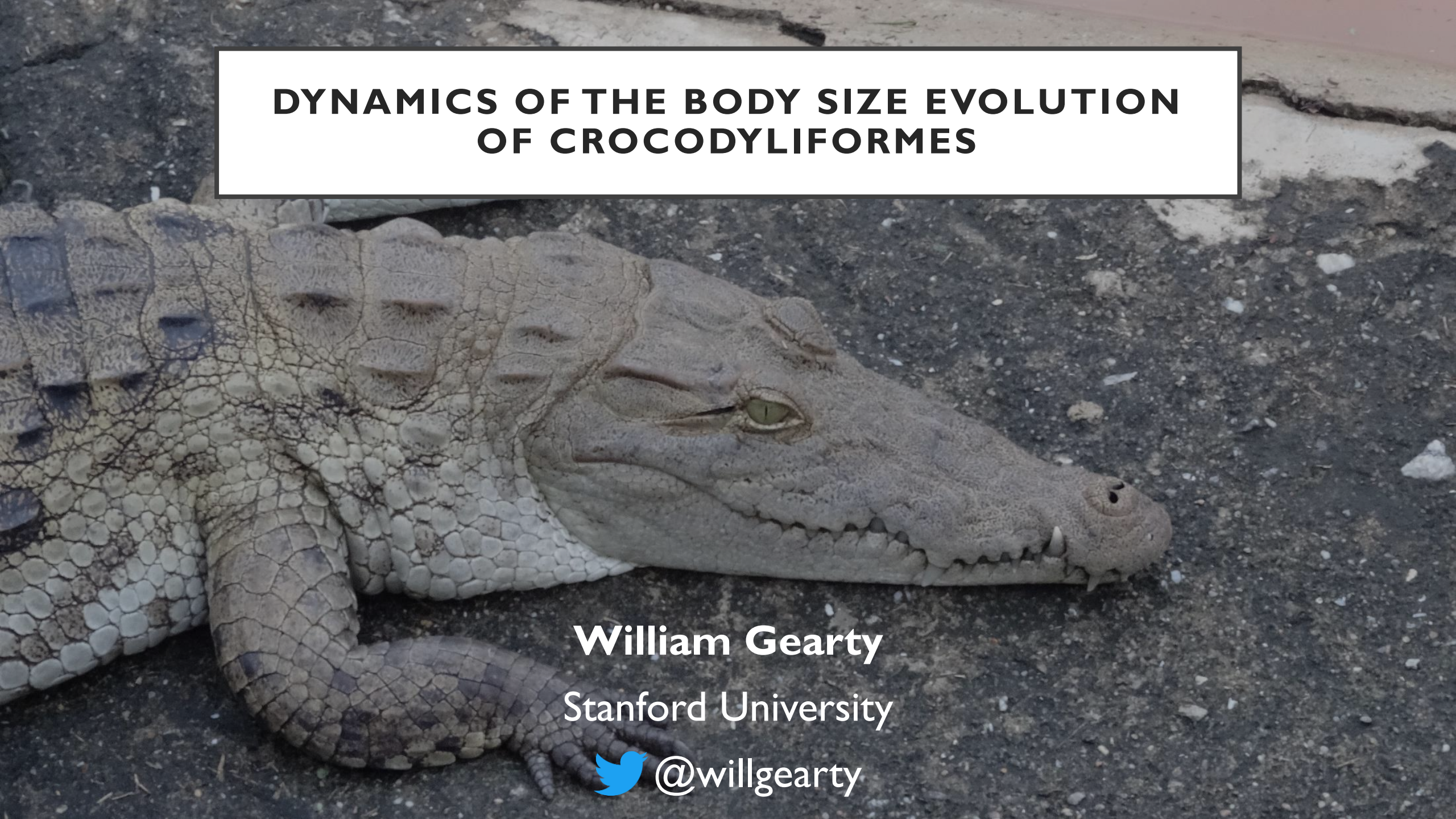

DYNAMICS OF THE BODY SIZE EVOLUTION OF CROCODYLIFORMES

William Gearty

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en.wikipedia.org

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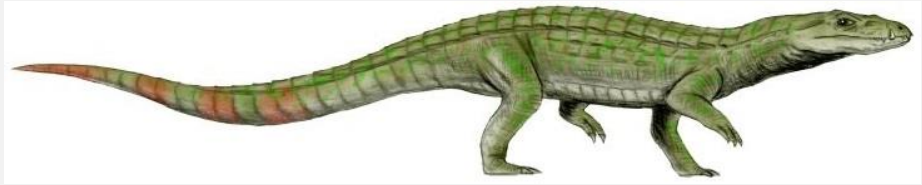
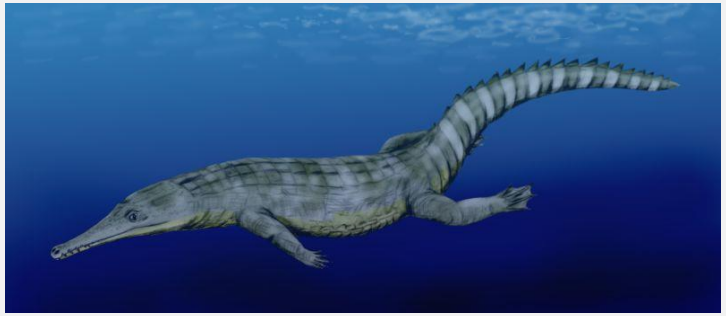
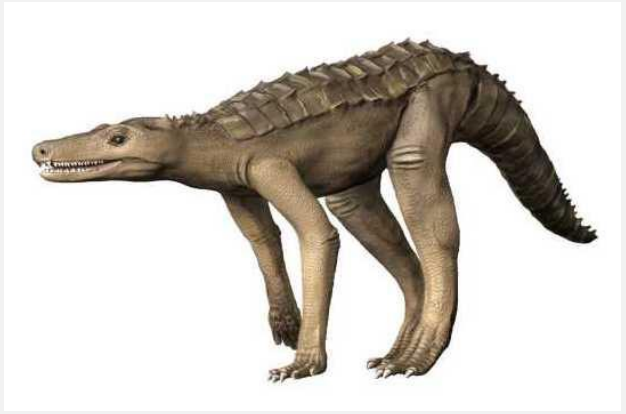
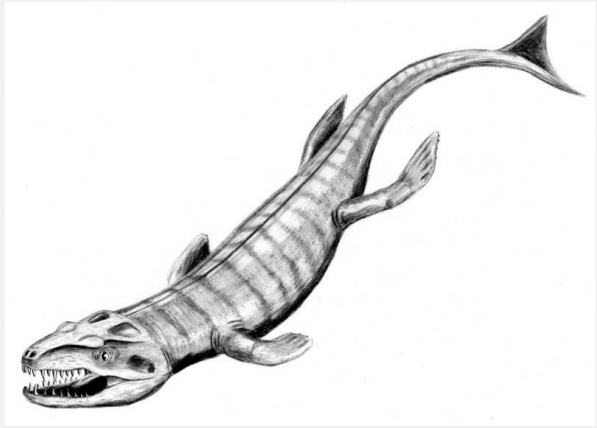
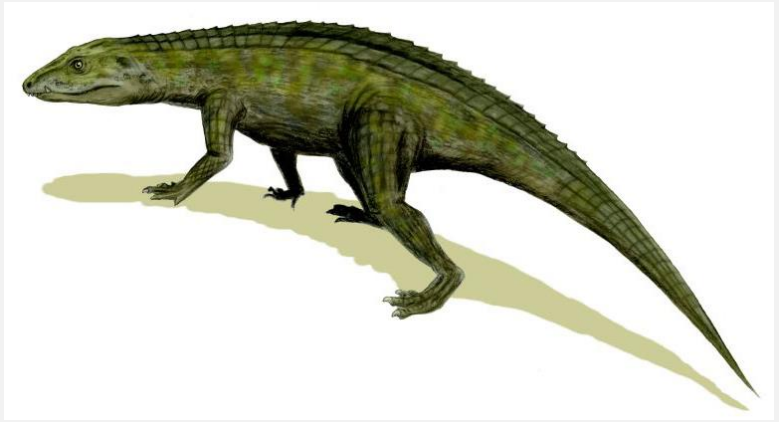
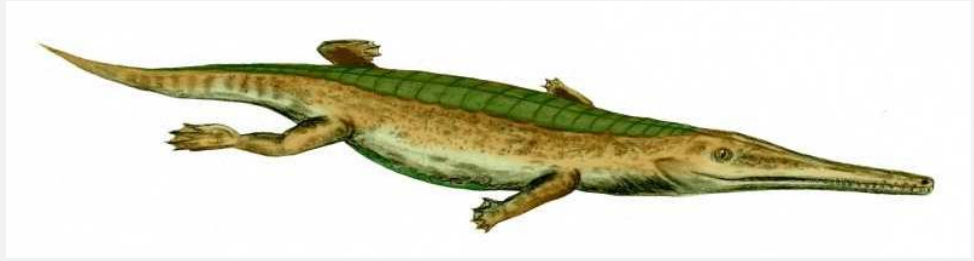


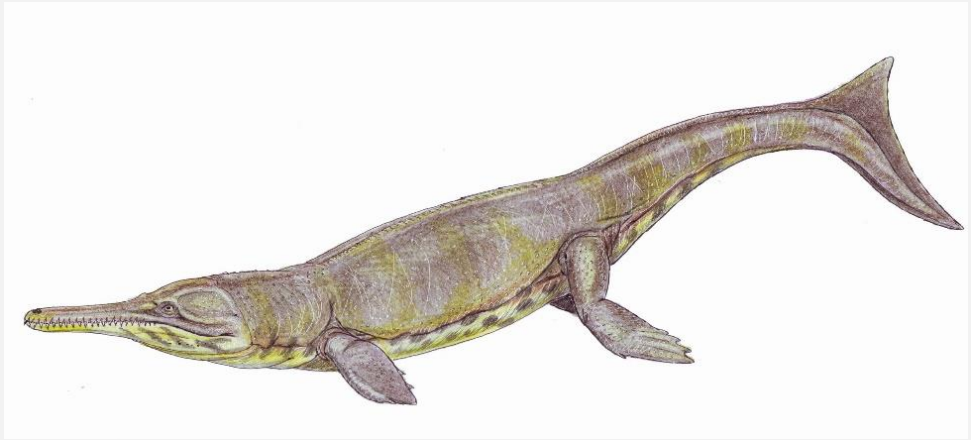










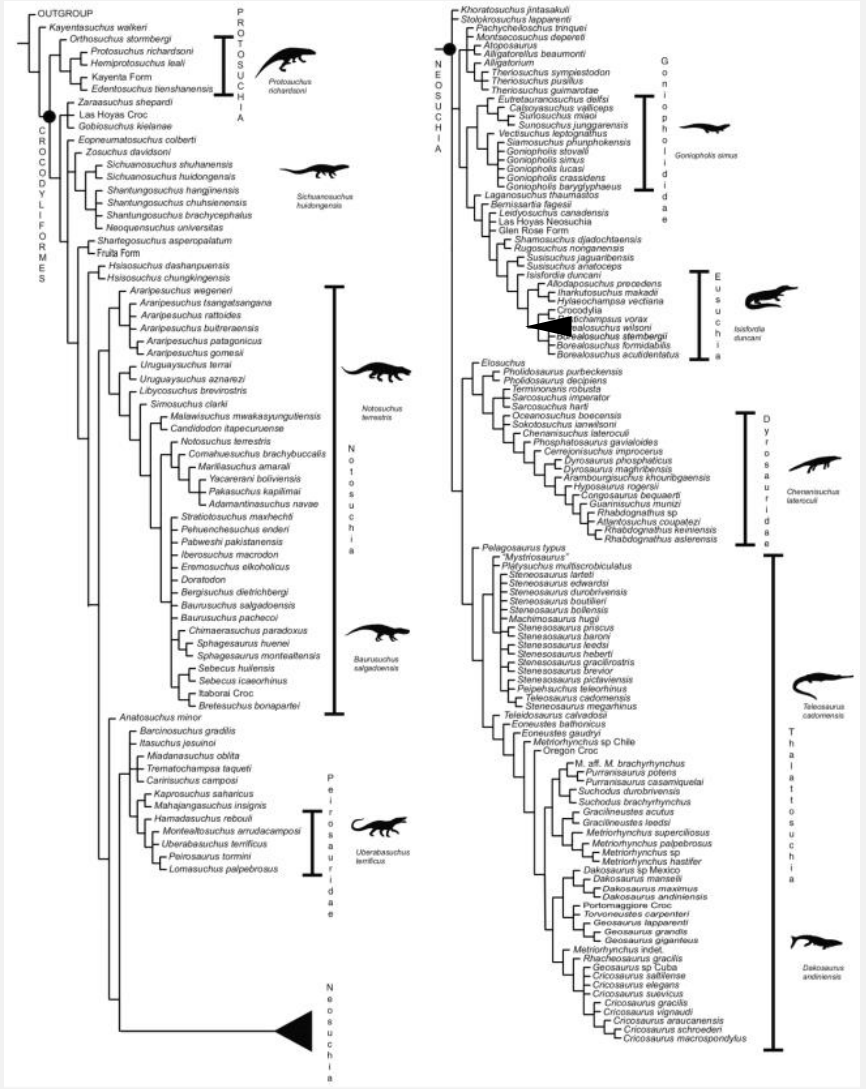


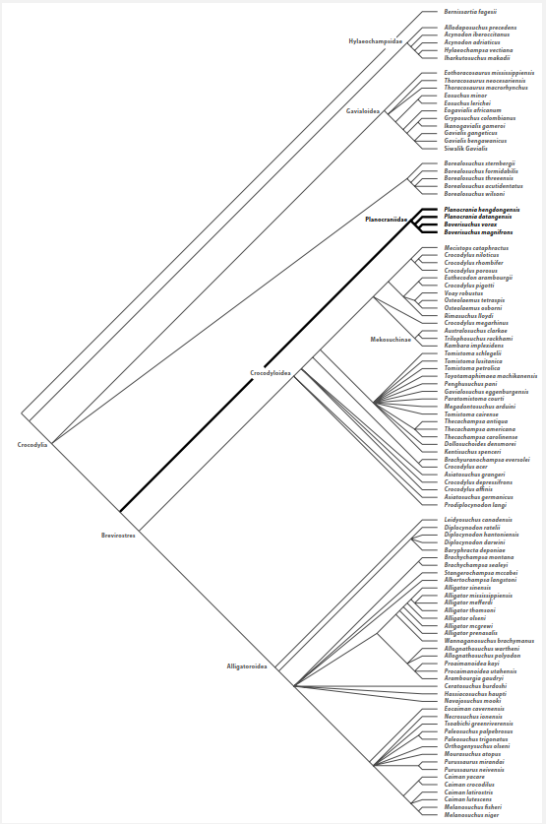
MATERIALS

- Body Size Data
  - Measured skulls and femurs from primary literature
  - Scaling equations
    - Farlow et al. 2005 (femur length, etc.)
    - Young et al. 2011 (cranial length)
- Habitat Codings (Terrestrial vs. Diving)
  - Primary literature/compendia
- Range data
  - Paleobiology Database
  - Primary literature/compendia
  - Martin et al. 2014 (marine croc diversity through time)

MATERIALS

- Supertree
  - 329 species
  - Have size and range data for ~250

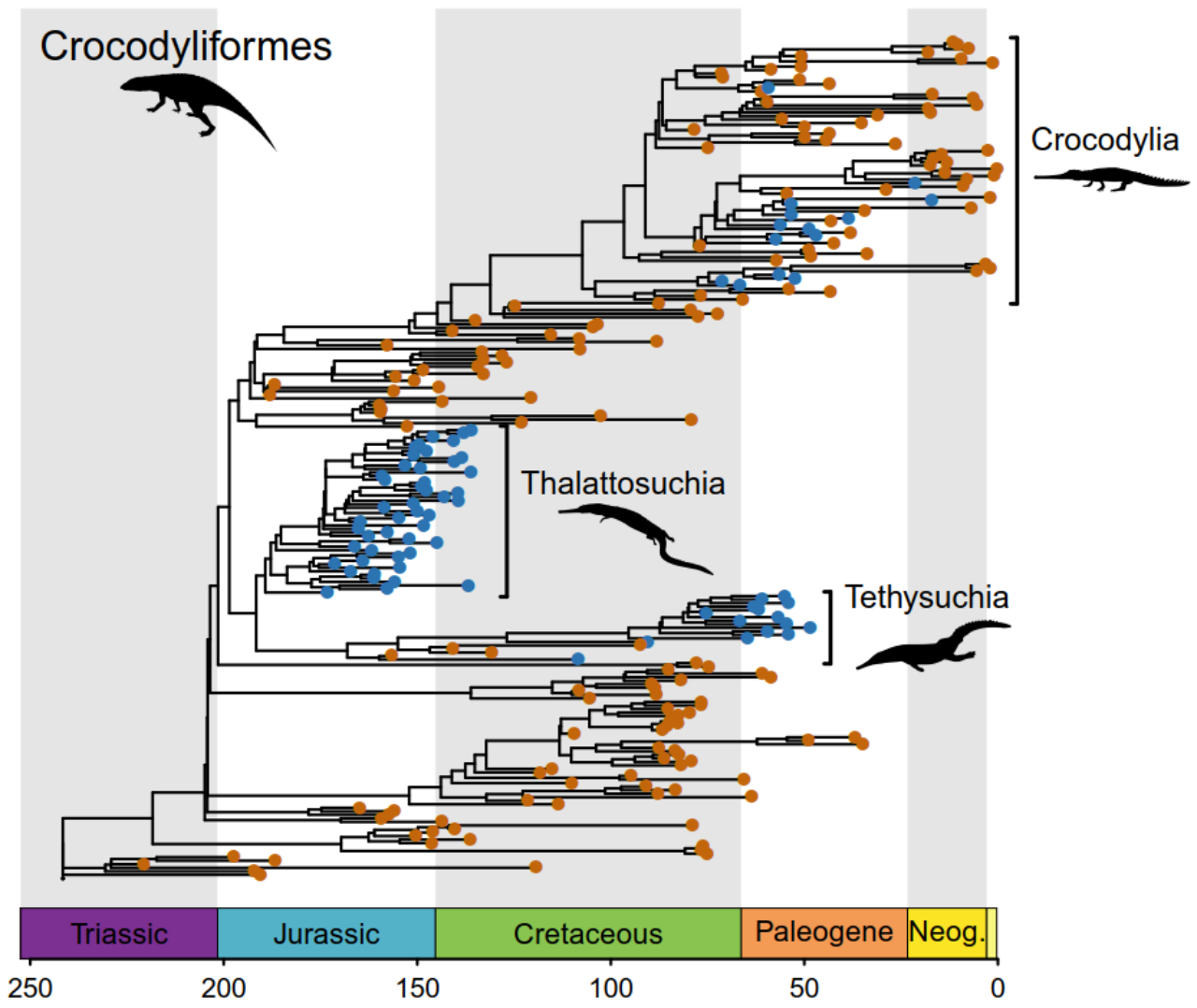


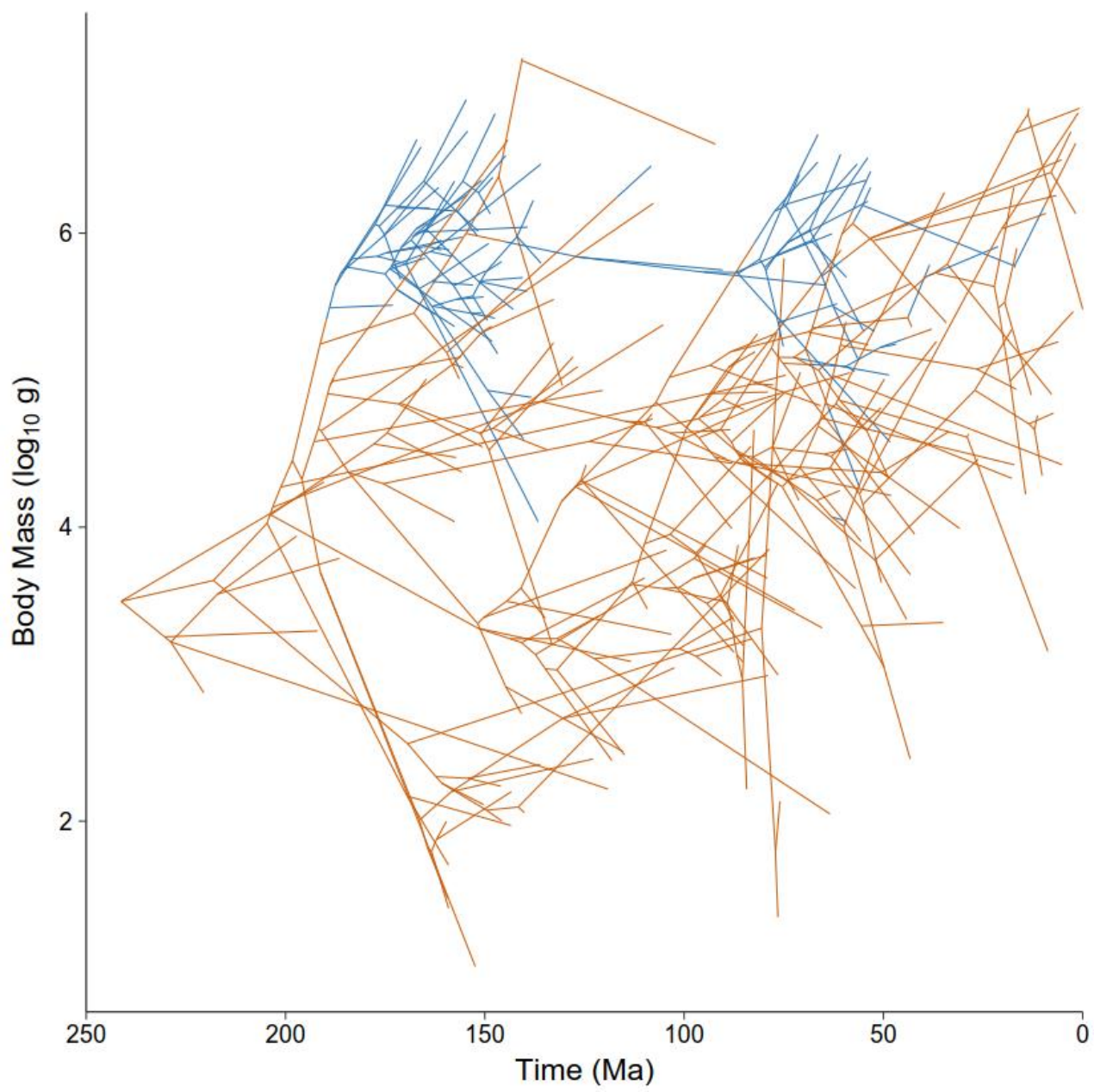


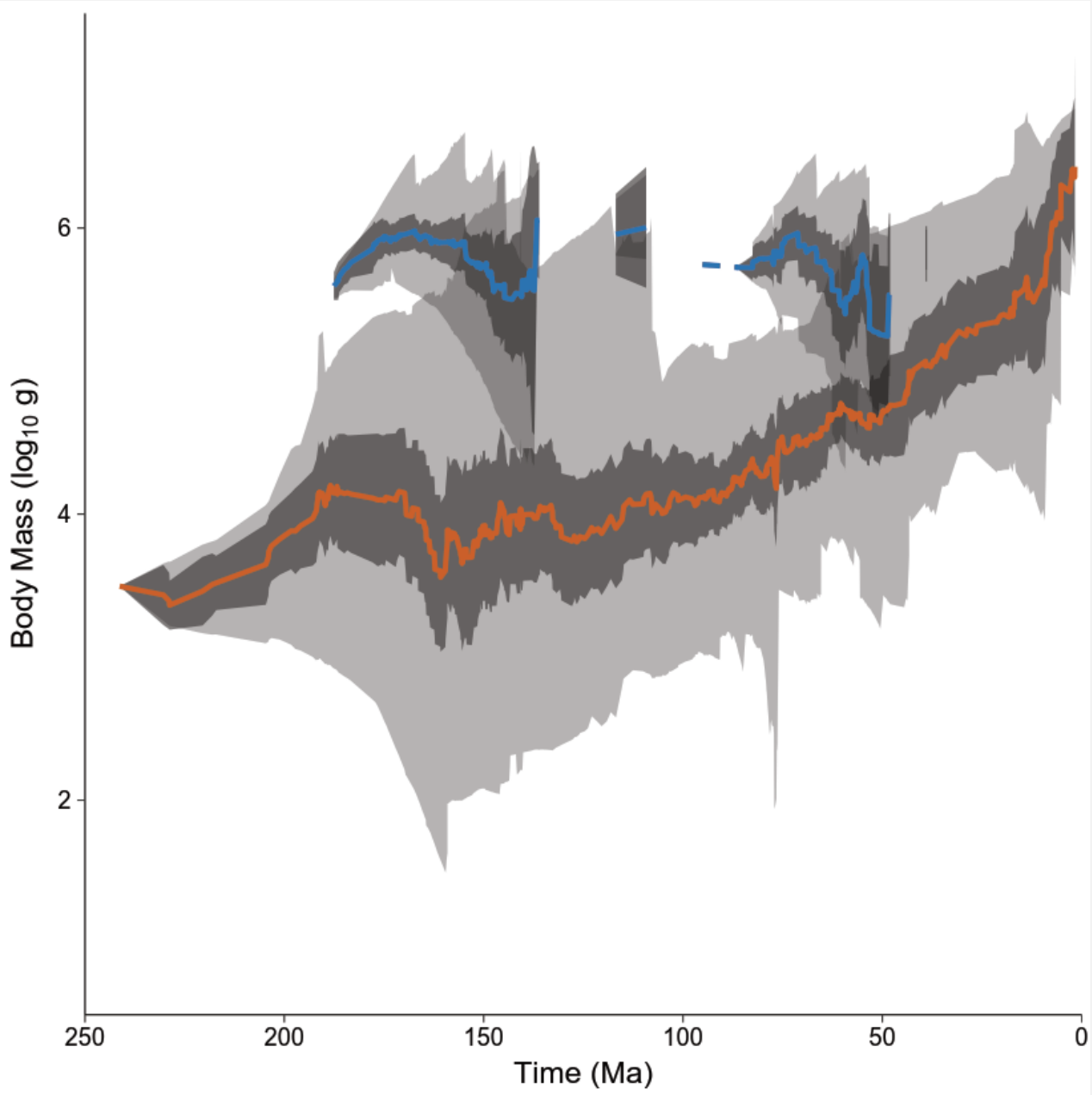
Bronzati et al. 2012, *Hist. Bio.*
Brochu 2012, *Earth Environ. Sci. Trans. R. Soc. Edinburgh*

METHODS

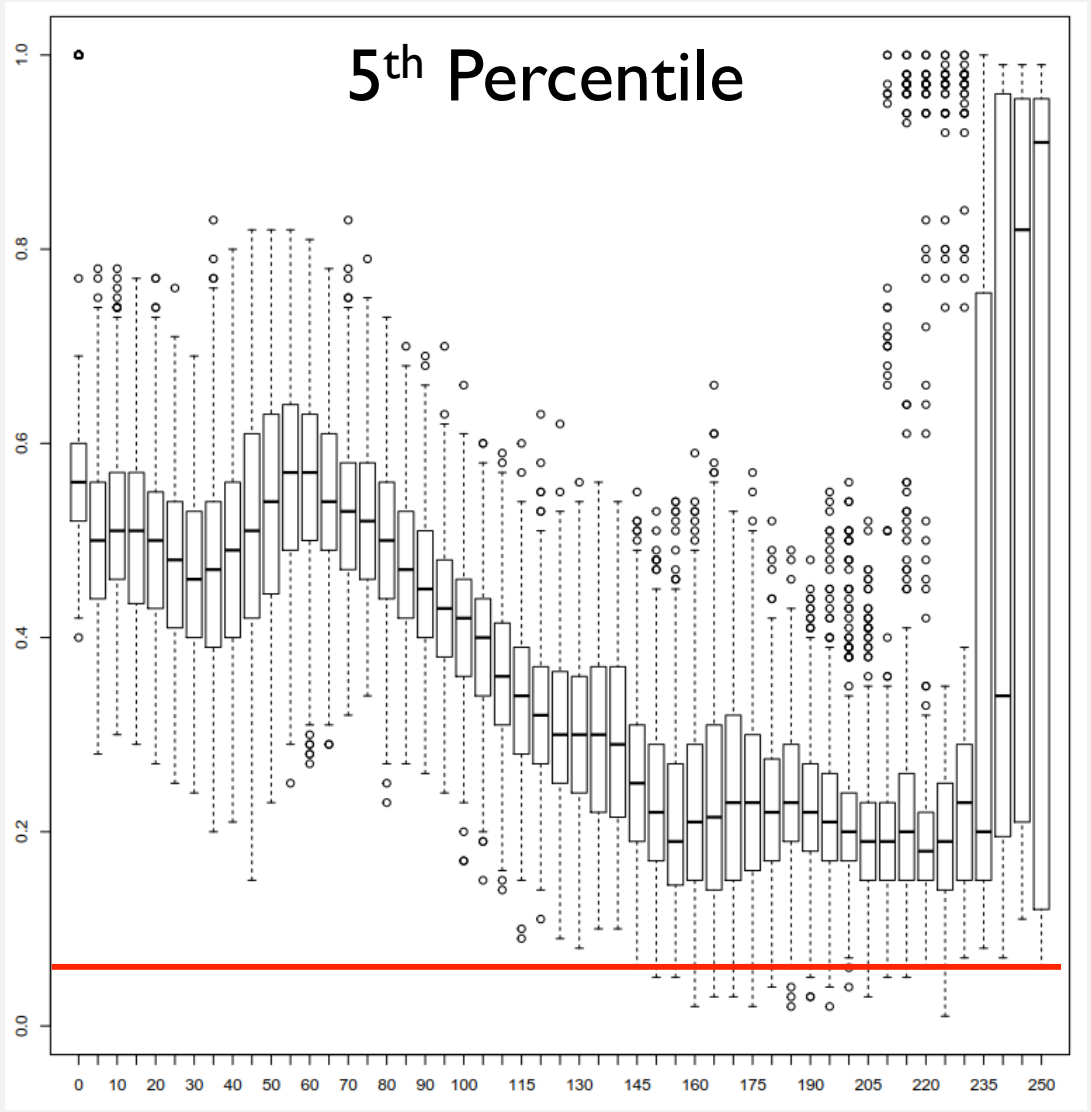
- Time-scaled supertree using character-less tip-dating in MrBayes using fossil lineage ages as constraints (thanks Dave Bapst!)

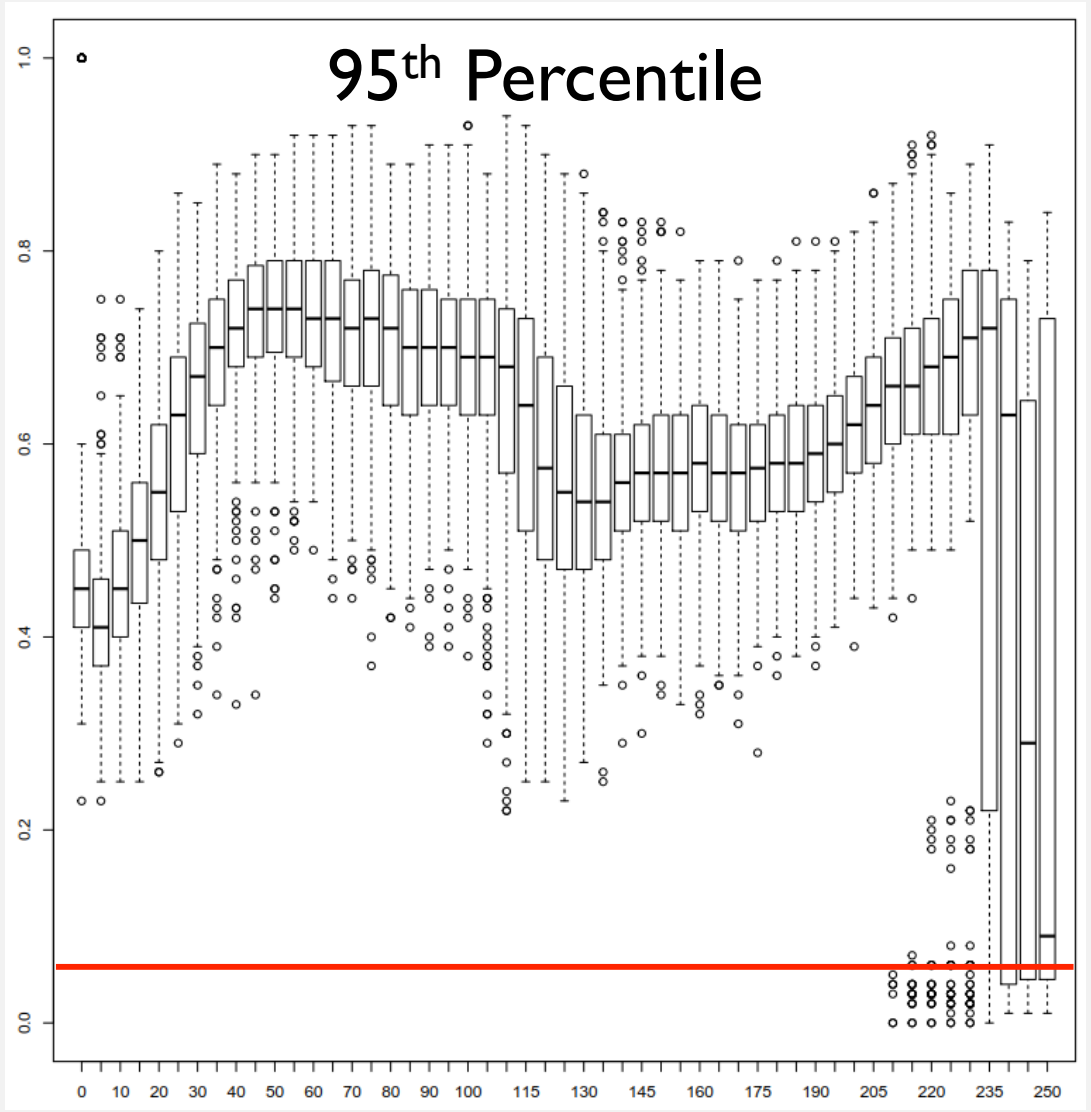



Body Mass (log10 g)
6
4
2
250
200
150
100
50
0
Time (Ma)


Body Mass (log10 g)
6
4
2
250
200
150
100
50
0
Time (Ma)

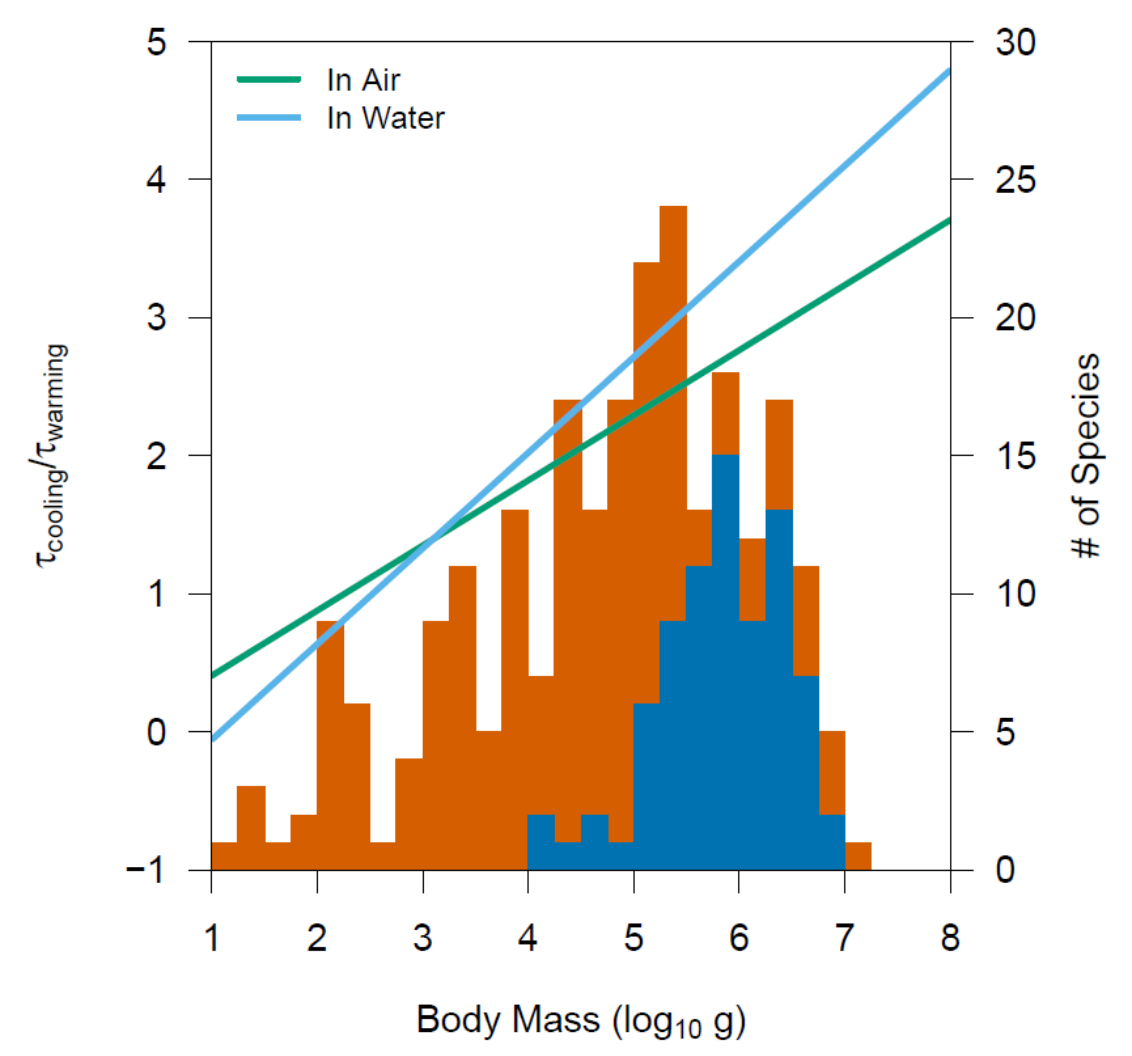
COPE'S RULE?



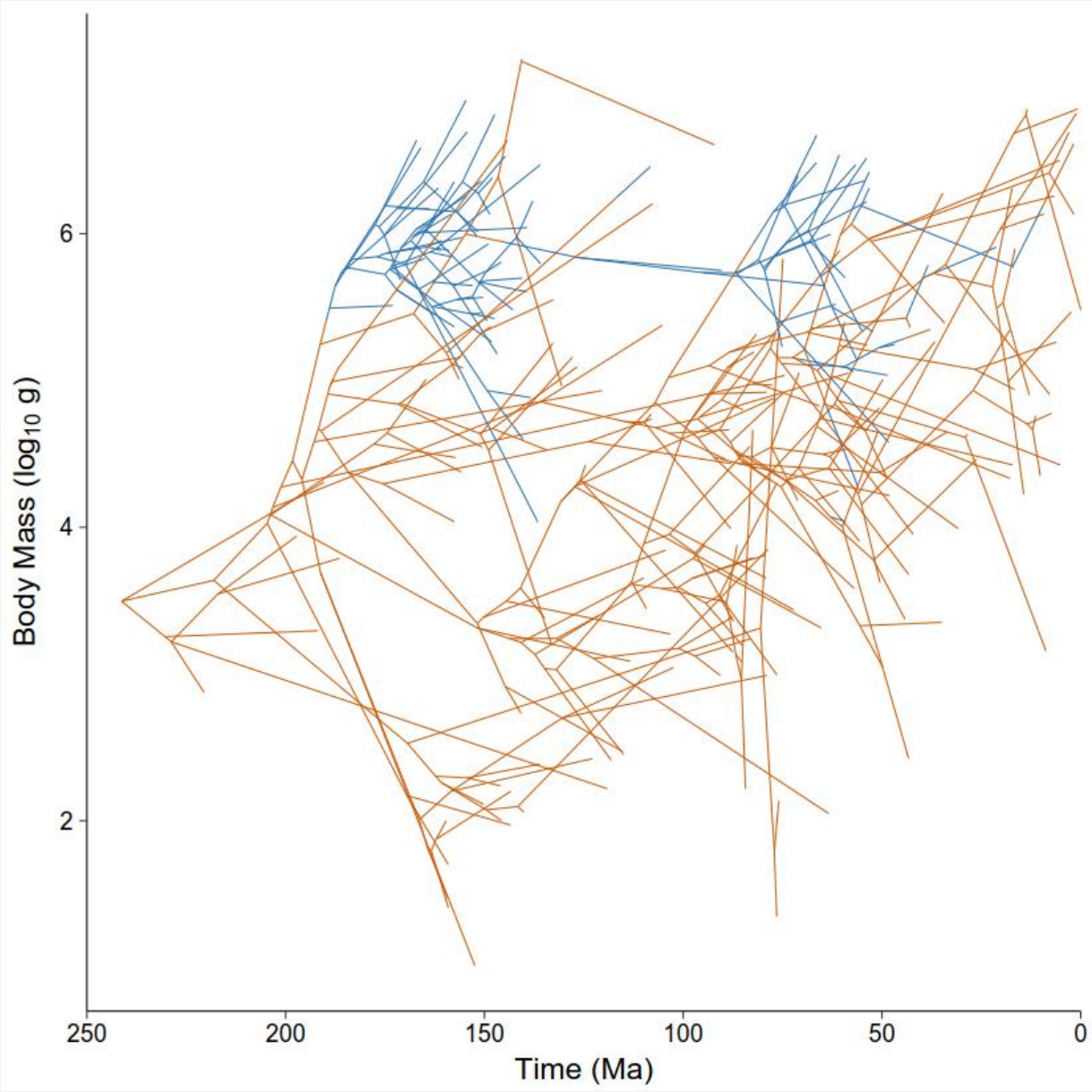


Time Since Root

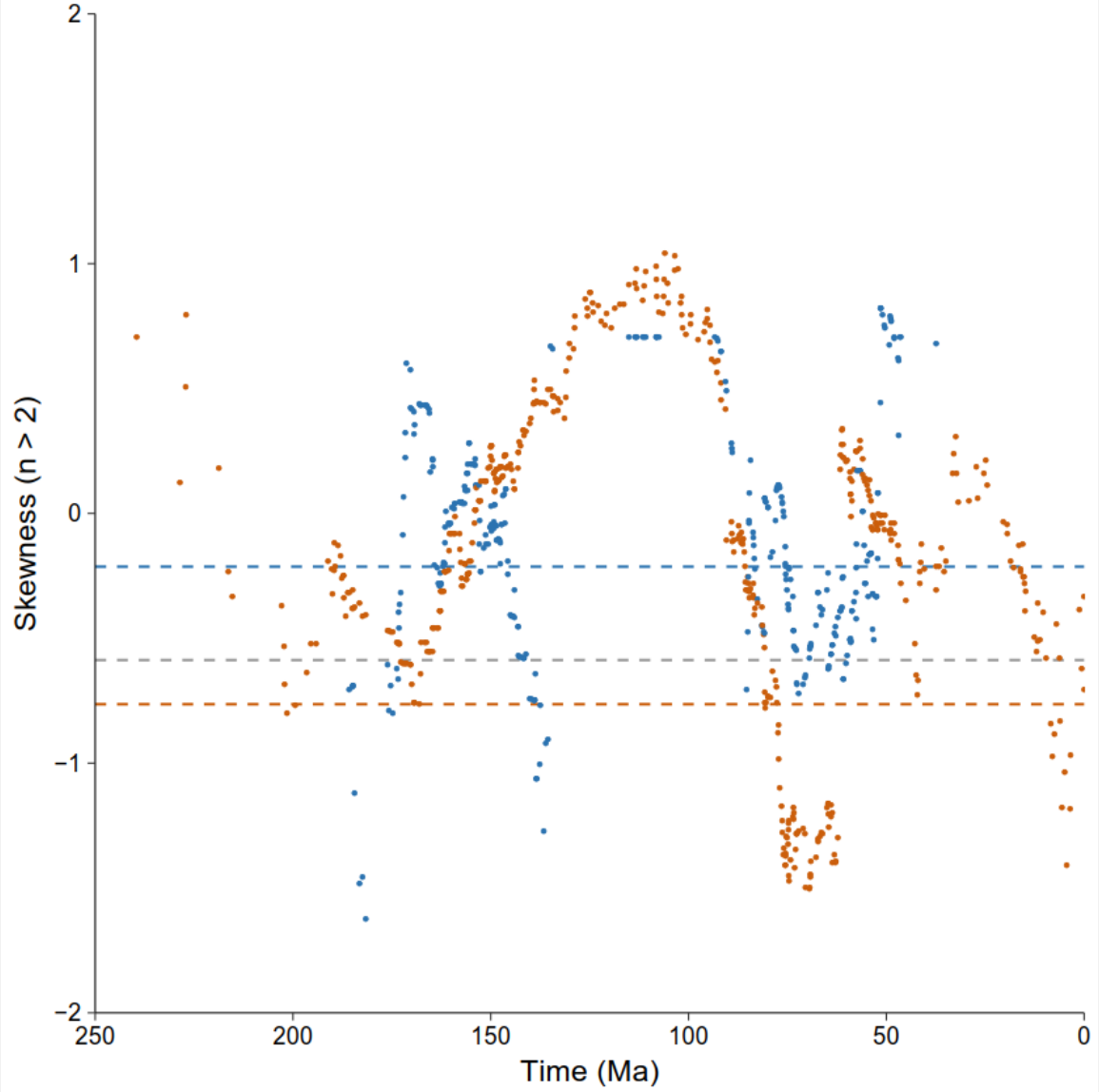
LEFT SKEWED IN AGGREGATE



SKEWNESS THROUGH TIME?

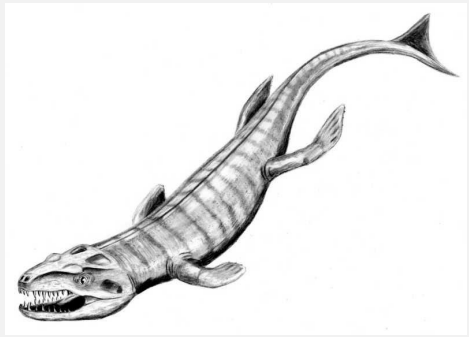


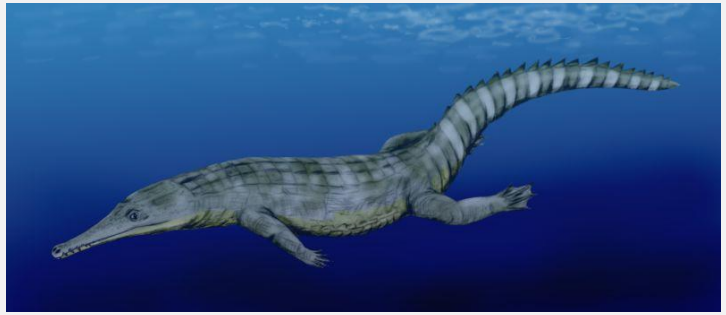
SKEWNESS VARIES THROUGH TIME

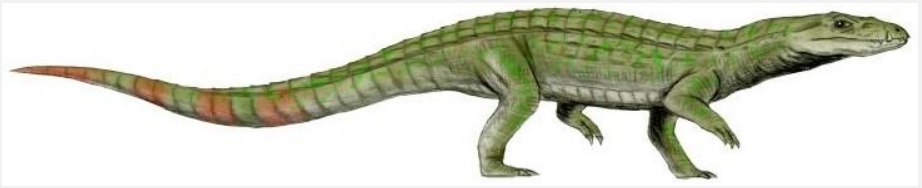


Aggregate Aquatic

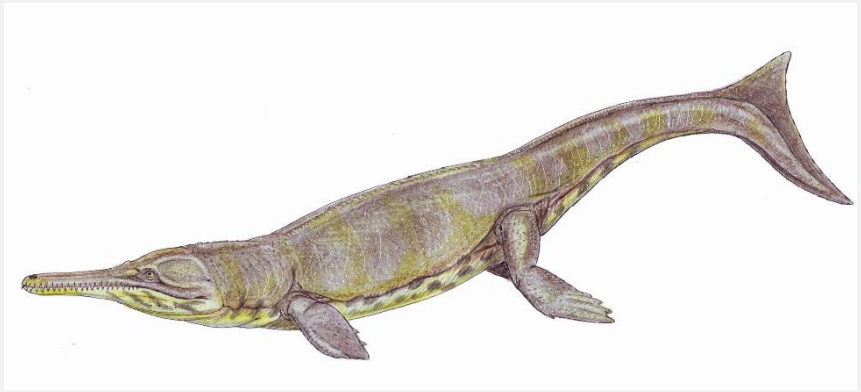
Aggregate All
Aggregate Terrestrial

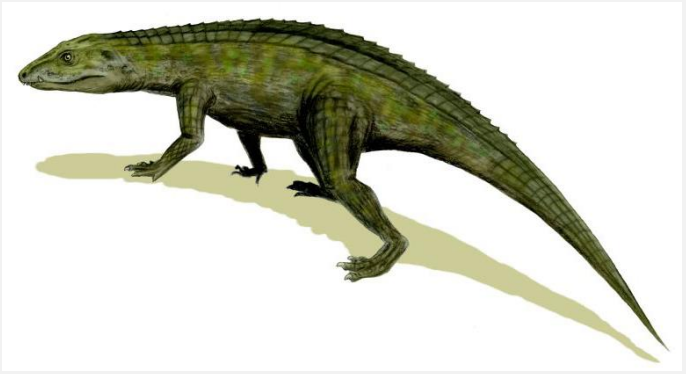


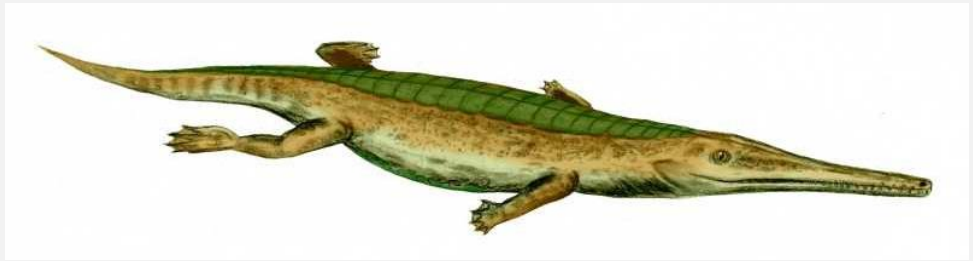


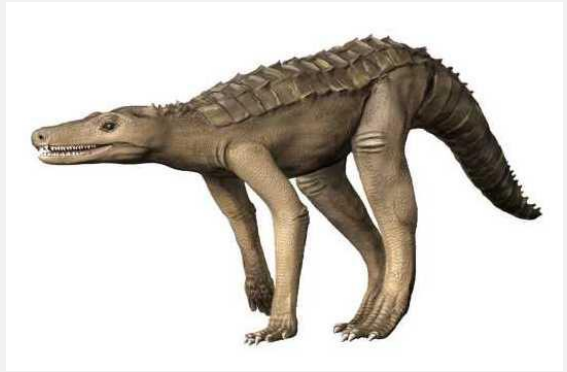


VS.



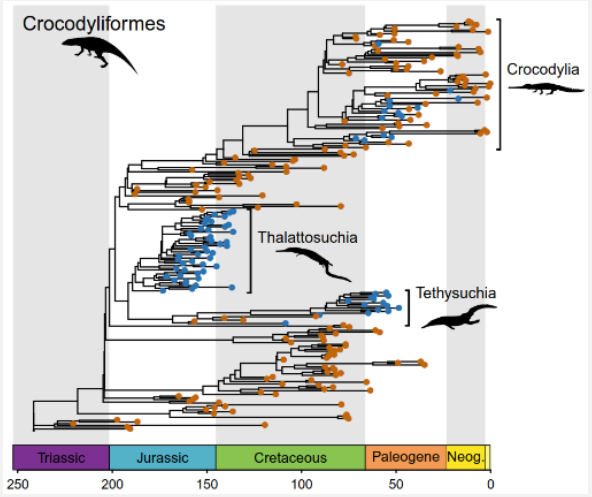


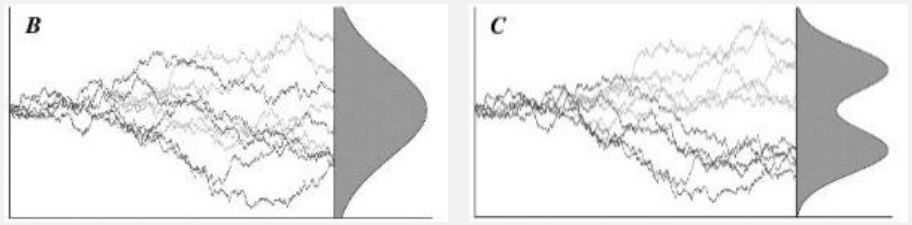




MODEL FITTING

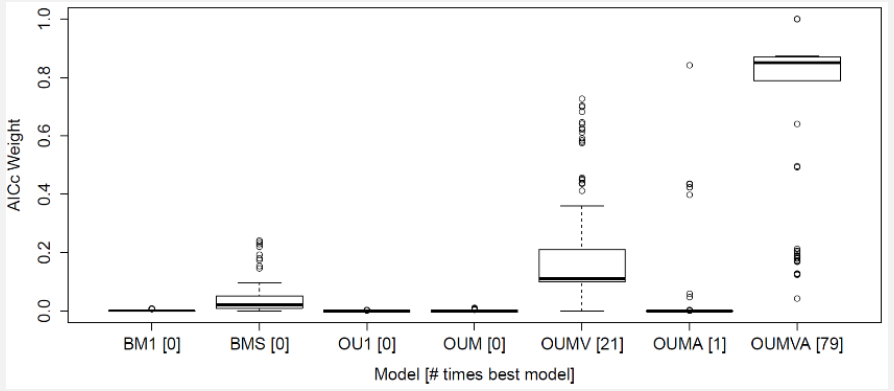
x100





Random evolution Adaptive evolution

OUwie



PARAMETER ESTIMATES

Body Size Optimum (θ)

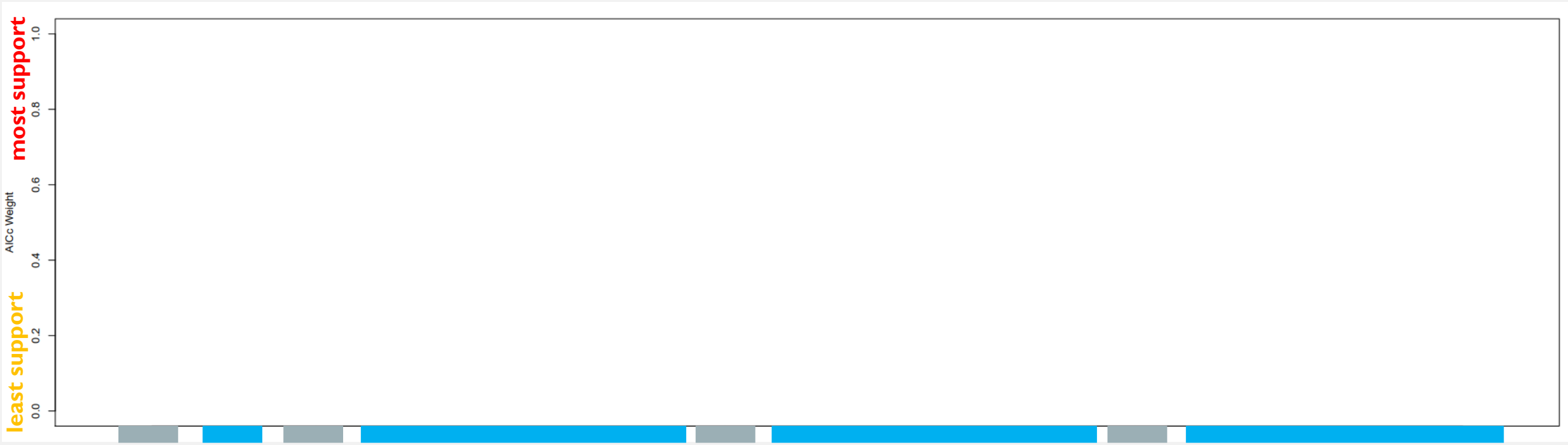
Phylogenetic Half-life ($ln(2)/\alpha$)

Stationary Variance ($\sigma^2/2\alpha$)

OUwie: Beaulieu et al. 2012, *Evolution*

MODEL SUPPORT

Random evolution | Adaptive evolution



All together

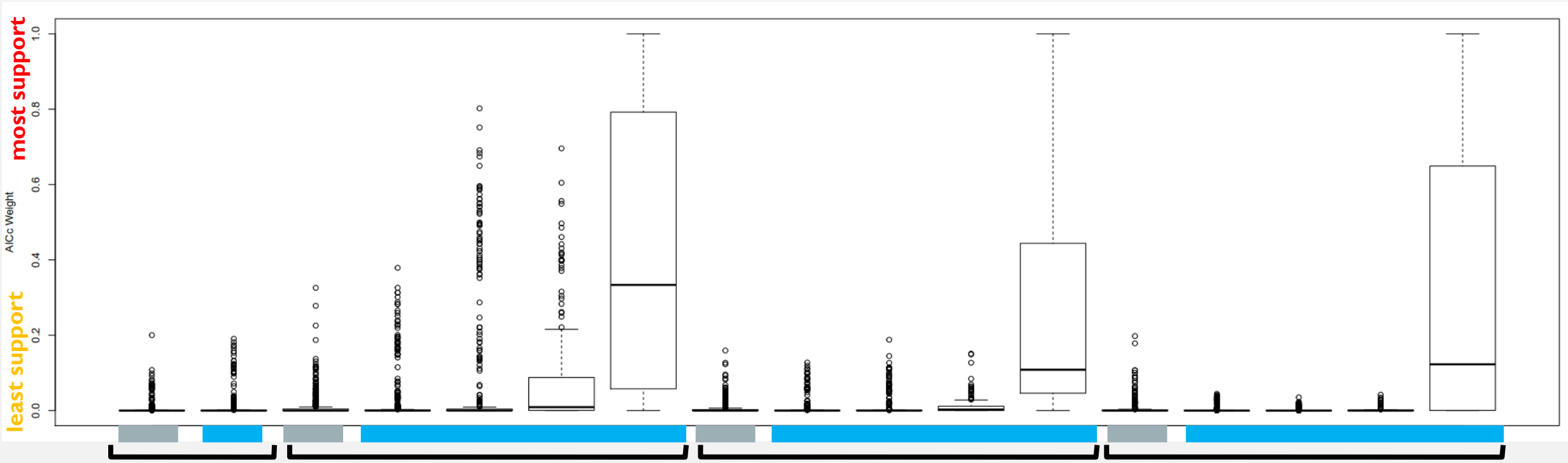
All Divers
vs.
All Terrestrial

Mesozoic Divers
vs.
Cenozoic Divers
vs.
Terrestrial

All regimes
separate

MODEL SUPPORT

Random evolution | Adaptive evolution



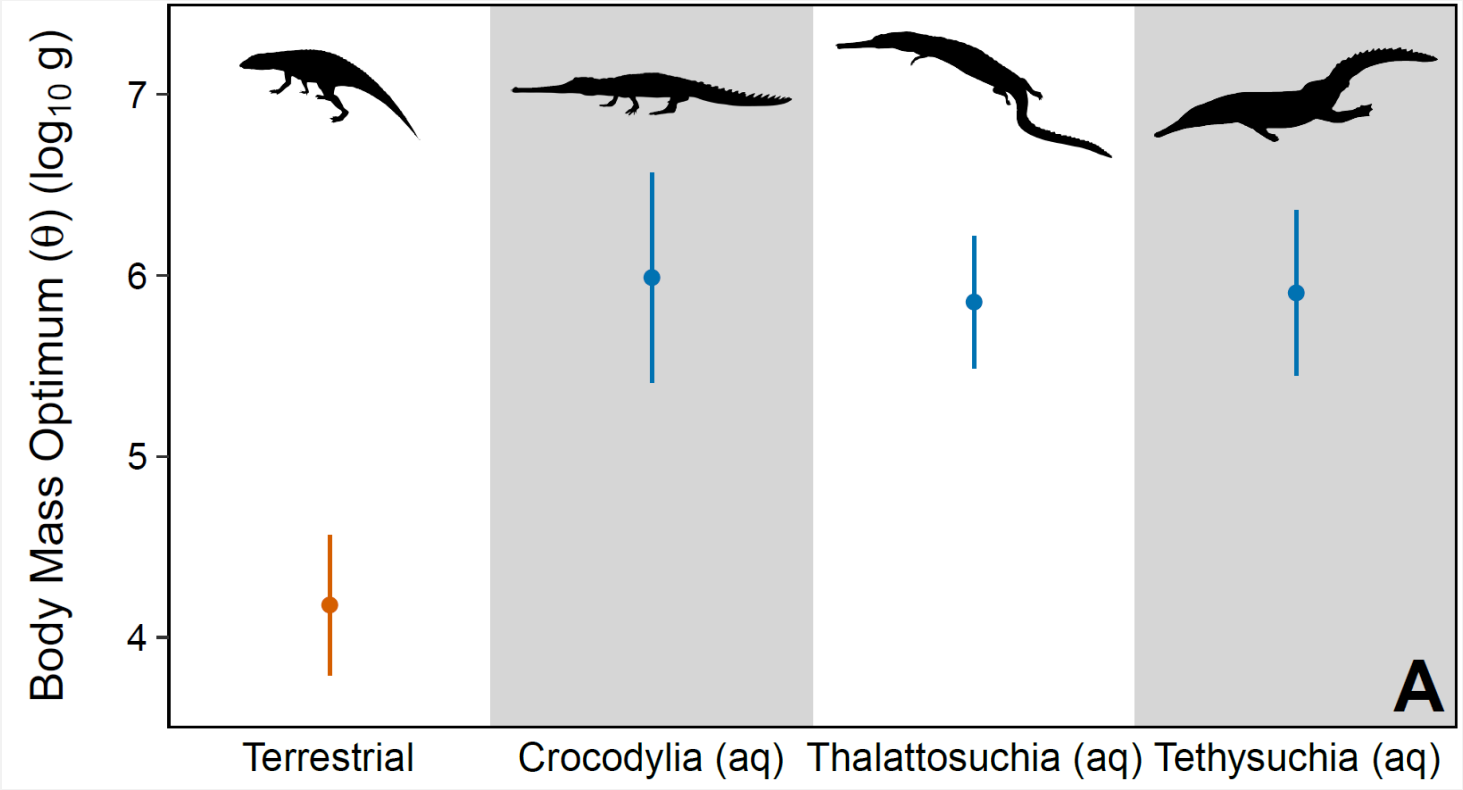
All together

All Divers
vs.
All Terrestrial

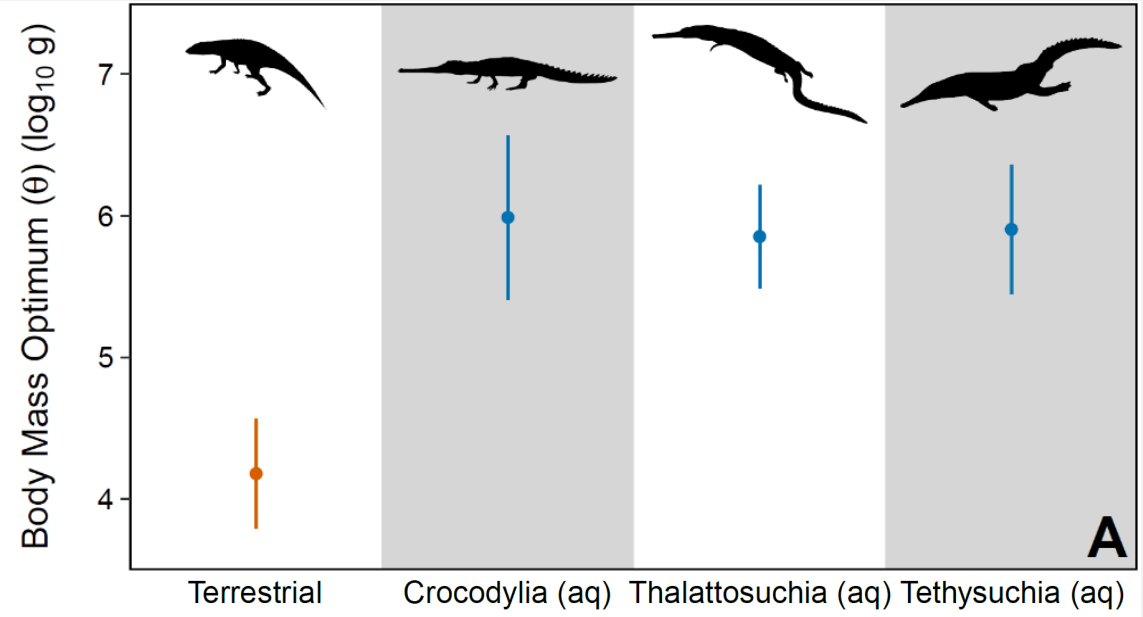
Mesozoic Divers
vs.
Cenozoic Divers
vs.
Terrestrial

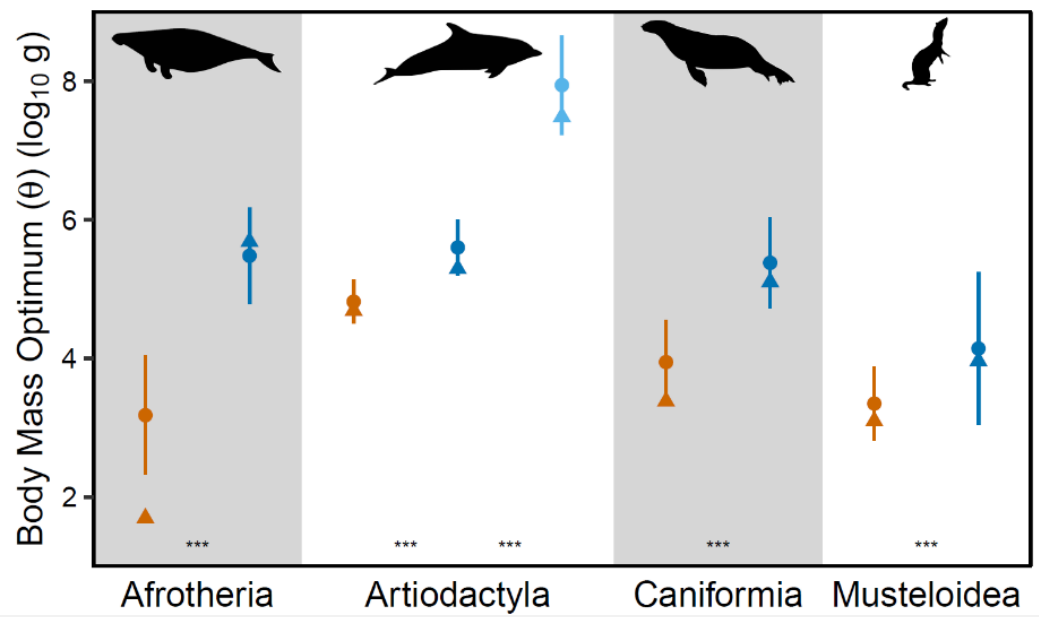
All regimes
separate

THEY GET BIGGER!



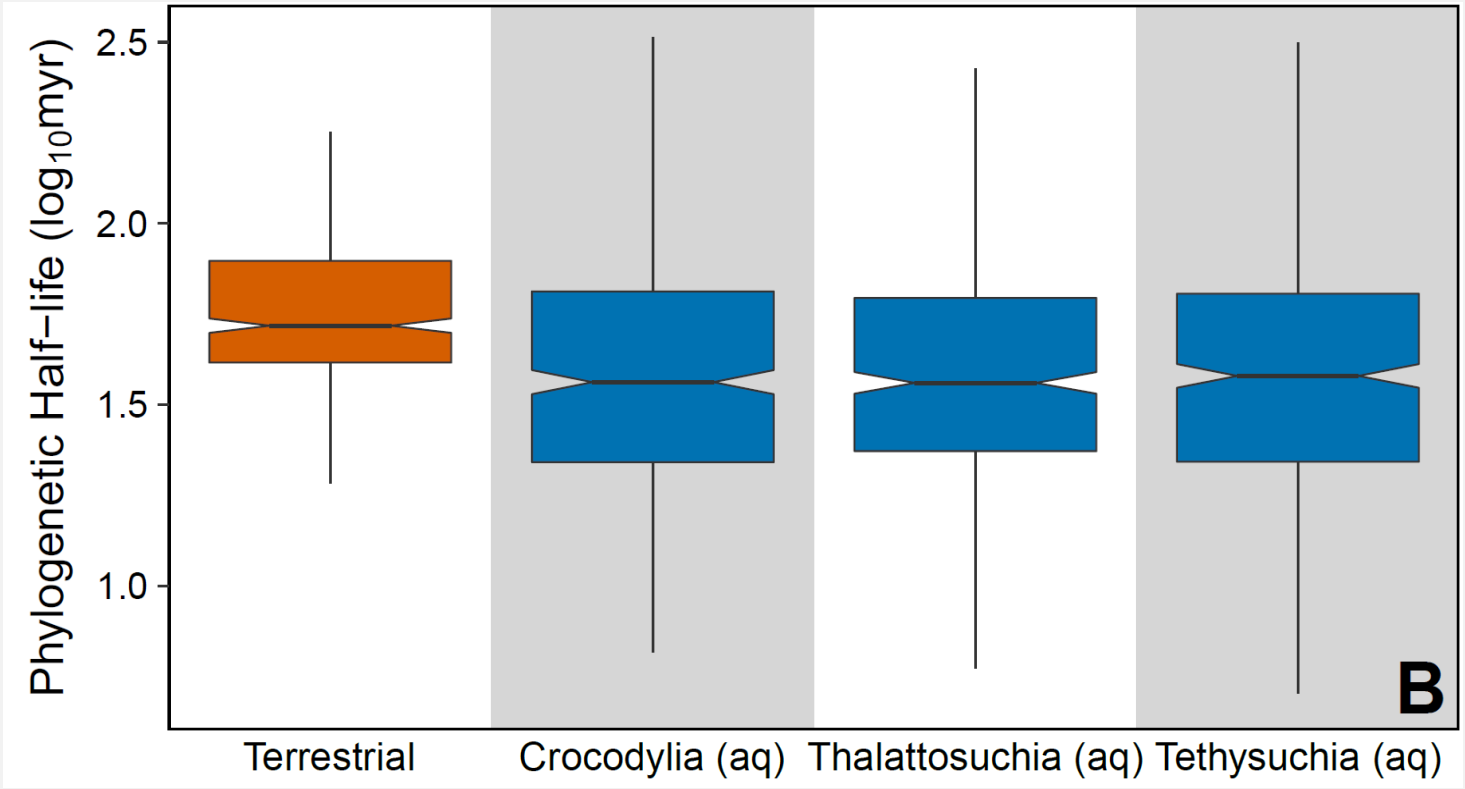
VERY SIMILAR TO MAMMALS!



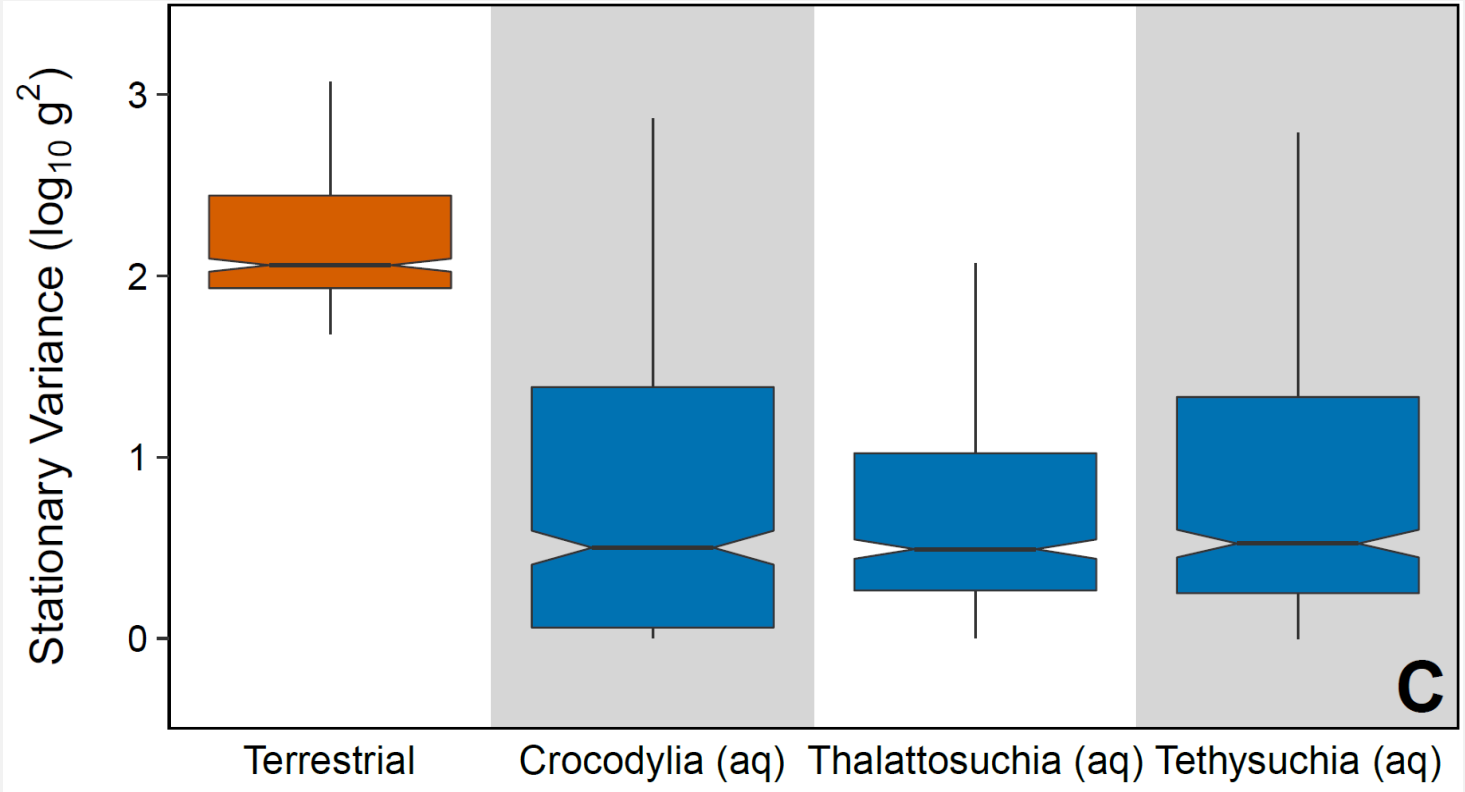


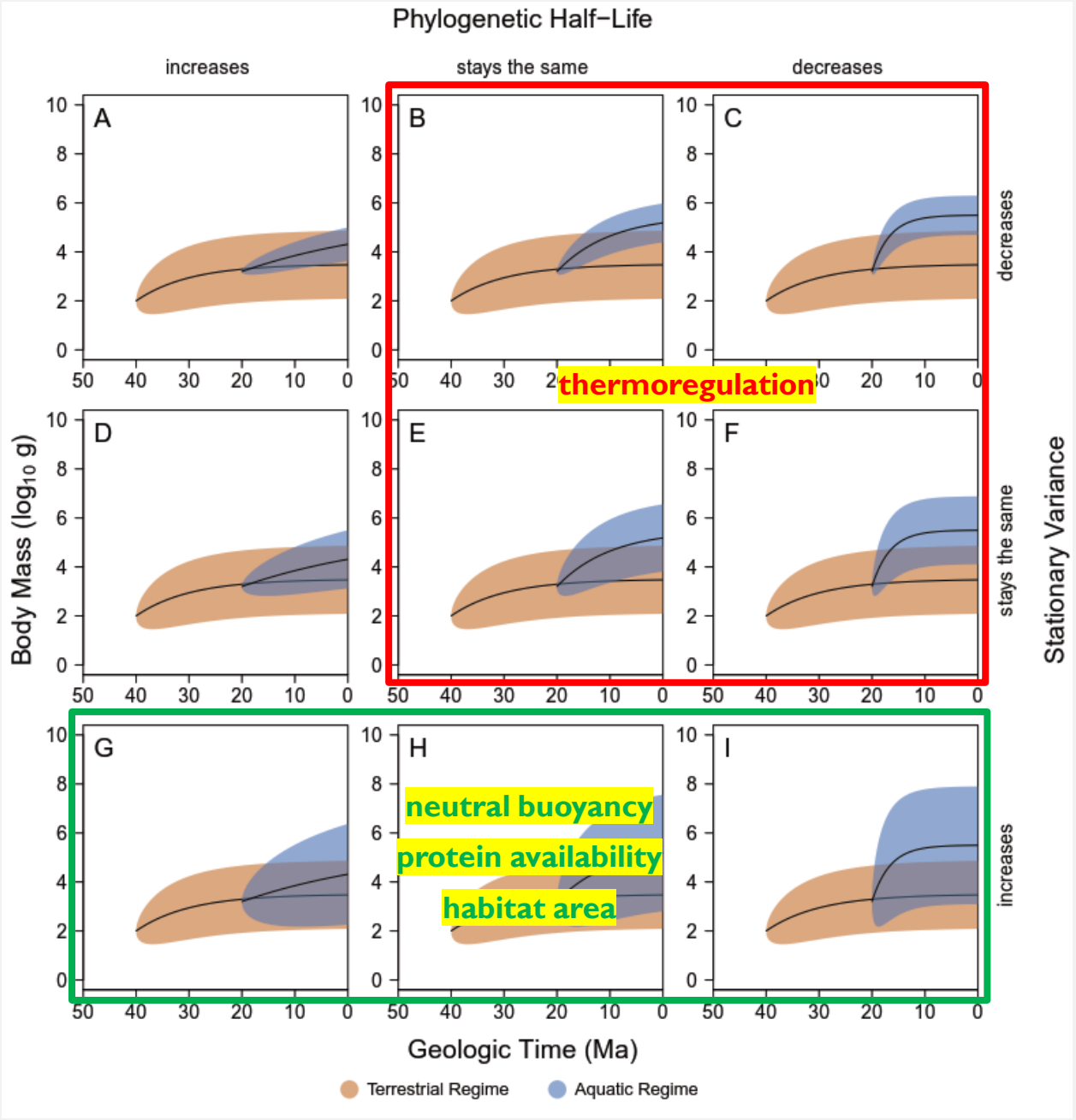
Gearty et al. 2018, *PNAS*

…WITH EQUAL OR STRONGER SELECTION…

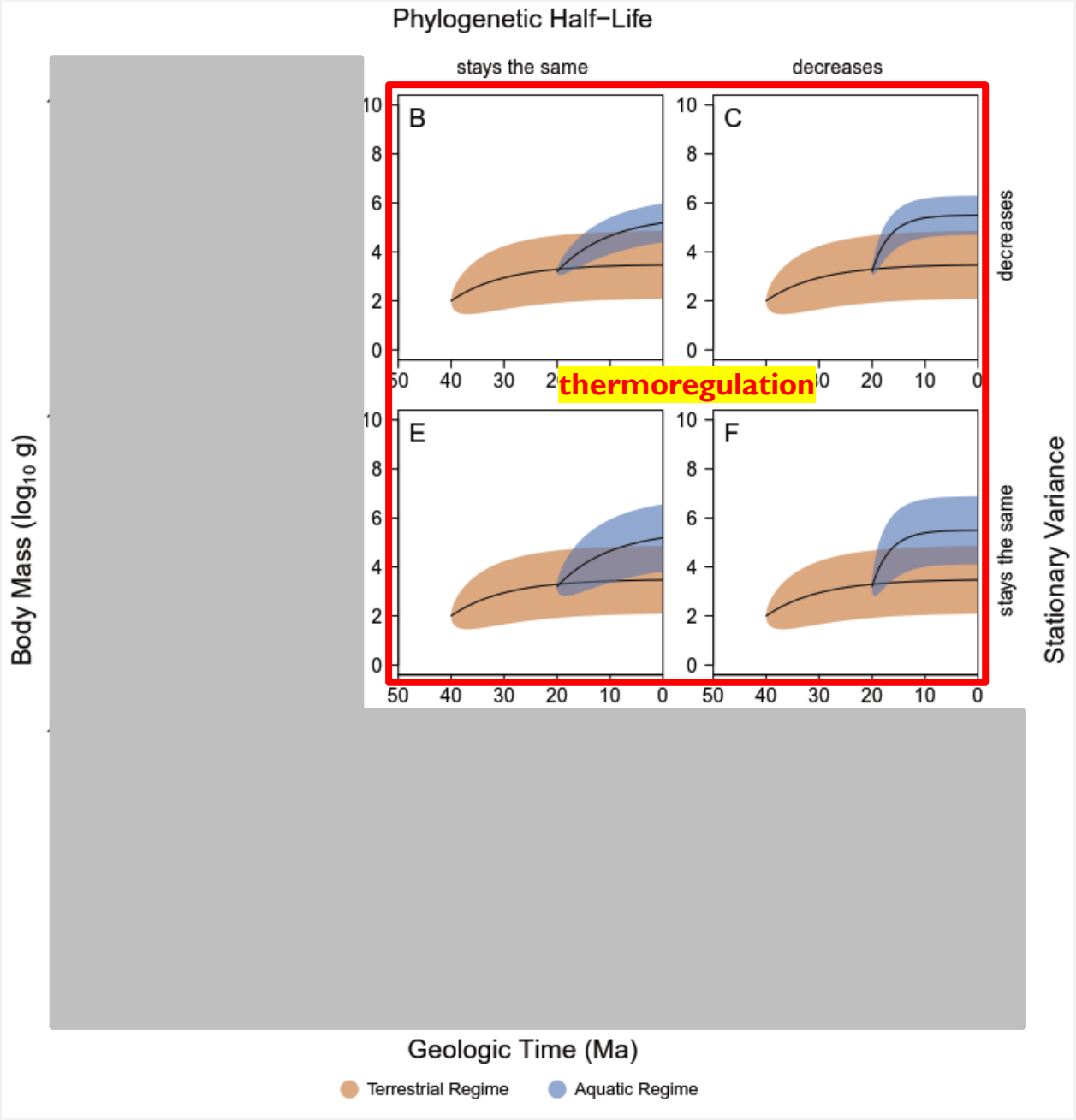


…AND EQUAL OR LESS VARIANCE





Modified from Gearty et al. 2018, *PNAS*

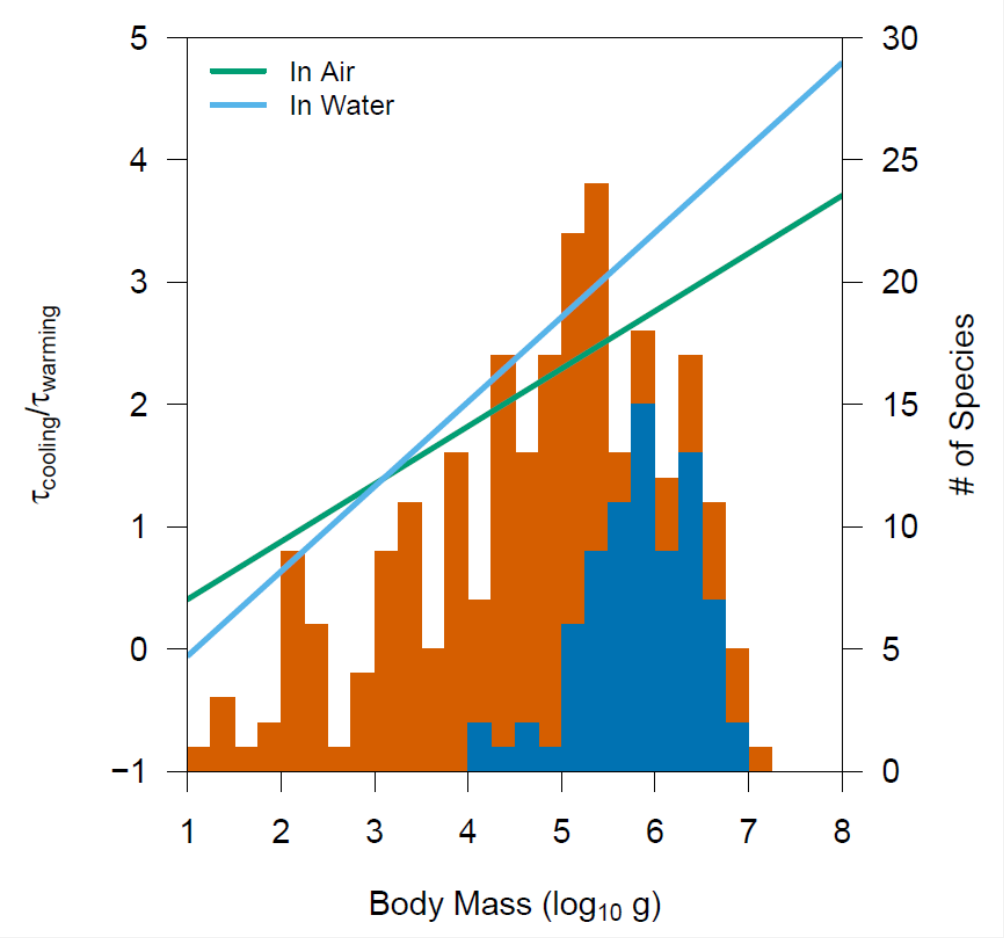


Modified from Gearty et al. 2018, *PNAS*

THERMOREGULATION?

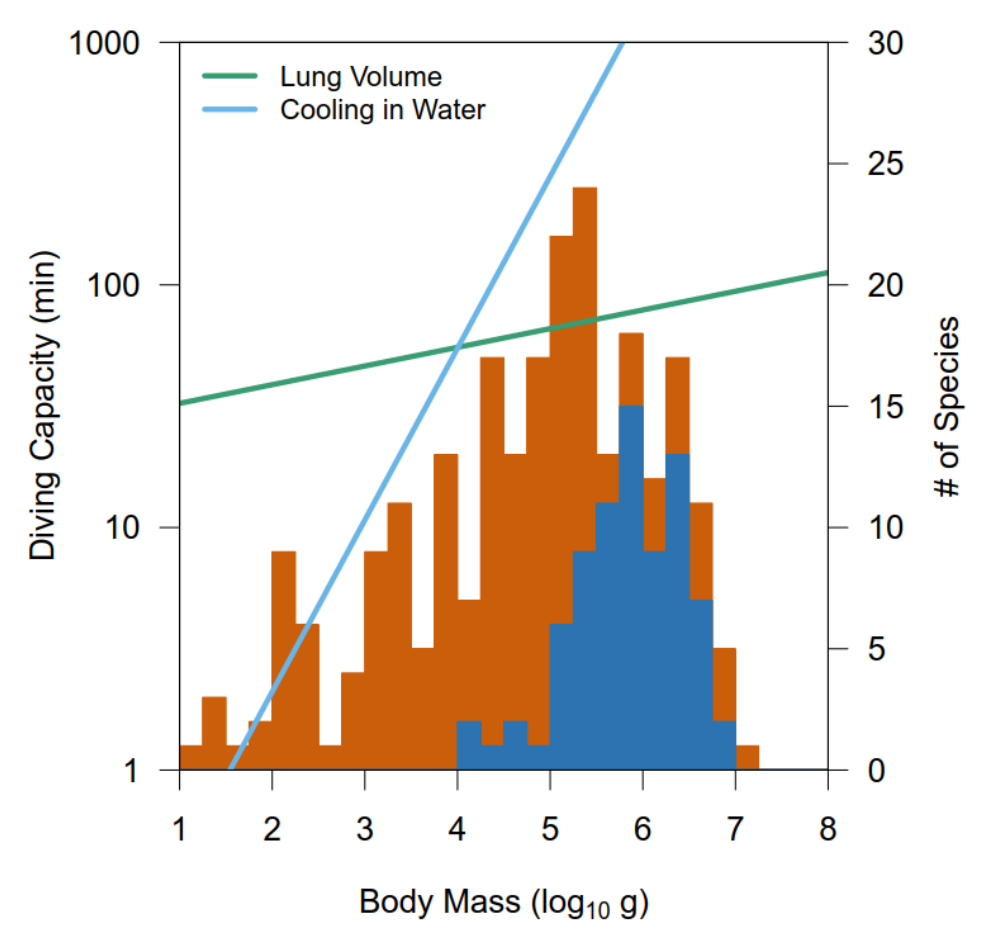
- Crocs are ectothermic, but they still need to worry about losing heat to the surrounding water, especially when diving for long periods of time
- It would be great if we could build a similar energetics model as with the mammals, but the available feeding data is not as precise for crocs
- However, we do have experimental data on cooling and warming rates…

THERMOREGULATION?



- Active blood flow to extremities during basking reduces time needed to warm up
- Cooling rate slows (relative to warming rate) at larger sizes due to thicker skin, larger surface area
- Increased benefits at larger size predicts left skewness

THERMOREGULATION'S EFFECT ON DIVING TIME…



- Lung volume long held as constraint on diving time in crocodyliformes
- Thermoregulation is only more limiting at sizes smaller than 10 kg
- Also predicts left skewness

CONCLUSIONS

- Despite a trend towards increasing sizes, crocodiles do not appear to be following Cope's Rule
- Skewness is highly variable through time (at least in crocs)
  - Implications for variable extinction/origination bias?
- Thermoregulation might impose a strong minimum size constraint in diving crocodyliformes, like in mammals
  - While crocs may not be endothermic, they may still be impacted by heat loss due to its impact on diving capacity

ACKNOWLEDGMENTS

Margaret Deng

Jonathan Payne

Payne Paleobiology Lab

Stanford | SCHOOL OF EARTH, ENERGY & ENVIRONMENTAL SCIENCES

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