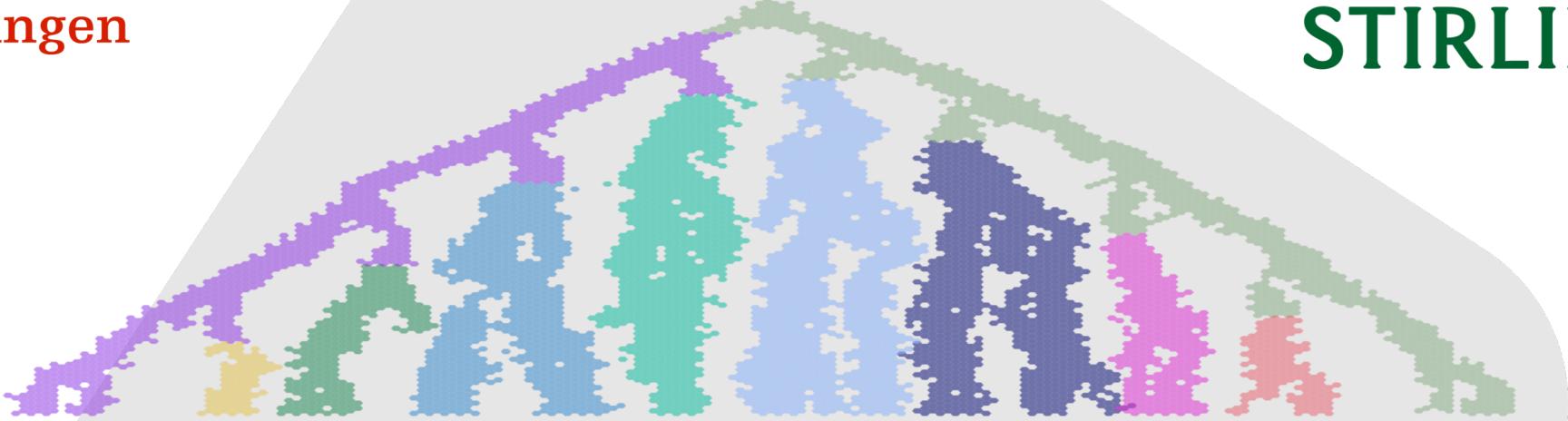




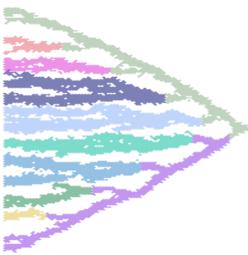
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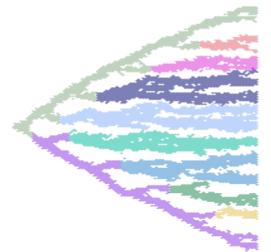


*Exponential diversity-dependence
in speciation and extinction rates
emerges from competition
in an individual-based
model*

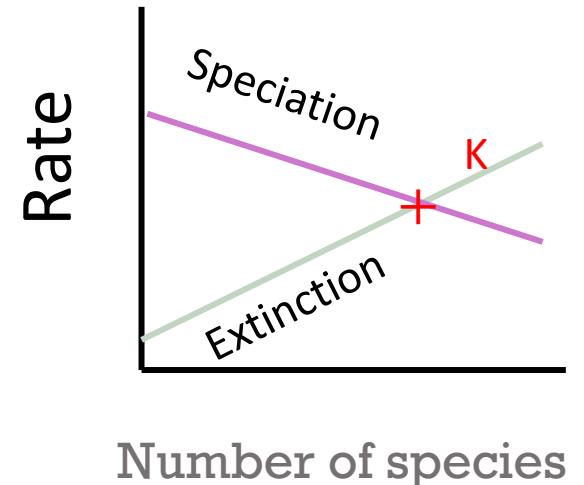
Théo Pannetier⁺
Brad Duthie
Rampal Etienne



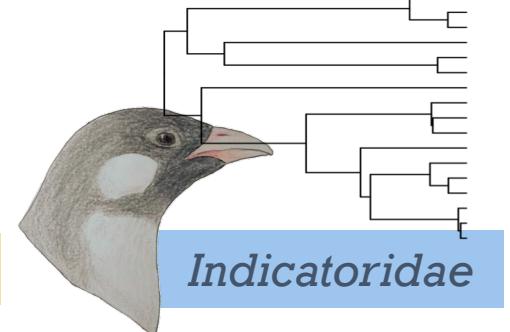
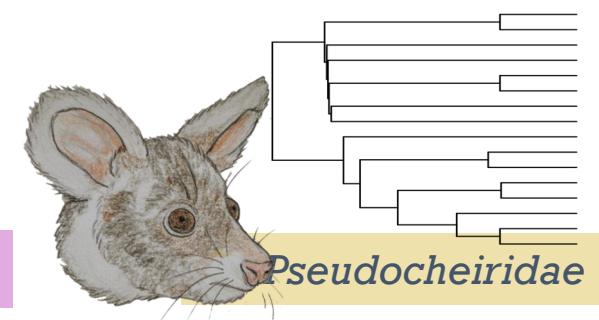
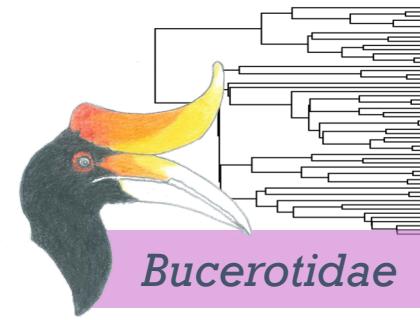
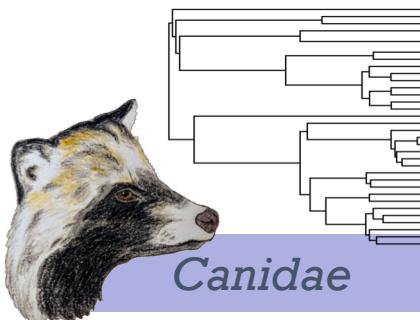
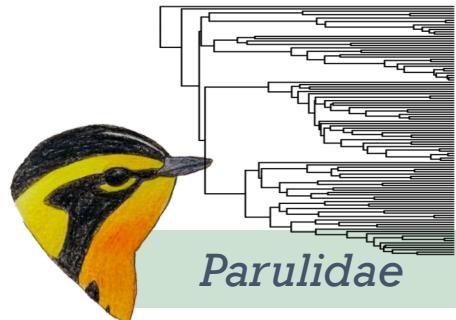
Diversity-dependence in macroevolution

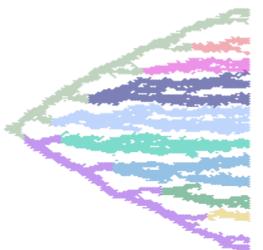
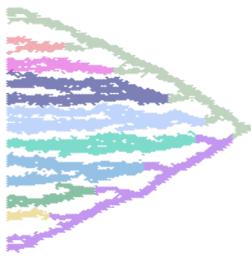


- Diversity-dependence: rate of diversification (speciation – extinction) depends on N
- Consequence of interspecific competition for limited resources
- Popular because
 1. Links macroevolution to ecology
 2. Widely applicable



Some examples:

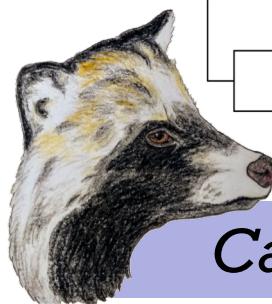




Testing for diversity-dependence

Birth-death framework

Timetree



Candidate models

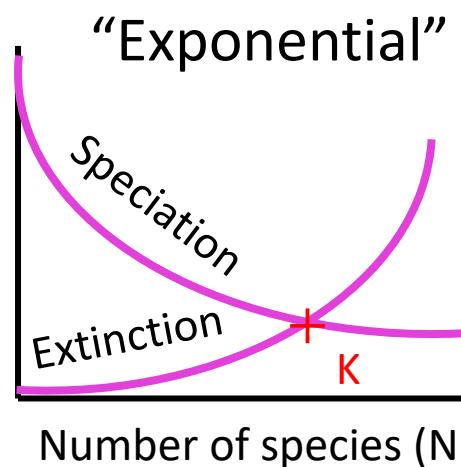
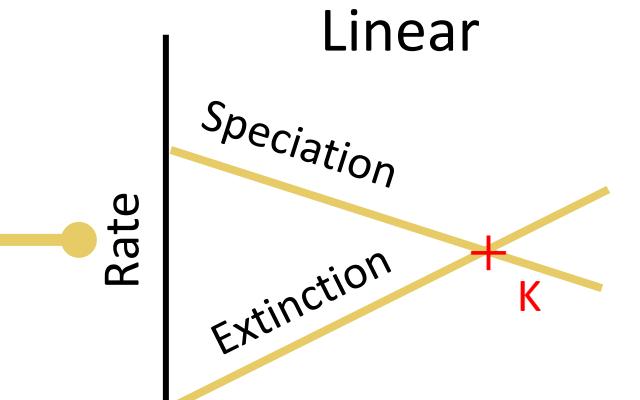
Constant-rates

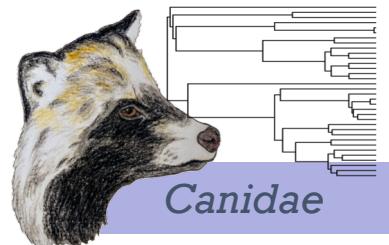
Time-dependent rates

...

Diversity-dependence (linear)

Diversity-dependence (exponential)





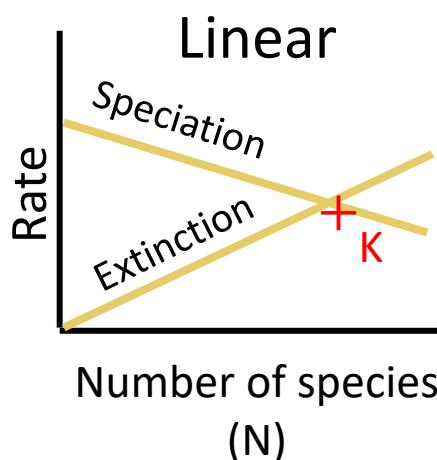
Linear
diversity-
dependence

Mammalia: Canidae

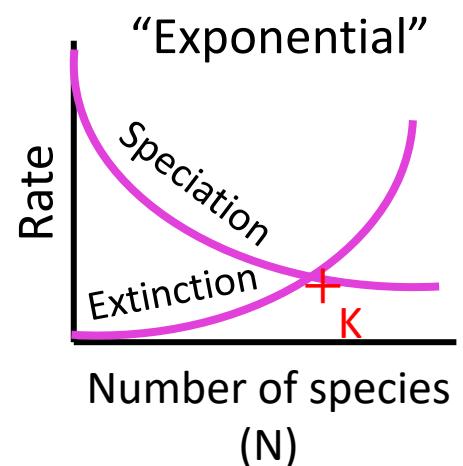
Clade diversity = 34 species, clade sampling fraction = 1, and clade age = 7 Myrs

Models	NP	logL	AICc	ΔAIC	AICω	λ0	α	μ0	β	K
DDL+E	3	-59.8	126.4	0	0.5	7.592		0.596		33.3
BCST	1	-63.9	129.9	3.5	0.1	0.369				
BTempVar_MTB	2	-63.6	131.7	5.3	0	0.48	0.59			
BTimeVar_EXPO	2	-63.9	132.1	5.7	0	0.351	0.022			
BTimeVar_LIN	2	-63.9	132.2	5.7	0	0.35	0.009			
BCSTDCT	2	-63.9	132.2	5.8	0	0.369		0		
BCSTDTimeVar_LIN	3	-63.9	134.6	8.2	0	0.371		0	0.001	
BTimeVarDTimeVar_EXPO	4	-63.9	137.1	10.7	0	0.351	0.022	0	0.009	
BTempVarDTempVar_EXPO	4	-63.9	137.2	10.8	0	0.362	0.005	0	0.024	
DDX+E	3	-68.6	144	17.6	0	0.468		0.468		3.8

Exponential
diversity-
dependence

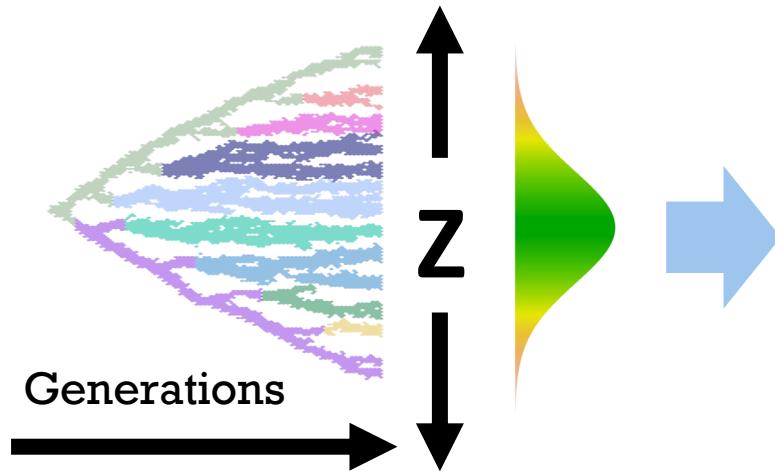


Competition driving
diversification?

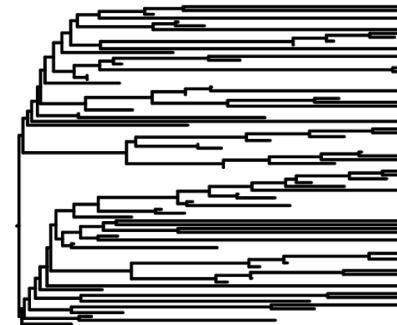


Methods - Reconstructing diversity-dependent speciation & extinction rates that emerge from competition at the level of individuals

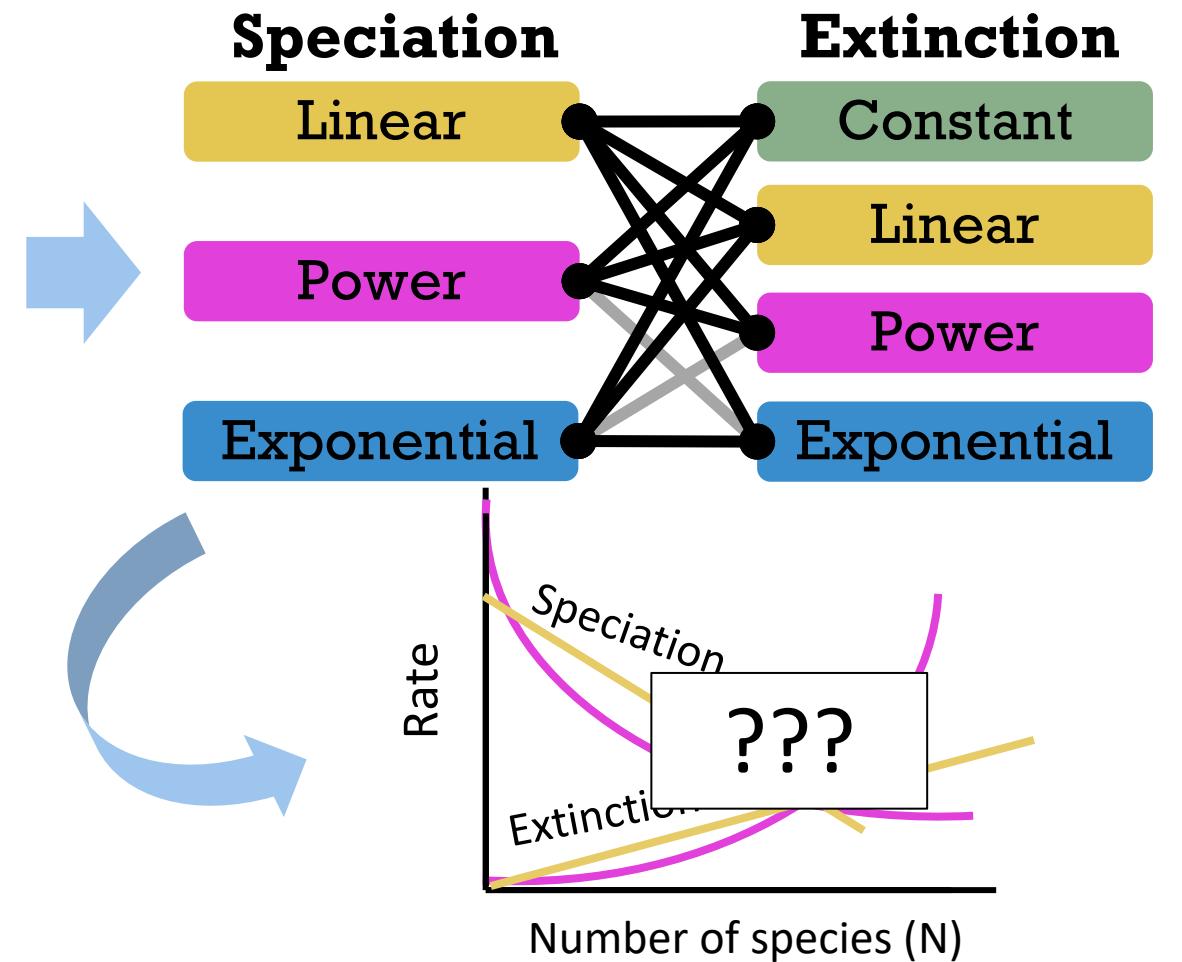
1. Simulation with an IBM



2. Extract phylogeny

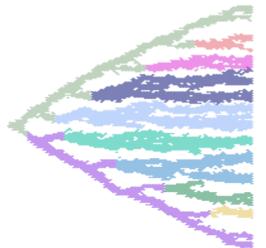
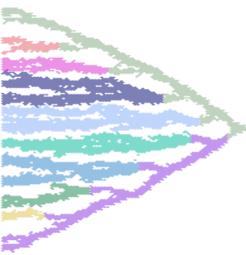


3. Model selection via maximum likelihood



Fitness function

$$W(z_i) = e^{r(1 - \frac{\sum_j \alpha(z_i, z_j)}{K(z_i)})}$$



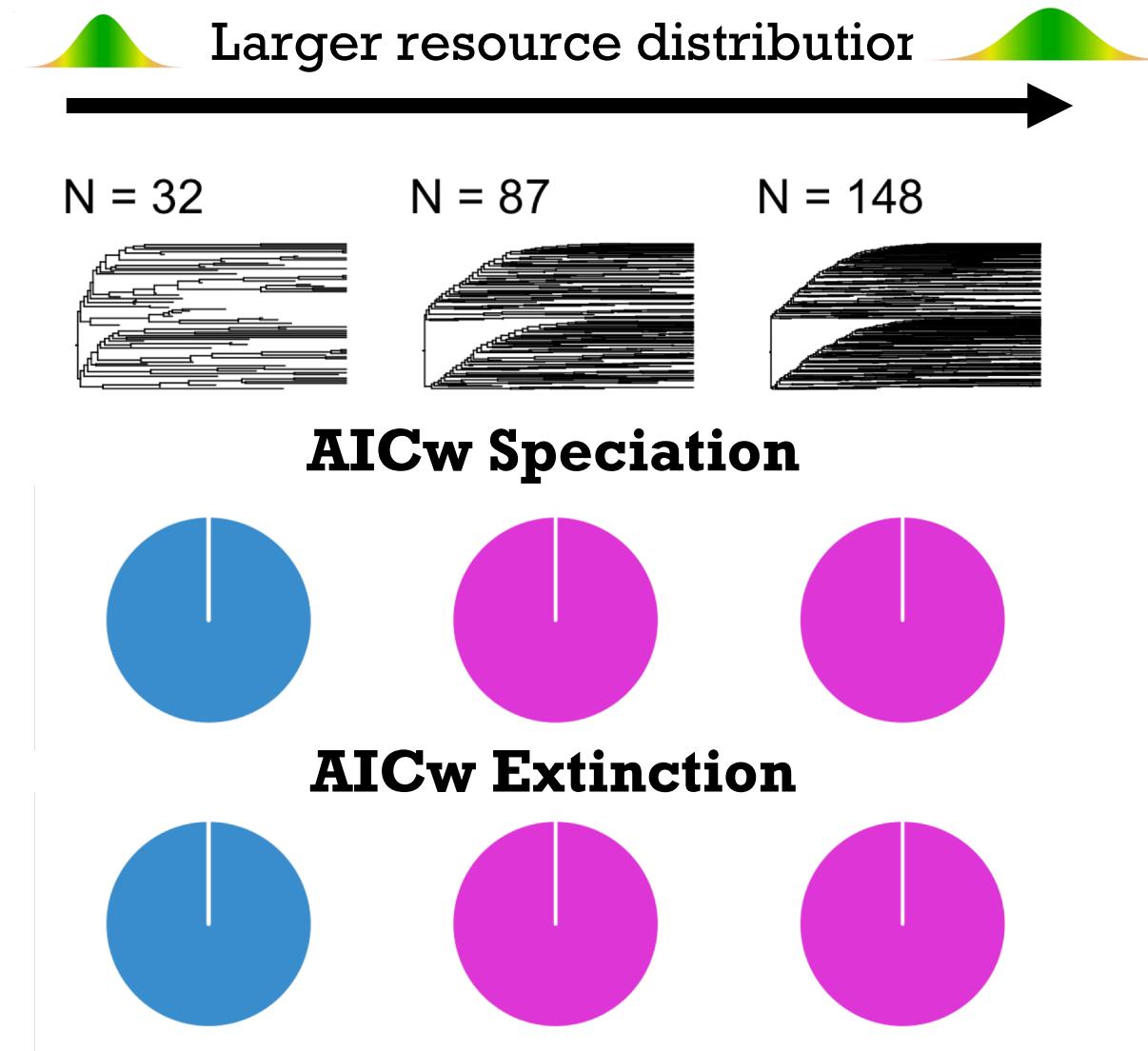
Results - 1. Complete phylogenies

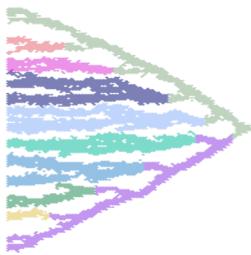
Speciation rate

- Best approximated by exponential or power function
- Explosive branching at low diversity, then linear-like decline

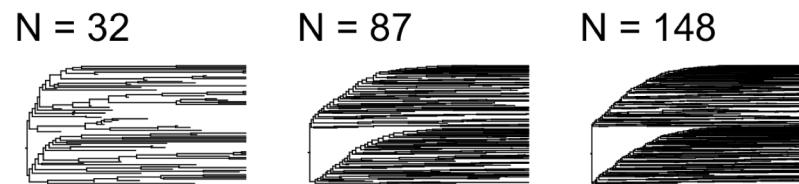
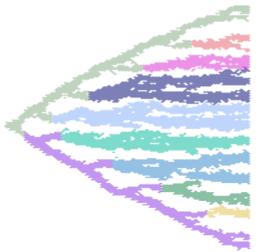
Extinction rate

- Exponential or power function, too
- Extinction diversity-dependent but low relative to speciation (for $N < K$)





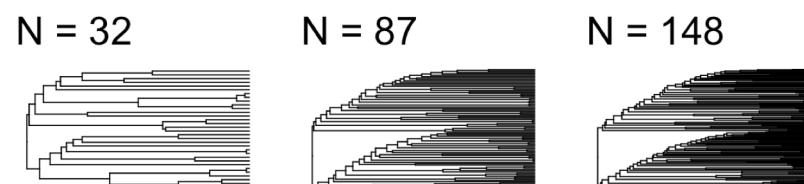
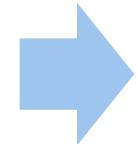
Results – 2. Reconstructed phylogenies



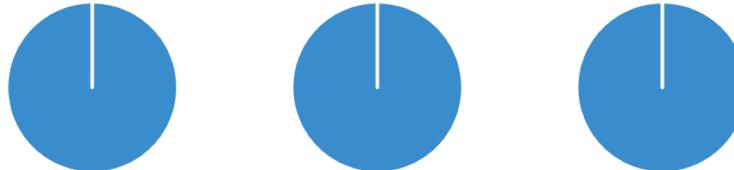
AICw Speciation



AICw Extinction



AICw Speciation



AICw Extinction



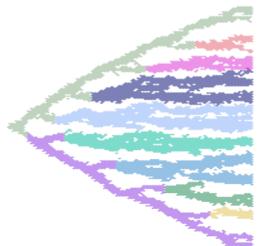
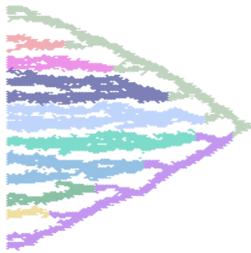
Type of function

Constant

Linear

Power

Exponential



Conclusion – what diversity-dependent model should be used to test for competition-driven diversification?

- Competition-driven diversification best approximated by diversity-dependence with **speciation as a power function of N** – recovered as **exponential** in molecular phylogenies
- At odds with empirical results where **linear diversity-dependence** is most often supported

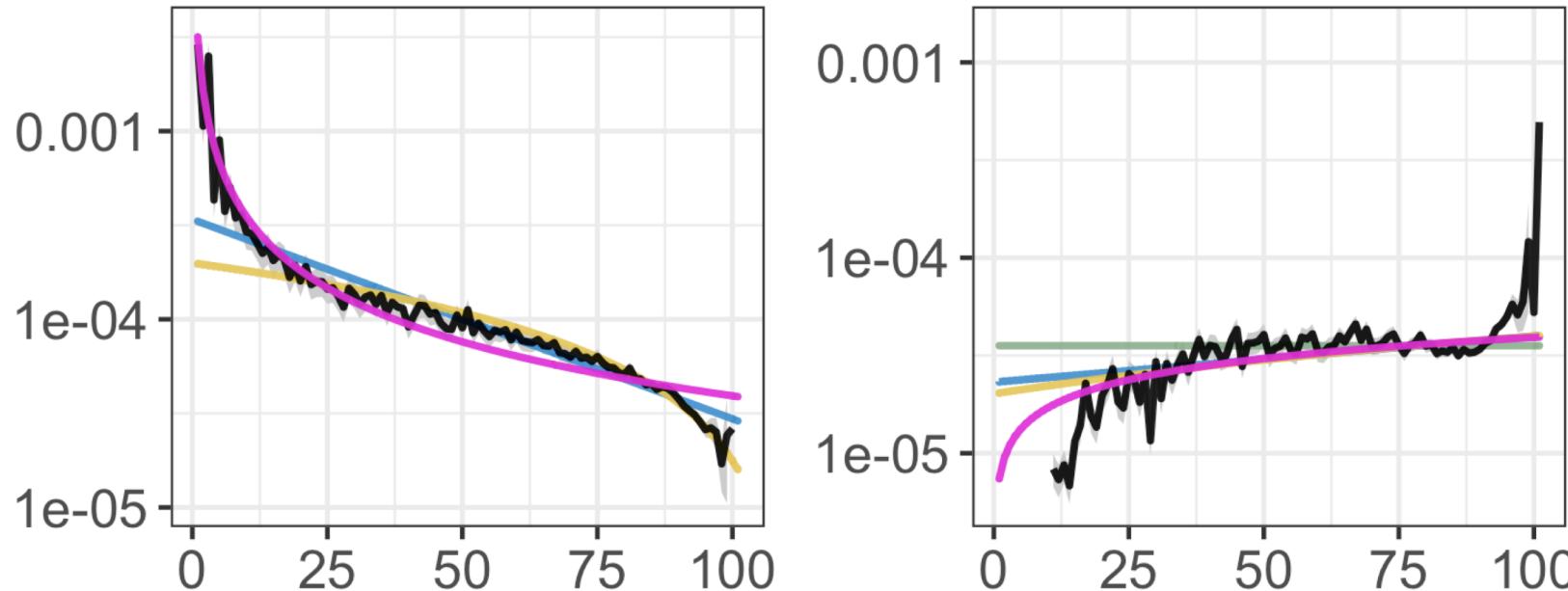
Model description	Form of dependency	Model acronym	Nb. of phylo
Diversity-dependent speciation and constant extinction	linear (on 96 clades)	DDL+E	10
	exponential (on 98 clades)	DDX+E	1

From Condamine, Rolland & Morlon (2019) *Ecol. Lett.*

- Weak diversity-dependence in the extinction rate, can be recovered for “large” phylogenies ($N > 80$ tips?)

Before you go – some perspectives!

1. Simple functions I used here may be missing part of the story – shifts in mode of diversity-dependence?



Rates estimated with:

- Maximum Likelihood
- Maximum
- Direct estimation

2. Gaussian resource distribution produces very balanced trees
Other distributions might produce different speciation-extinction dynamics?

Thank you for stopping by!

Questions?

Want to hear or see more?

Did I miss something?



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[@TheoBranchingOut](https://twitter.com/TheoBranchingOut)

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