The latitudinal gradient of diversification rates in mammals

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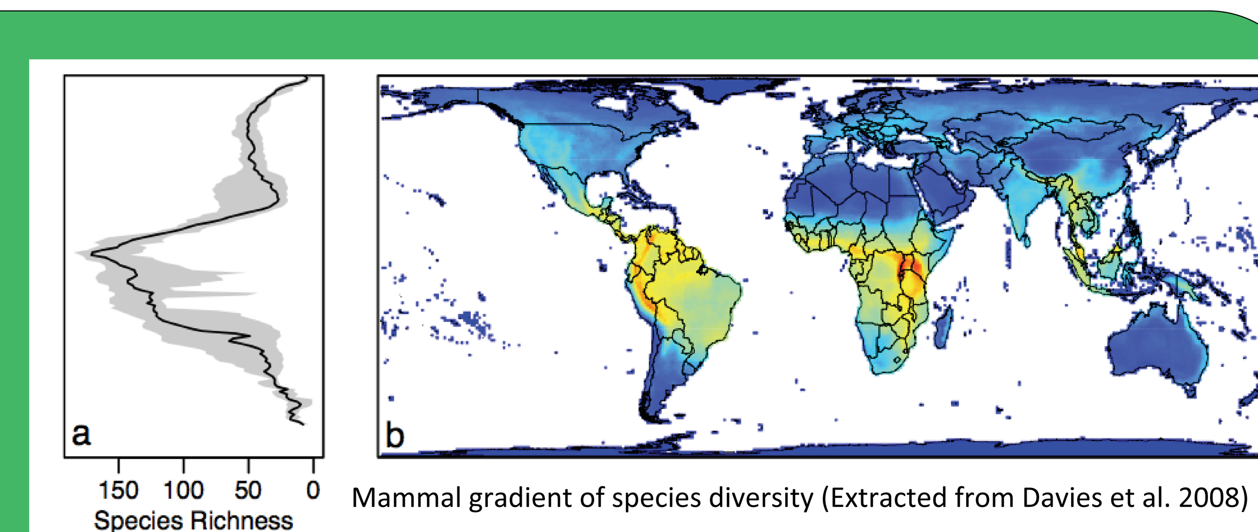
Introduction

The global increase of **species richness** toward the equator, defined as the **latitudinal diversity gradient (LDG)**, has passionate ecologists from the early stage of ecology (Darwin 1859; Wallace 1878).

The LDG is one of the best-known ecological patterns, as it has been described for a **wide variety of living and fossil organisms** (e.g. bacteria, Fuhrman et al. 2008; birds, Ricklefs 2006; butterflies, Condamine et al. 2012; foraminifera Ezard et al. 2011; frogs, Wiens et al. 2009, 2011; marine bivalves, Jablonski et al. 2006).

Nonetheless, it also remains one of the most mysterious patterns because consensus on the causal explanations is lacking.



Mammal gradient of species diversity (Extracted from Davies et al. 2008)

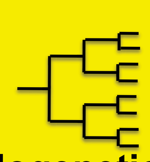
Hypothesis

LDG may be explained by variations in **diversification rates (Speciation – Extinction rates).**

We aim to answer two particular questions: **(i)** are mammal **diversification rates higher in the tropics** than in temperate biomes?
(ii) how do rates of **speciation** and **extinction** contribute to this pattern?

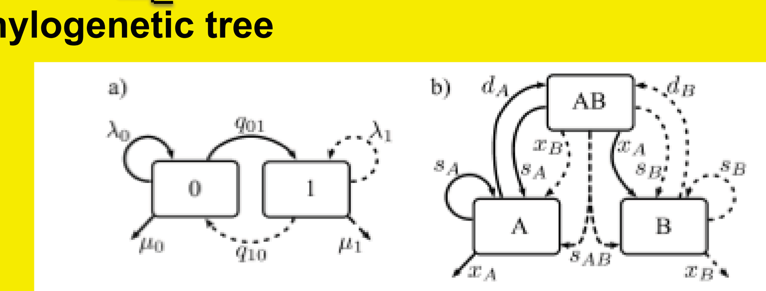
Material and Methods

We used **latitude data** from the scientific literature (Jones 2009). We then categorized each species as either living in tropical (**<25° latitude**) or temperate biome (>25° latitude) or both, and compiled these data with virtually complete molecular dated phylogeny of 5020 mammal species (Bininda Emonds 2007) to run the diversification analyses.



Phylogenetic tree + **Latitudinal data** → **Speciation, extinction, and transition rates estimations**

We first analyzed the data mapped upon the phylogeny by comparing the fit of 8 evolutionary models using a maximum-likelihood approach: GeoSSE (Goldberg 2011) or to be estimated, with separate rates for temperate regions and tropics. The best-fitting model were found according to the Likelihood Ratio Test (LRT) and the Akaike Information Criterion (AIC), which accounts for the number of parameters used in the model as well as the goodness of fit to the data.

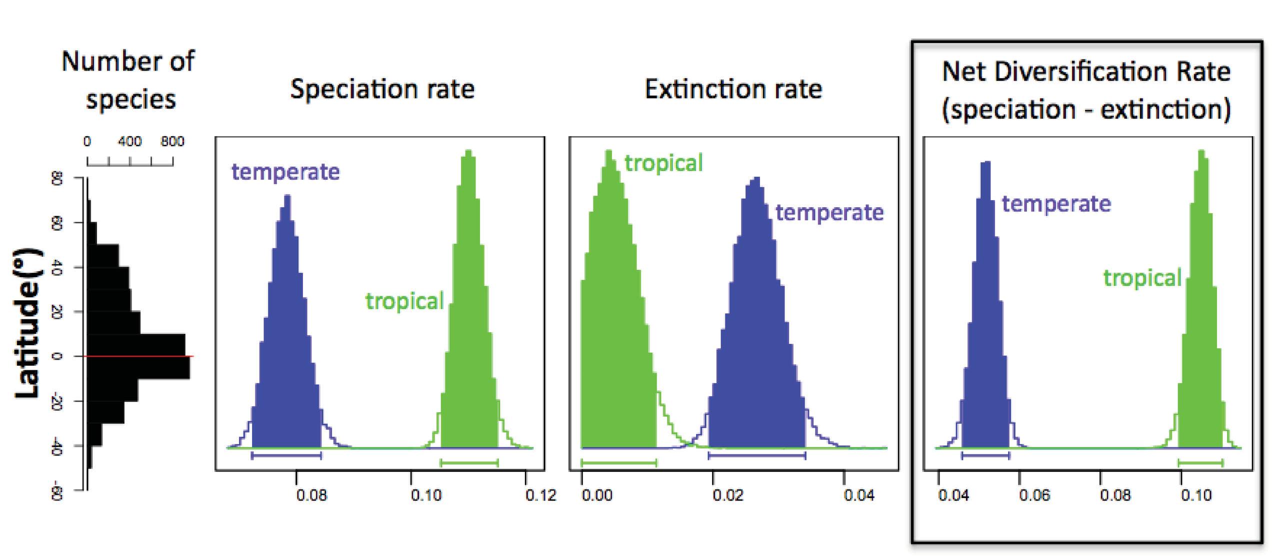


Parameters of BiSSE and GeoSSE models

20 000 steps **MCMC** → distribution of the parameters

Results

Global estimates for mammals (5417 spp.)

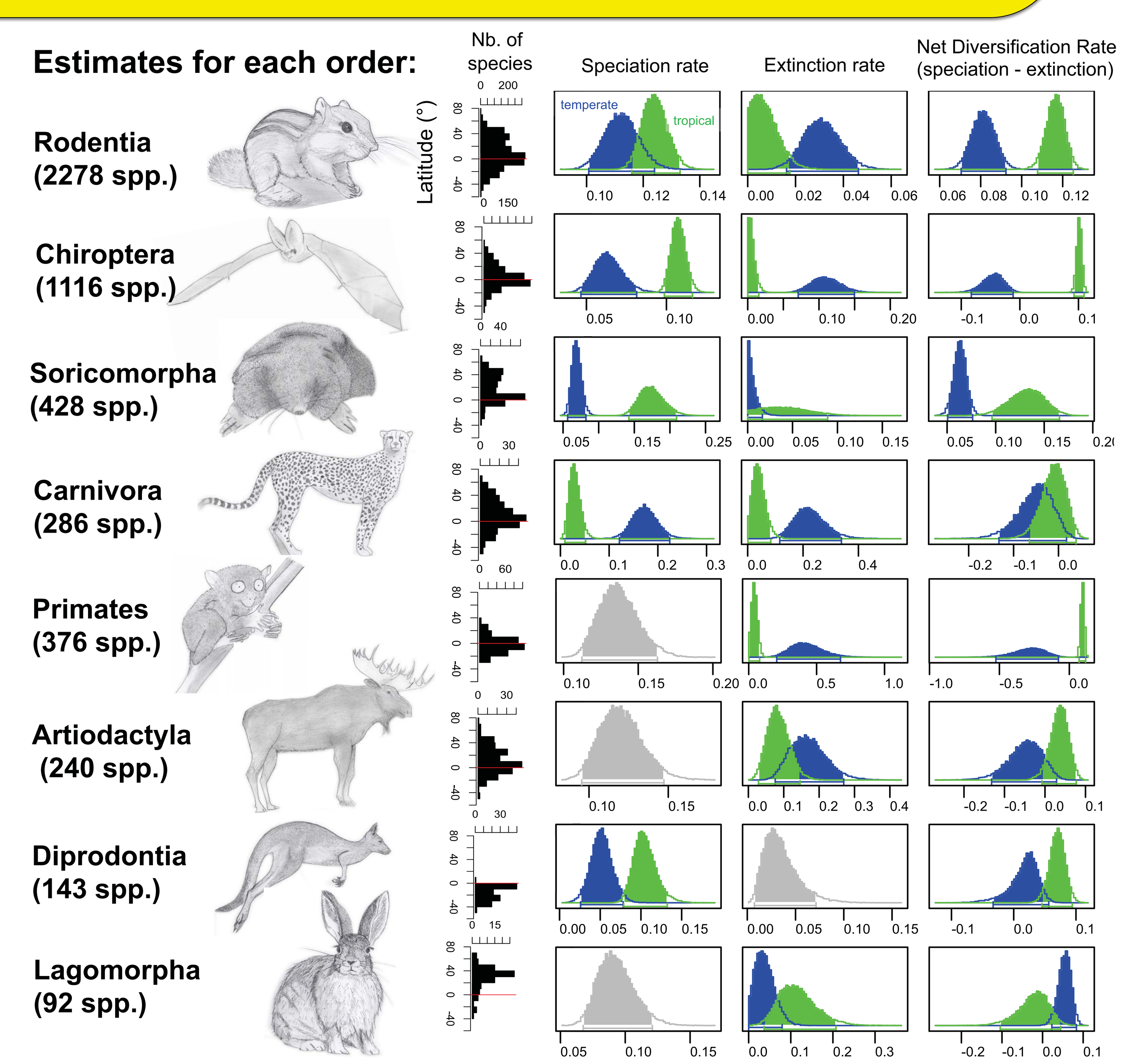


Using the collection of latitudinal data, we first confirmed that mammals show a striking **increase of diversity at low latitude**. 55% of the species were tropical, 21% were temperate and 24% were distributed in both regions.

Concerning diversification analyses, according to the LRT and the AIC, the model for which **speciation rate** and **extinction rate varied between biomes** was the best.
(I) Diversification rates were **twice higher in tropical regions** than in temperate regions.
(ii) We observed that **speciation rates** was **higher in the tropics** and contributed to 60% of the difference in diversification rates, while **extinction** rates were **higher in temperate regions** than in tropical regions and contributed to 40% of the difference .

All the orders show a LDG with more species occurring in tropical areas except the Lagomorpha, which have an inverse LDG (temperate regions harbor more species). We show that these peaks of diversity are maily driven either by an **increase of diversification rates** mainly due to **low extinction rates** (Artyodactyla, Primates, Lagomorpha and Carnivora) or **high speciation rates** (Diprodontia and Soricomorpha) or **both** (Chiroptera and Rodentia).

Estimates for each order:



Conclusion

High speciation in tropical regions and high extinction rates in temperate regions are underlined as ones of the major drivers of the mammal diversity associated with latitude. Diversification rate hypothesis has been shown to be a good candidate for explaining the latitudinal gradient of mammal diversity. Also, several drivers may act in concert to shape diversification and build the gradient. In the future, scientist will have to focus both on the understanding of the biogeographical history of mammals and the proximal factors (as temperature, precipitation or seasonality) acting directly on their diversification.

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