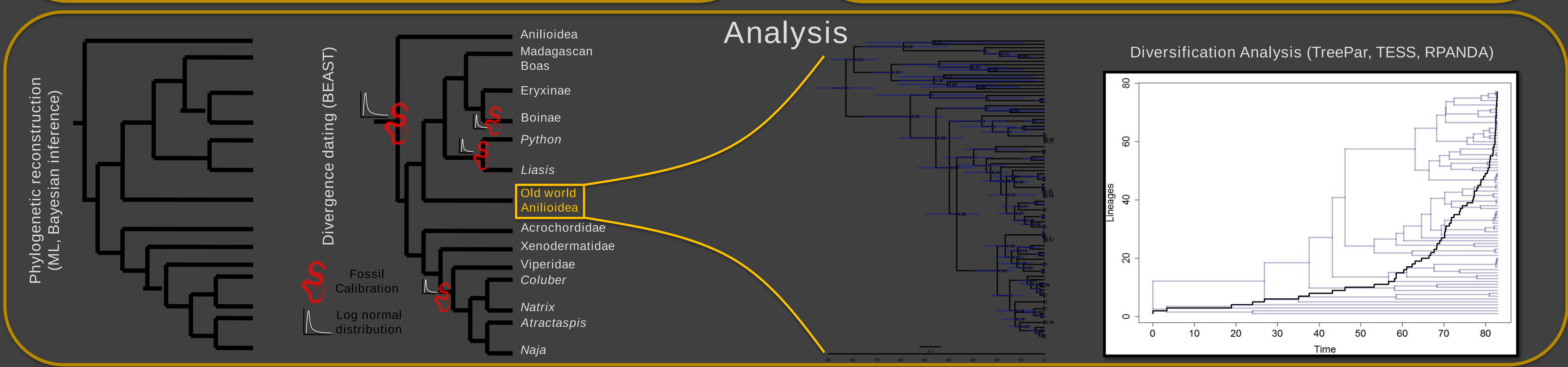
How paleoenvironment has influenced temporal diversification in fossorial taxa is not understood.

Investigated temporal diversification in Uropeltidae, a highly specialized group of fossorial snakes found in the moist forests of peninsular India and Sri Lanka

Materials and methods



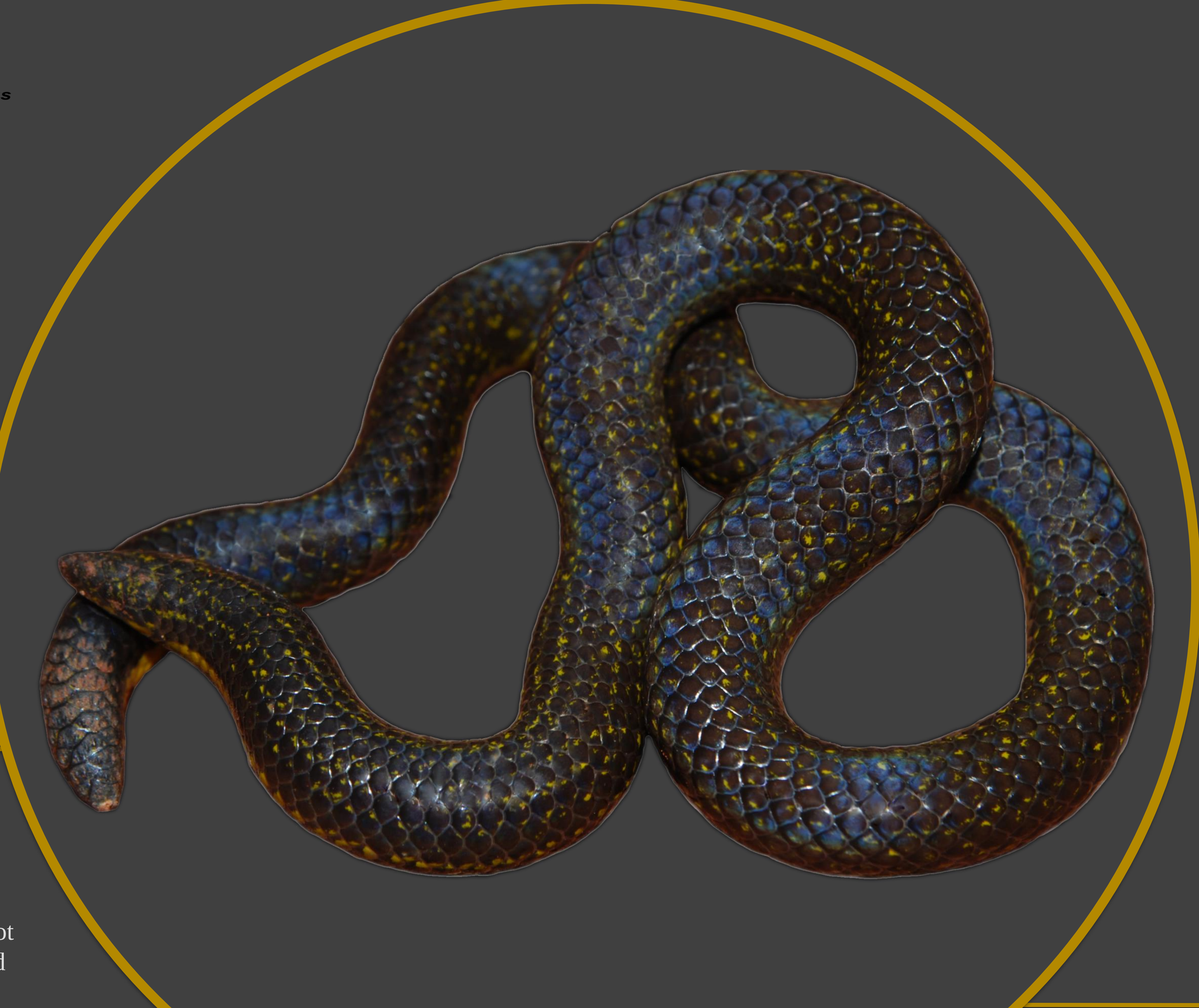




Results

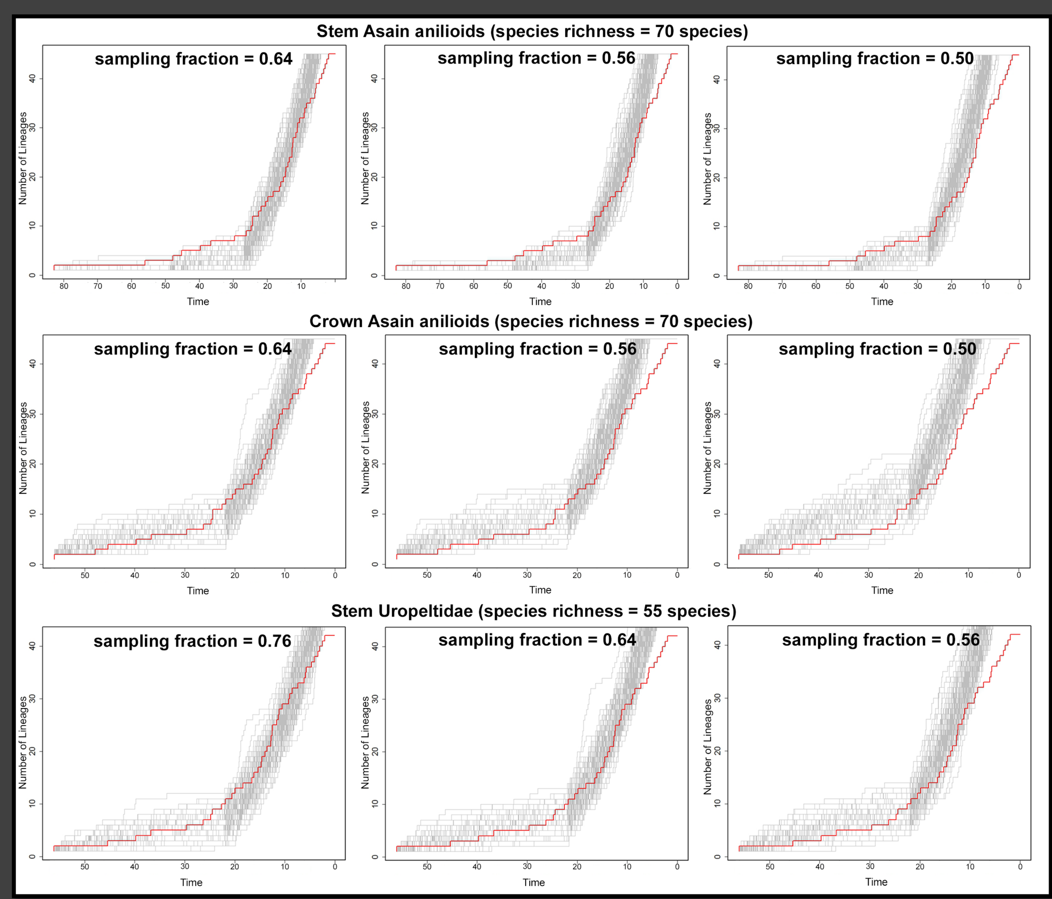
Divergence Dating

Fig 1: Ultrametric tree of the Asian anilioids (Uropeltidae + Cylindrophidae + Anomochilidae) and outgroups, with divergence time estimates from the BEAST analysis. Nodal values indicate posterior probabilities and bars at the node indicate the 95% confidence intervals. The four major clades recovered from the MrBayes analysis are indicated at the node by a blue circle. The shaded grey and white regions of the image indicate adjacent geological time periods.



Modeling Mass Extinctions

Fig 3: LTT plots for the 100 simulated trees modeled with a 2:1 birth-death process with one mass extinction for the crown Asian anilioids and stem Uropeltidae, and two mass extinction events for the stem Uropeltidae. The red line represents the empirical LTT plot while the gray lines represent the simulated LTT plots. The plots in the centre and right are simulated by reducing the sampling fraction to account for cryptic diversity within the clade.



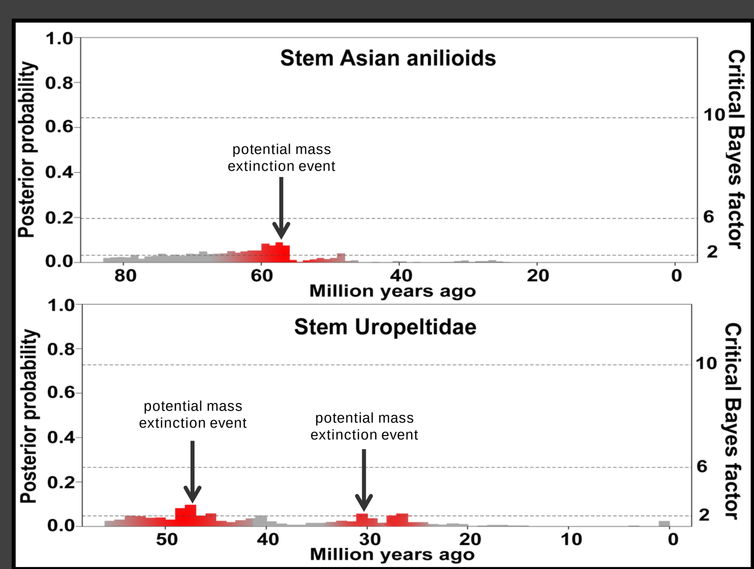


Fig 4: Plots showing the posterior probability of the timing of mass extinction events for the CoMET model assuming λM = 2. A critical Bayes factor 2lnBF > 2 is considered as positive support and 2lnBF > 6 is considered as strong support for a mass extinction event.

Time-dependant Diversification

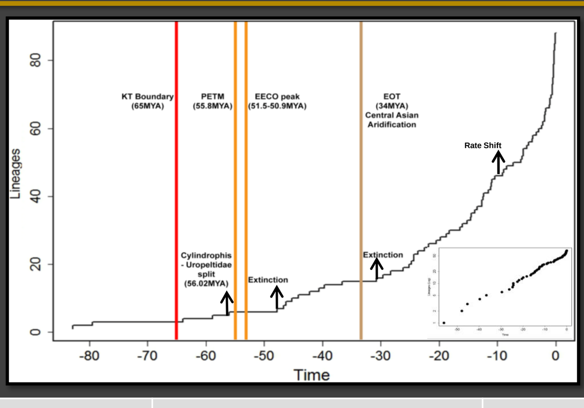


Fig 2: Lineage Through Time (LTT) plot of Asian anilioids + outgroup. Coloured vertical lines major geological events. Arrows indicate patterns that indicate possible extinction and rate shift events.

	Stem Asian anilioids		Crown Asian anilioids		Stem Uropeltidae	
Best model	**2-rate model-uniform sampling**		**Constant birth-death model-uniform sampling**		**2-rate model-uniform sampling**	
Parameter estimates (TreePar)	Diversification rate/Turnover Rate **0.03097/0.08253 0.01433/0.92994**	Rate shift time **10.93**	Diversification rate/Turnover Rate **0.068554/0.000001**	Rate shift time **-**	Diversification rate/Turnover Rate **0.03360/0.07655 0.02900/0.85558**	Rate shift time **11.02**
Best model	**2-rate model-diversified sampling**		**2-rate model-diversified sampling**		**2-rate model- diversified sampling**	
Parameter estimates (TESS)	Diversification rate/Extinction Rate **0.03412/0.03587 0.62548/1.12187**	Rate shift time **10.93**	Diversification rate/Extinction Rate **0.03412/0.03587 0.62548/1.12187**	Rate shift time **10.93**	Diversification/Extinction Rate **0.04636/0.02711 0.41041/1.29649**	Rate shift time **11.02**

Table 1: Parameter estimates for the birth-death-shift (BDS) model with diversification rate per million years and rate shift times in million years. Estimates are ordered from the recent to the past with the of values indicating diversification rates prior to rate shift event. Best-fit models were selected by assessing the fit of 4 rate constant and 32 rate variable models with and without extinction

Paleoclimate-dependant Diversification

Best-fit model	Crown Asian anilioids		Stem Uropeltidae	
	Parameter	**Dependency**	**Parameter**	**Dependency**
	Speciation	**linear**	**Speciation**	**linear**
	Extinction	**linear**	**Extinction**	**linear**
logLik	**-159.89**		**−149.50**	
λ	**-0.03**		**−0.03**	
α	**0.024**		**0.028**	
μ	**-0.199**		**−0.34**	
β	**0.039**		**0.06**	

Table 2: Parameter estimates of the best-fit paleoenvironment-dependant model for the crown Asian anilioids and stem Uropeltidae. λ and μ are initial speciation and extinction rates respectively when temperature is 0 while α and β are the rate of change of speciation and extinction rates respectively.

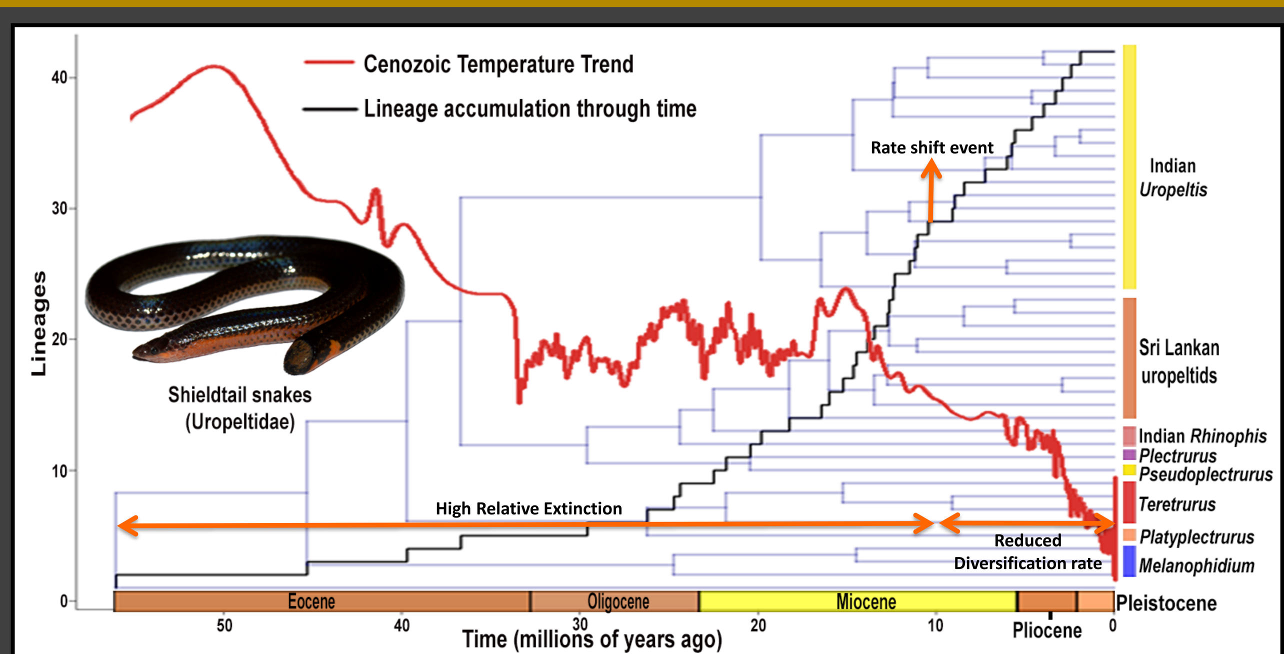
Conclusions

Asian anilioids originated in the upper cretaceous (ca. 82Ma) and Uropeltidae split from its sister during the Paleocene – Eocene boundary (ca. 56Ma)

Temporal diversification was punctuated by a decrease in diversification rates from the Miocene associated with expansion of grasslands and contraction of forests.

High relative extinction during periods of environmental fluctuation. However, no strong support for mass extinction events.

Diversification rates correlated with paleotemperature. Rate of change of extinction rates higher than rates of change of speciation rate.



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