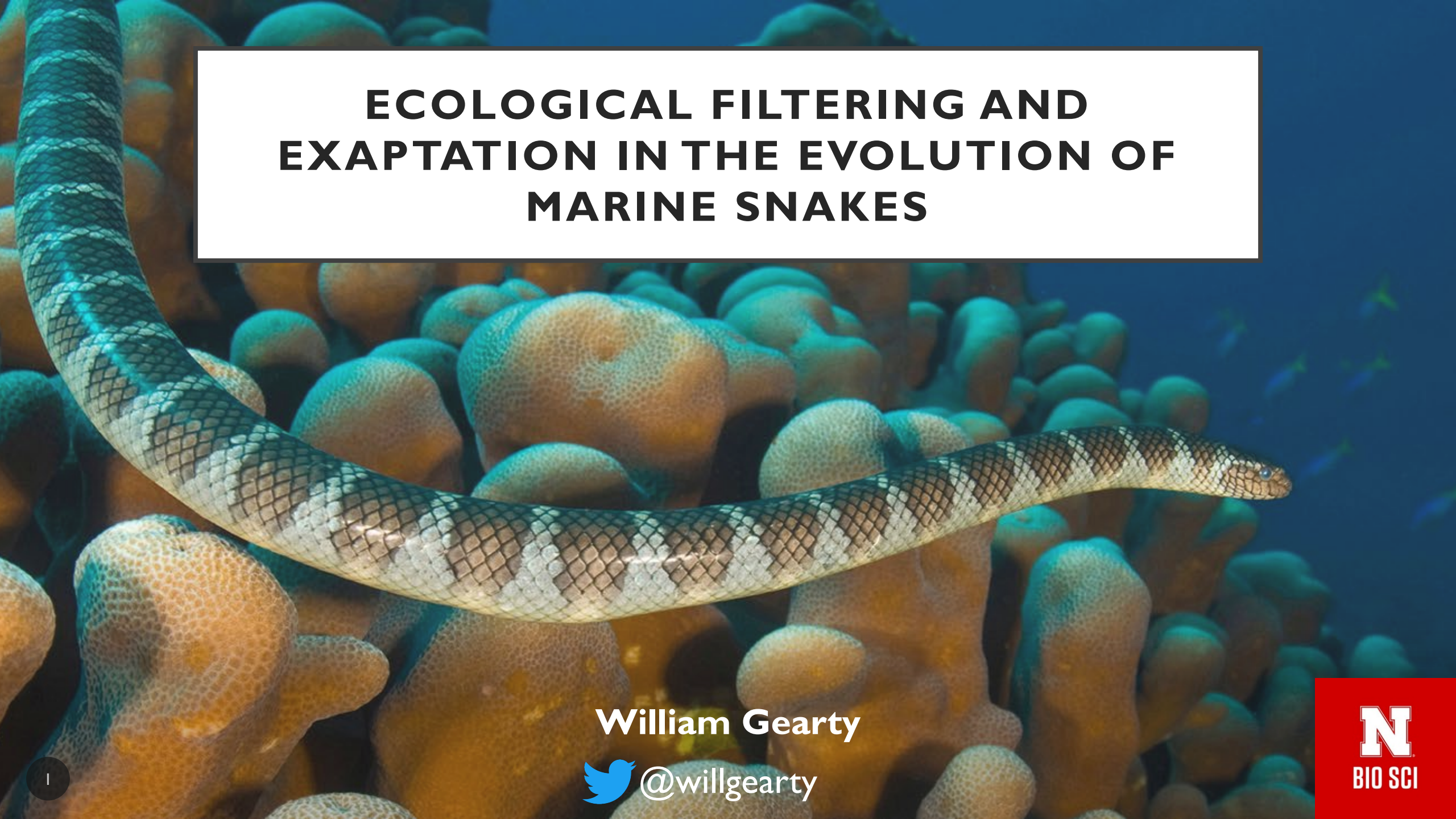
ECOLOGICAL FILTERING AND EXAPTATION IN THE EVOLUTION OF MARINE SNAKES

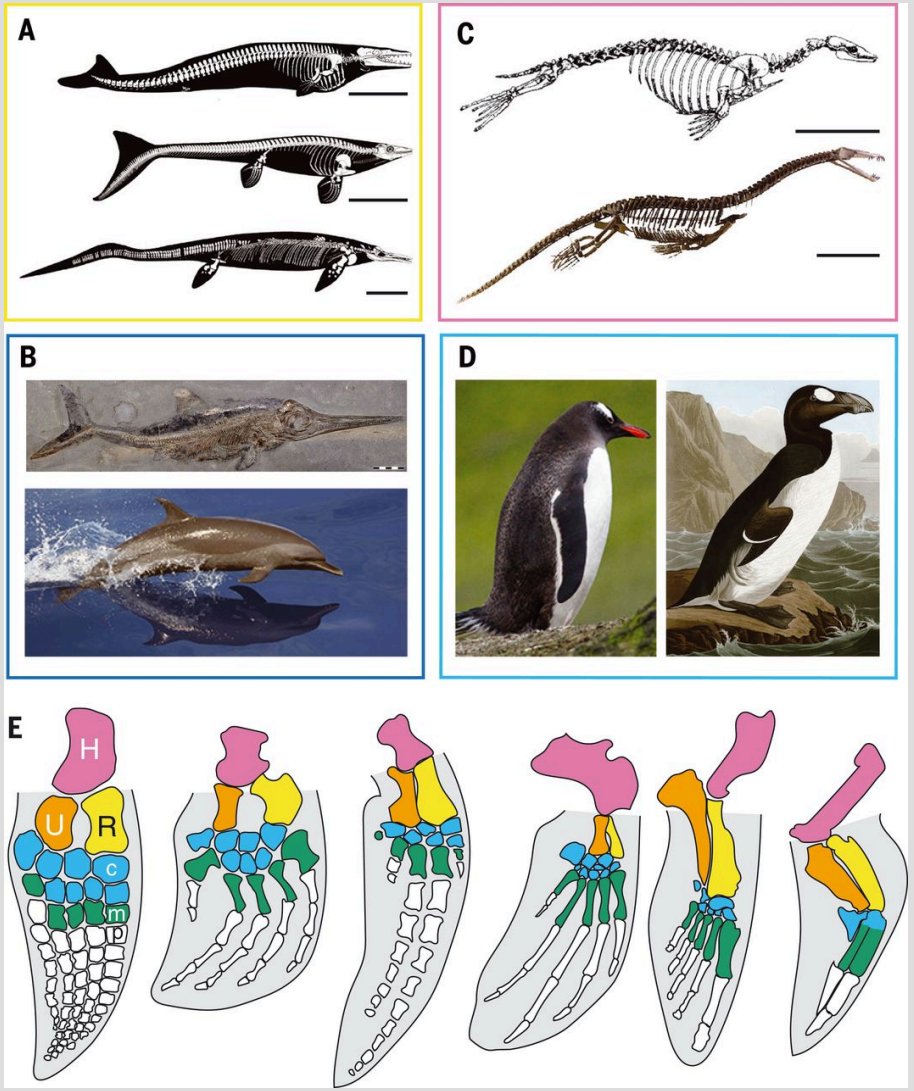


William Gearty

@willgearty

BIO SCI

CONVERGENT EVOLUTION IS COMMON



Kelley and Pyenson 2015, *Science*

BUT NOT ALWAYS DUE TO ADAPTATION

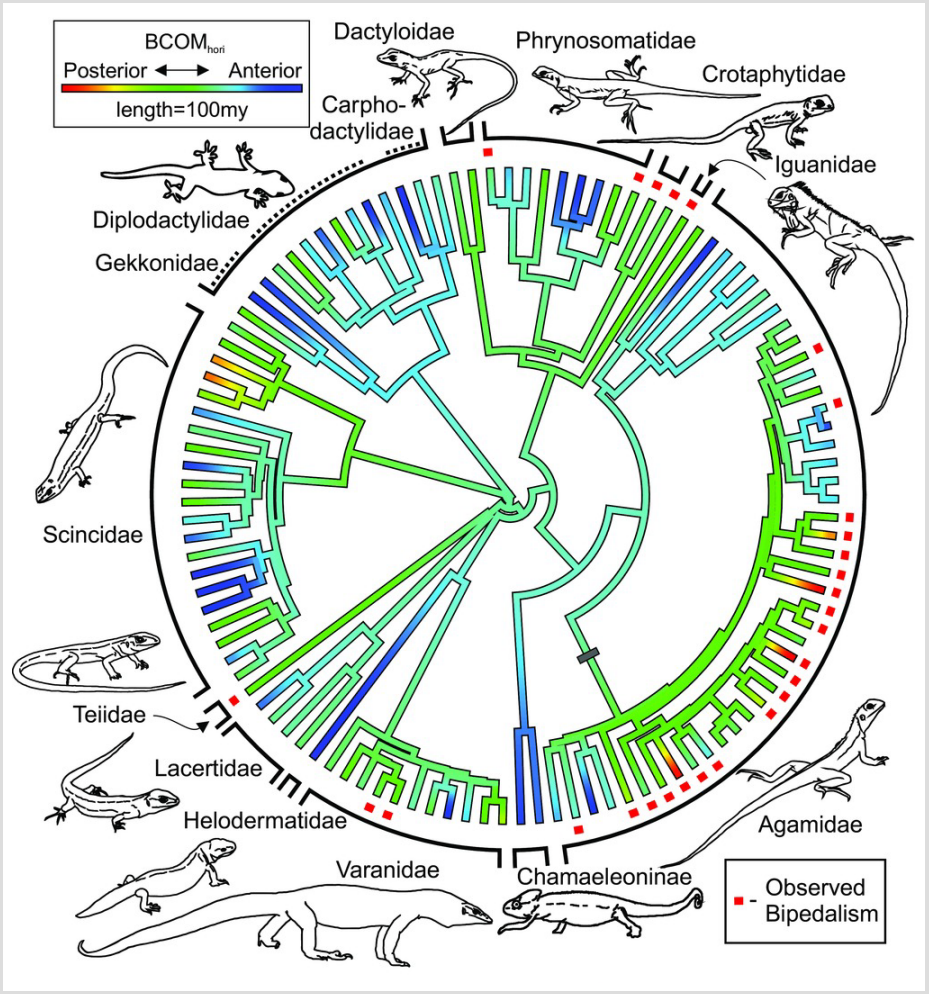
EXAPTATION

National Geographic

BUT NOT ALWAYS DUE TO ADAPTATION

EXAPTATION

National Geographic

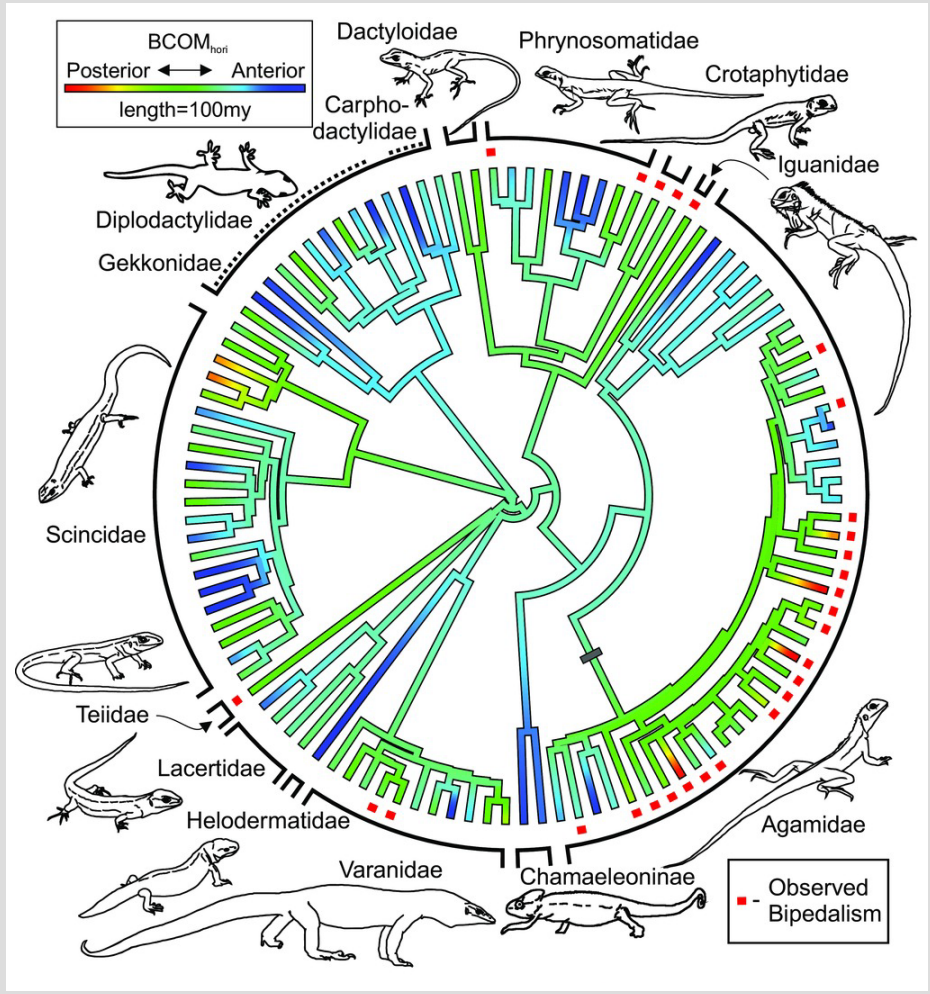


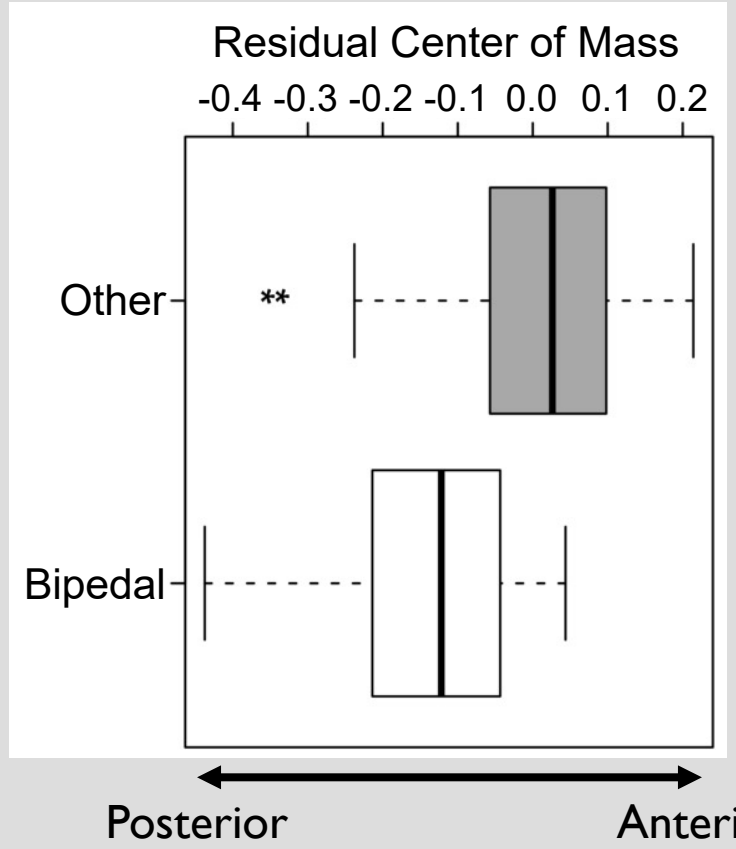
Clemente 2014, *Evolution*

BUT NOT ALWAYS DUE TO ADAPTATION

EXAPTATION

National Geographic





Clemente 2014, *Evolution*

BUT NOT ALWAYS DUE TO ADAPTATION

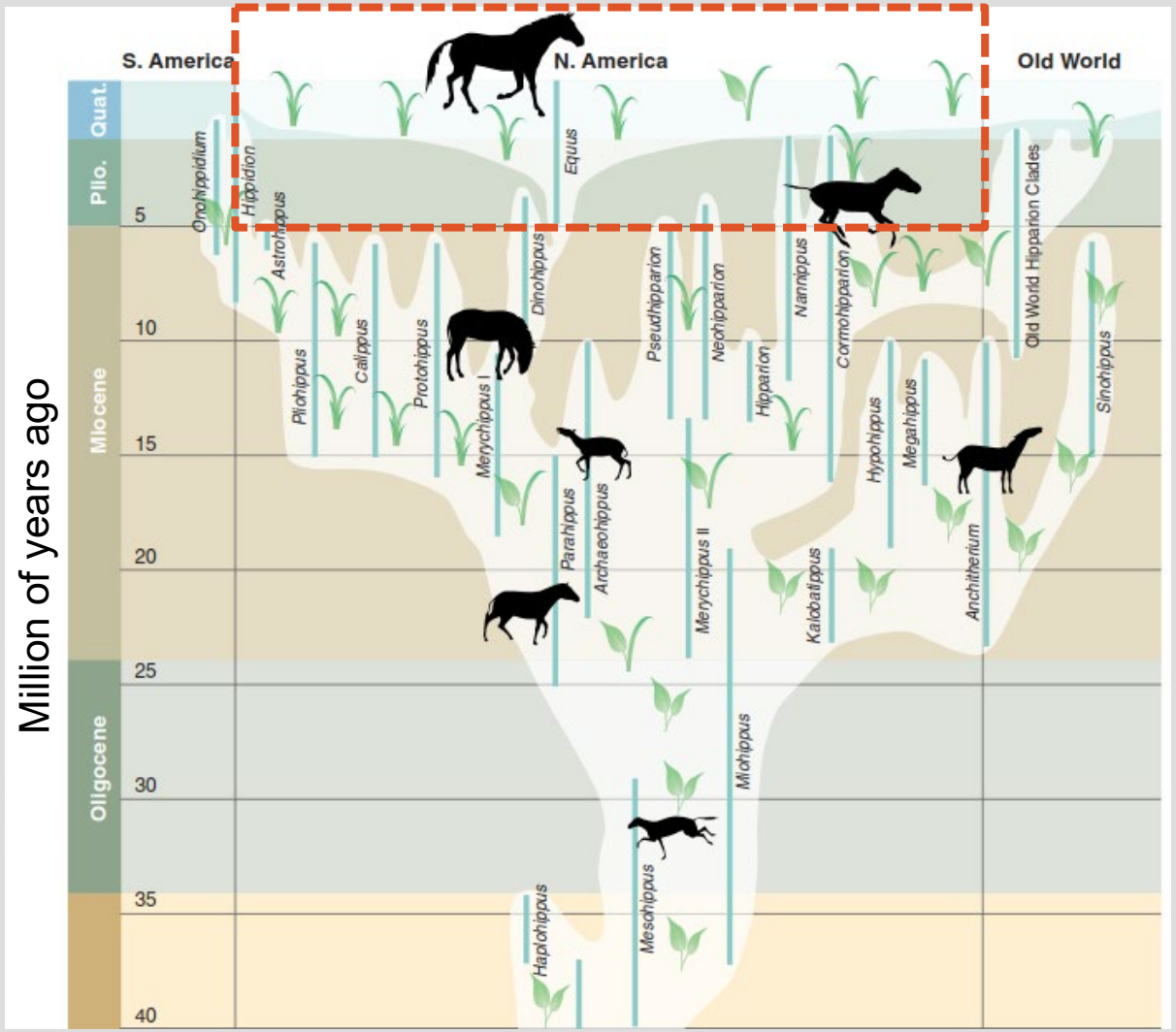
ECOLOGICAL FILTERING

AMNH

BUT NOT ALWAYS DUE TO ADAPTATION

ECOLOGICAL FILTERING

AMNH



Increasing aridity and spread of grasslands in North America

Grazers
Mixed Feeders
Browsers

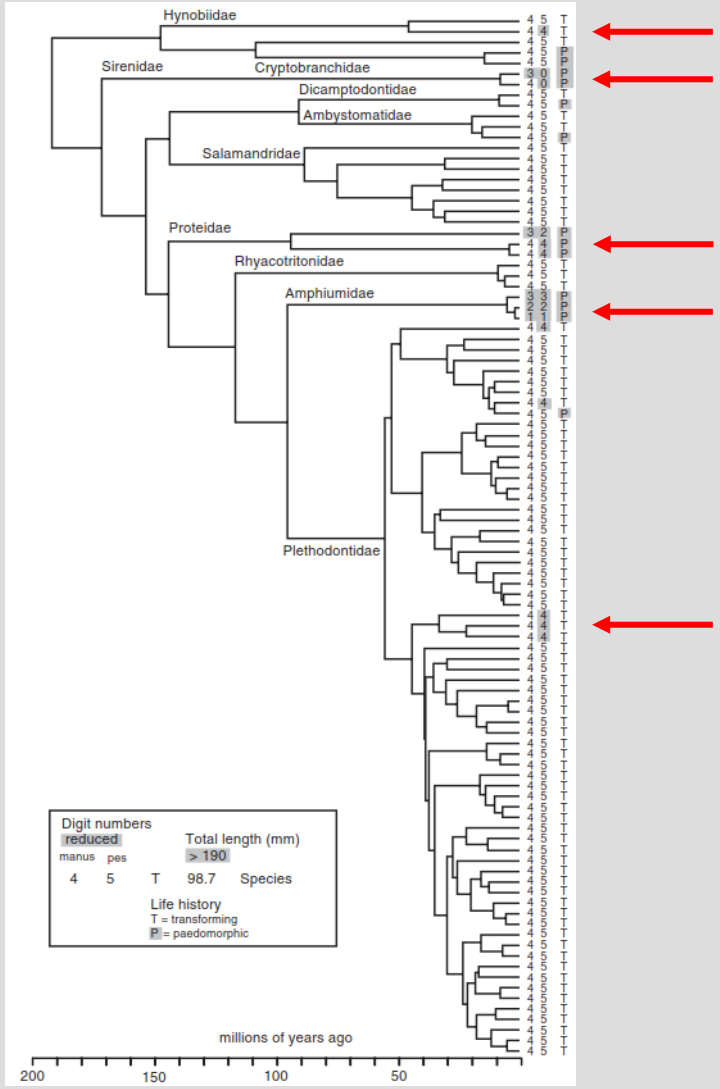
Modified from MacFadden 2005, *Science*

BUT NOT ALWAYS DUE TO ADAPTATION

NONAPTATION

BUT NOT ALWAYS DUE TO ADAPTATION

NONAPTATION

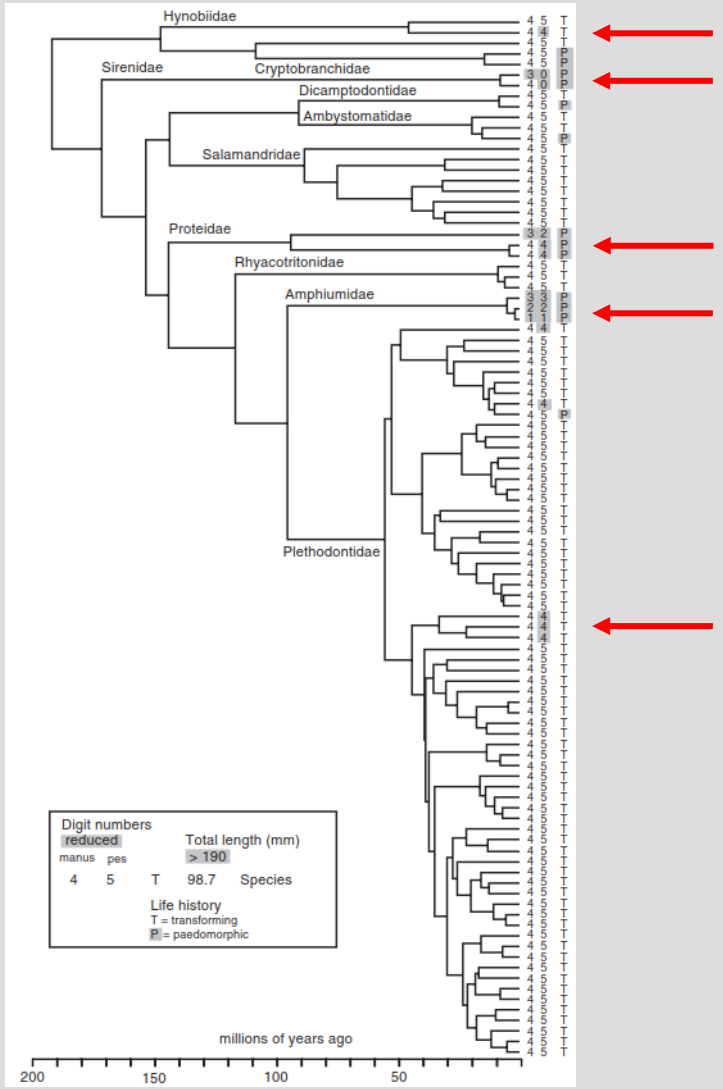


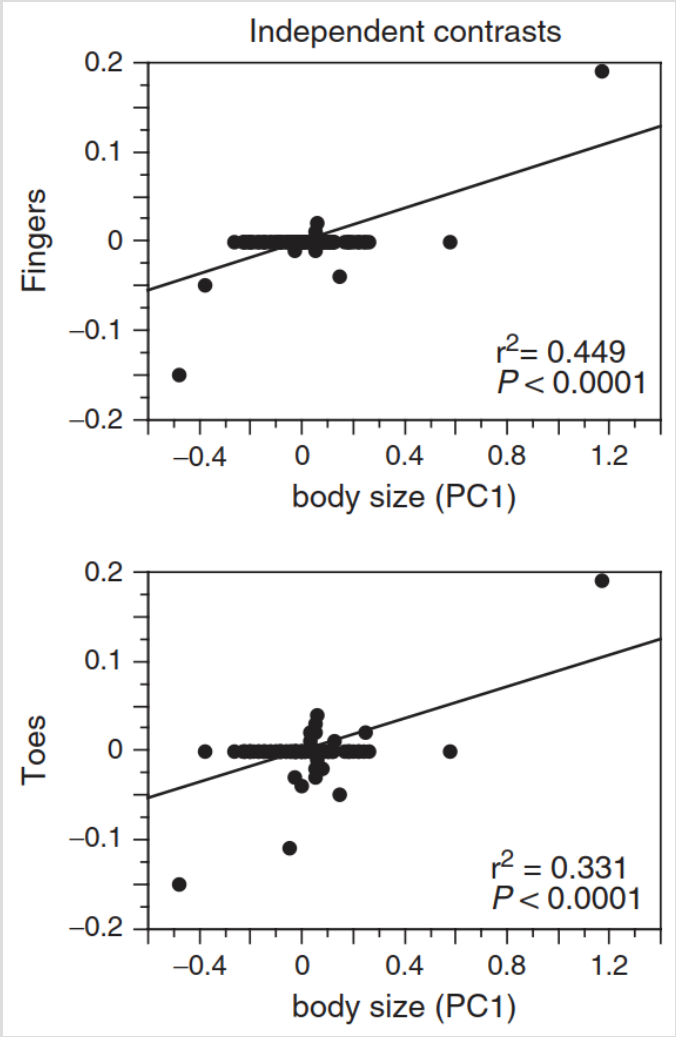
Wiens and Hoverman 2008, *Evolution and Development*

BUT NOT ALWAYS DUE TO ADAPTATION

NONAPTATION

Digit Loss

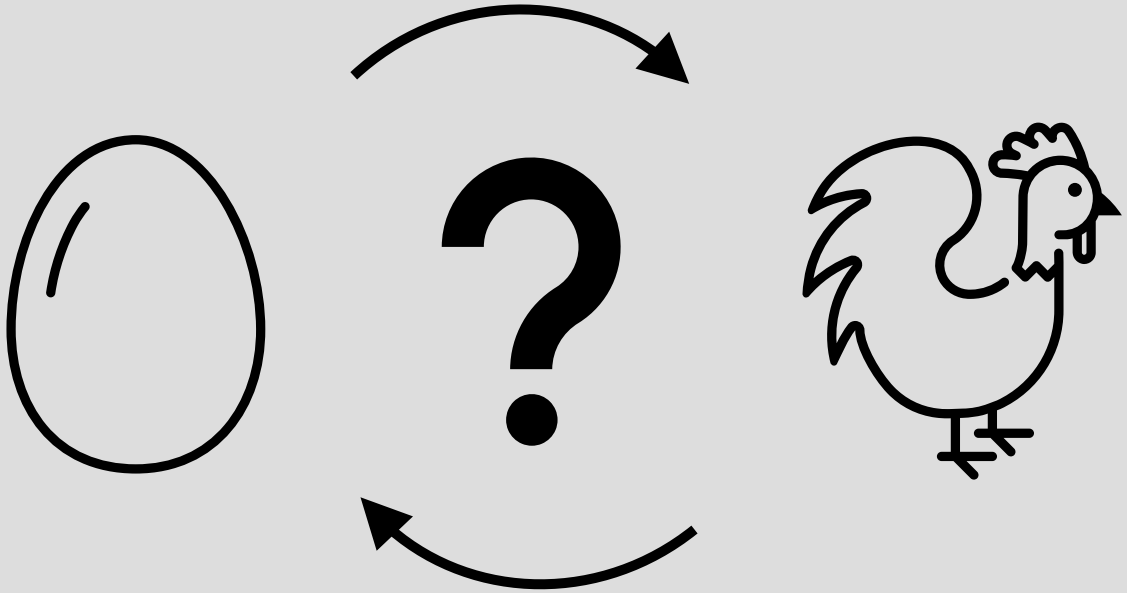




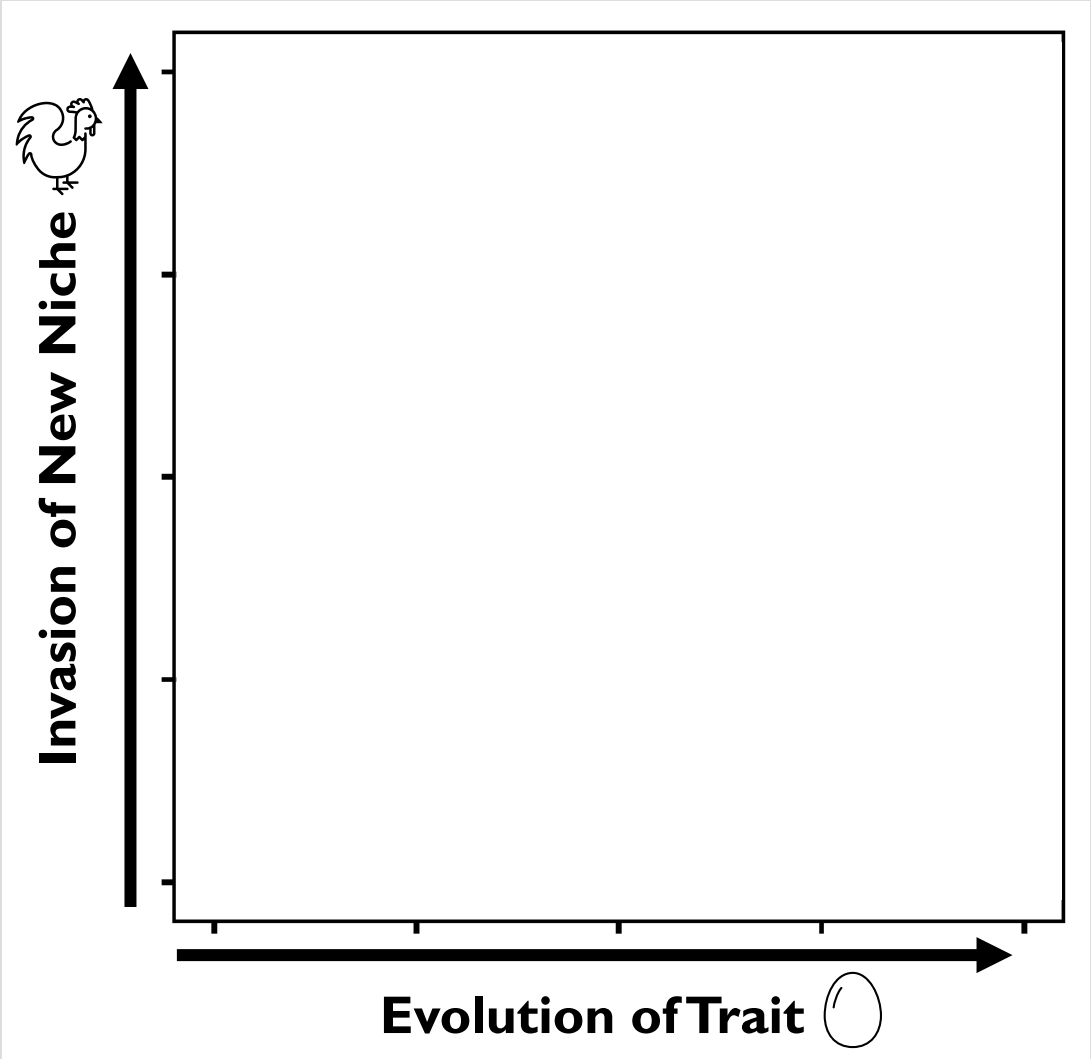
Wiens and Hoverman 2008, *Evolution and Development*

HOW TO DISCRIMINATE IN DEEP TIME?

HOW TO DISCRIMINATE IN DEEP TIME?

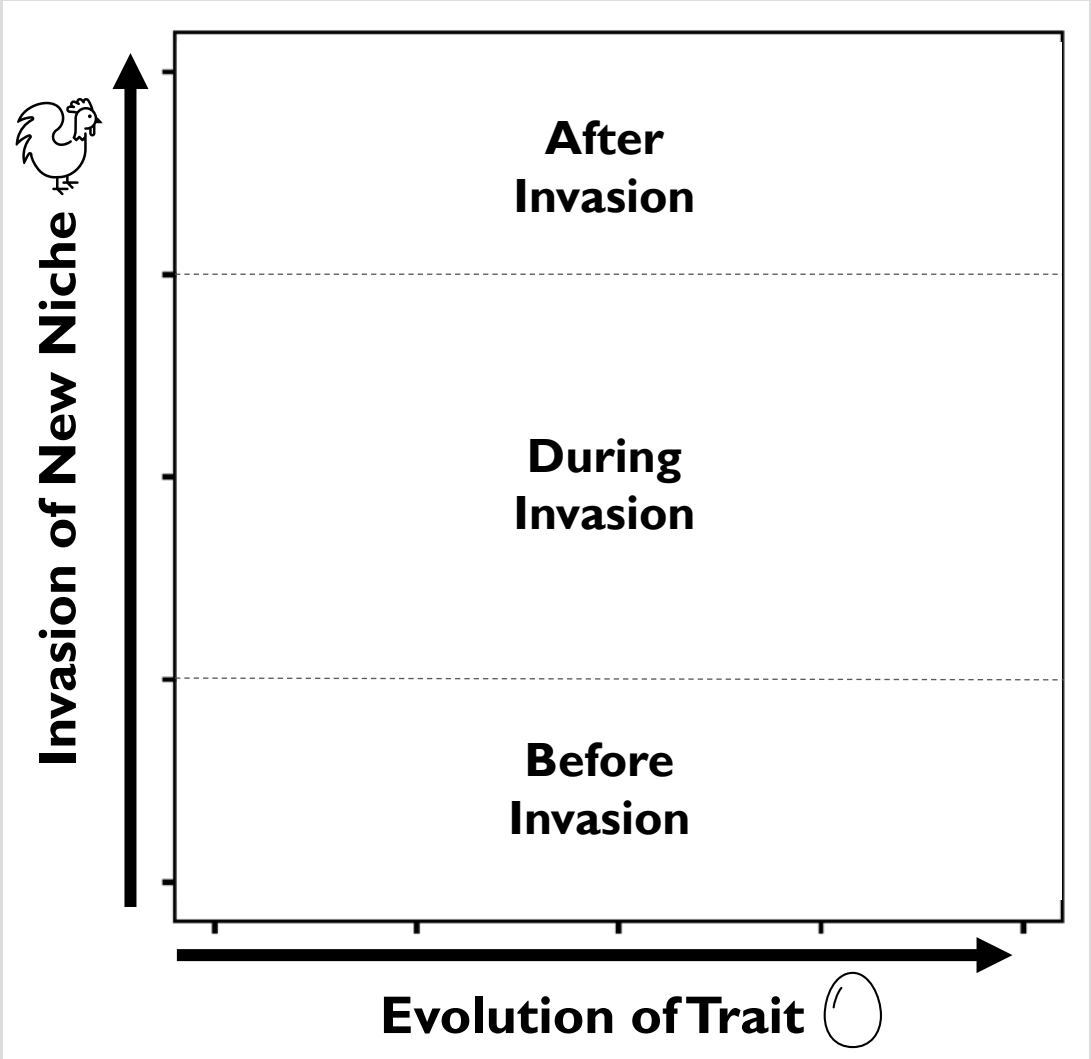


DISCRIMINATING AMONG MECHANISMS



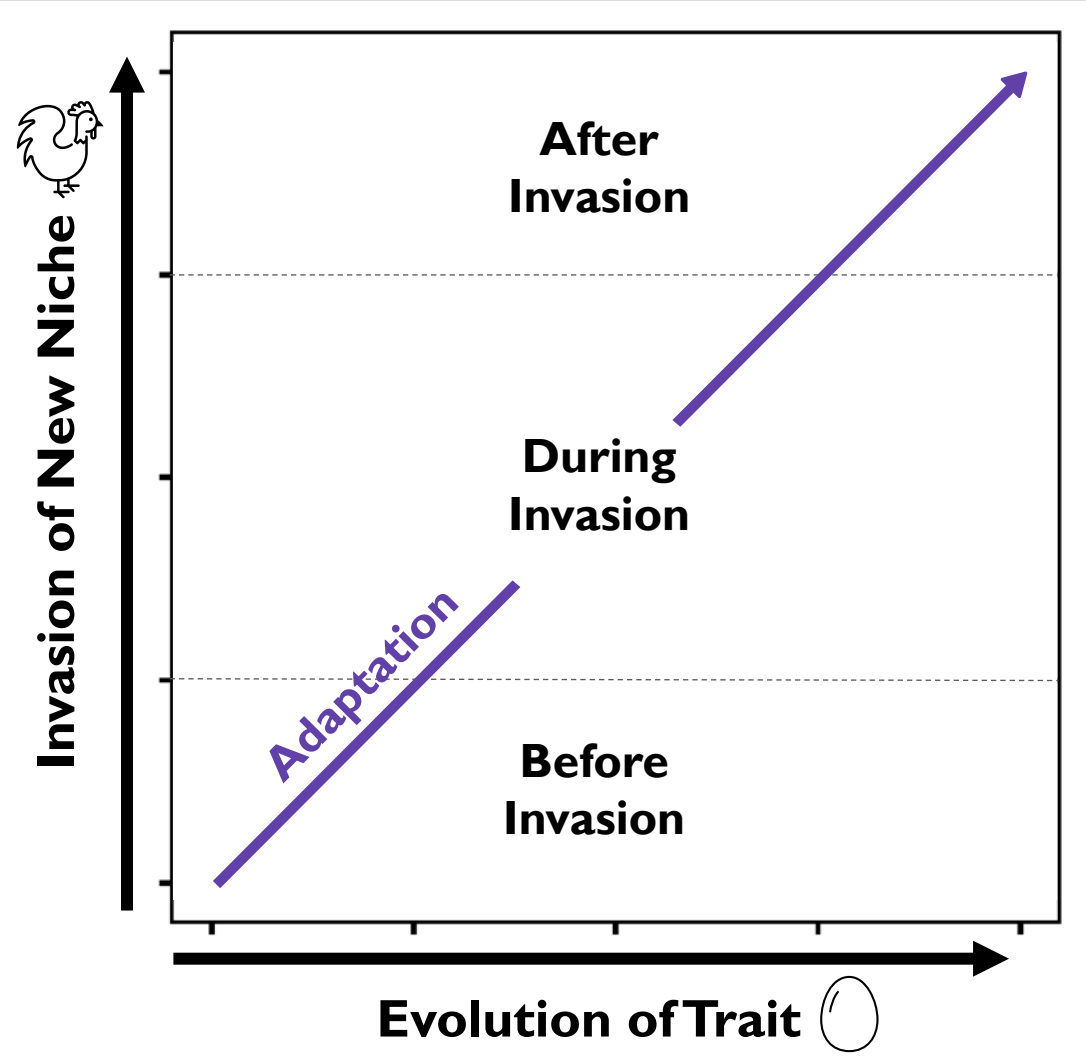
Modified from Gearty, Carrillo, and Payne 2021, *The American Naturalist*

DISCRIMINATING AMONG MECHANISMS



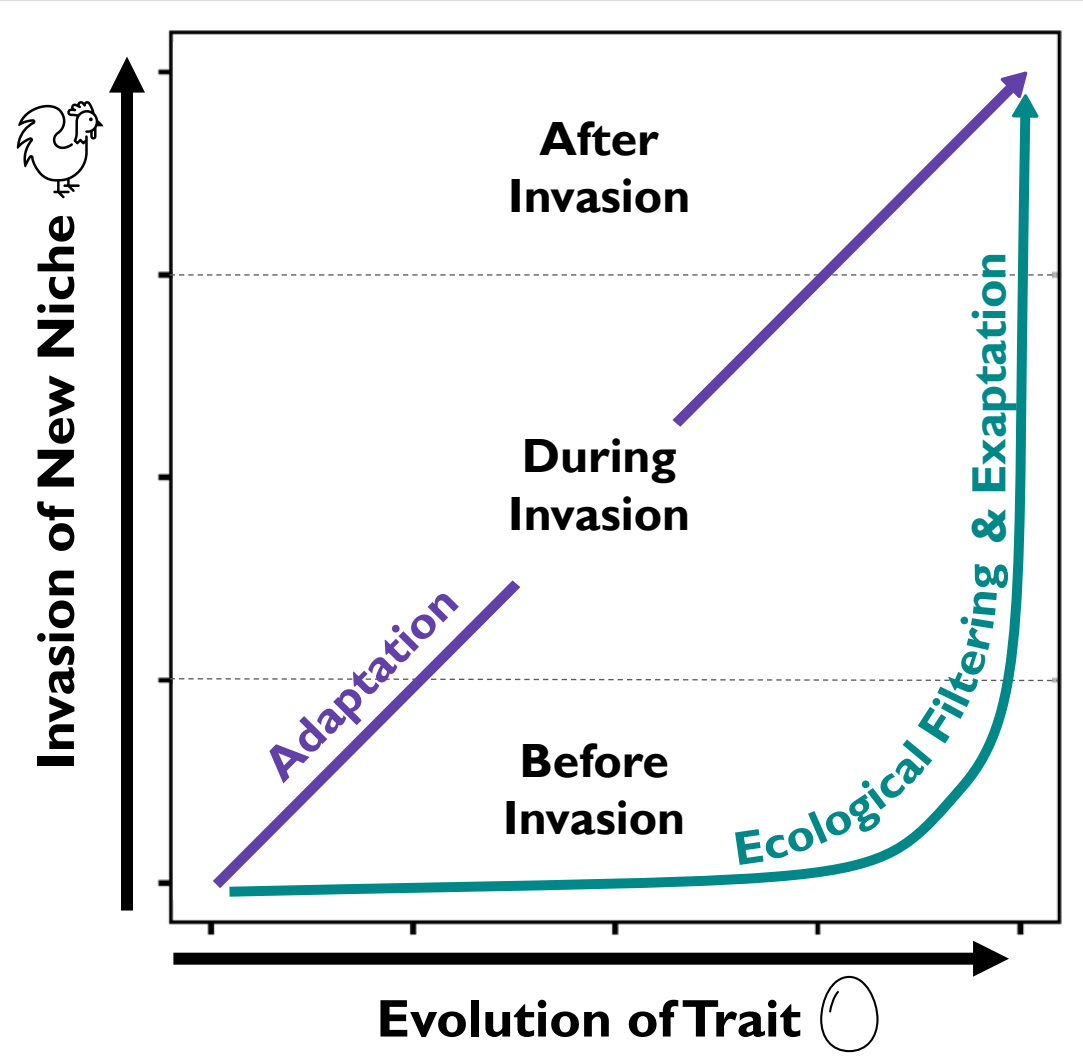
Modified from Gearty, Carrillo, and Payne 2021, *The American Naturalist*

DISCRIMINATING AMONG MECHANISMS



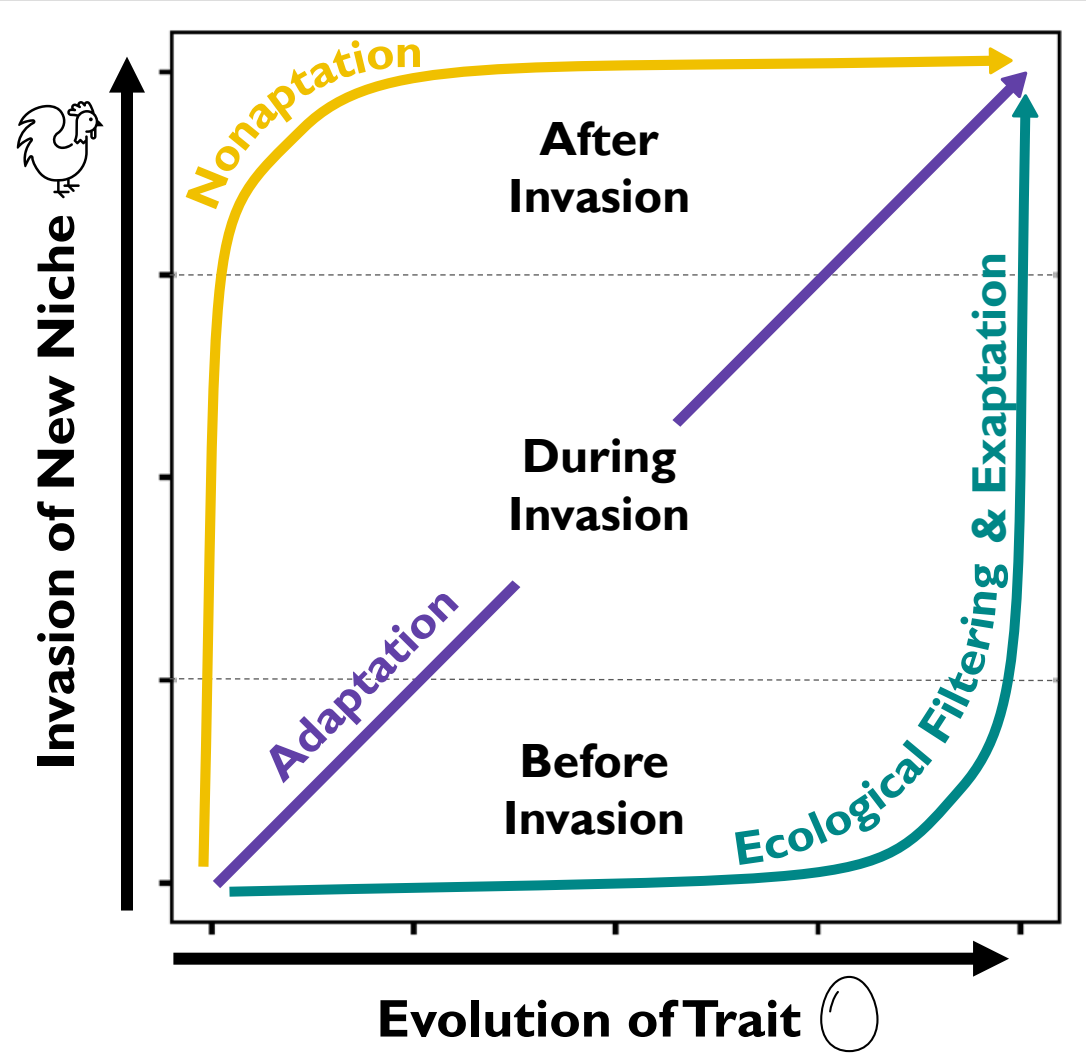
Modified from Gearty, Carrillo, and Payne 2021, *The American Naturalist*

DISCRIMINATING AMONG MECHANISMS



Modified from Gearty, Carrillo, and Payne 2021, *The American Naturalist*

DISCRIMINATING AMONG MECHANISMS



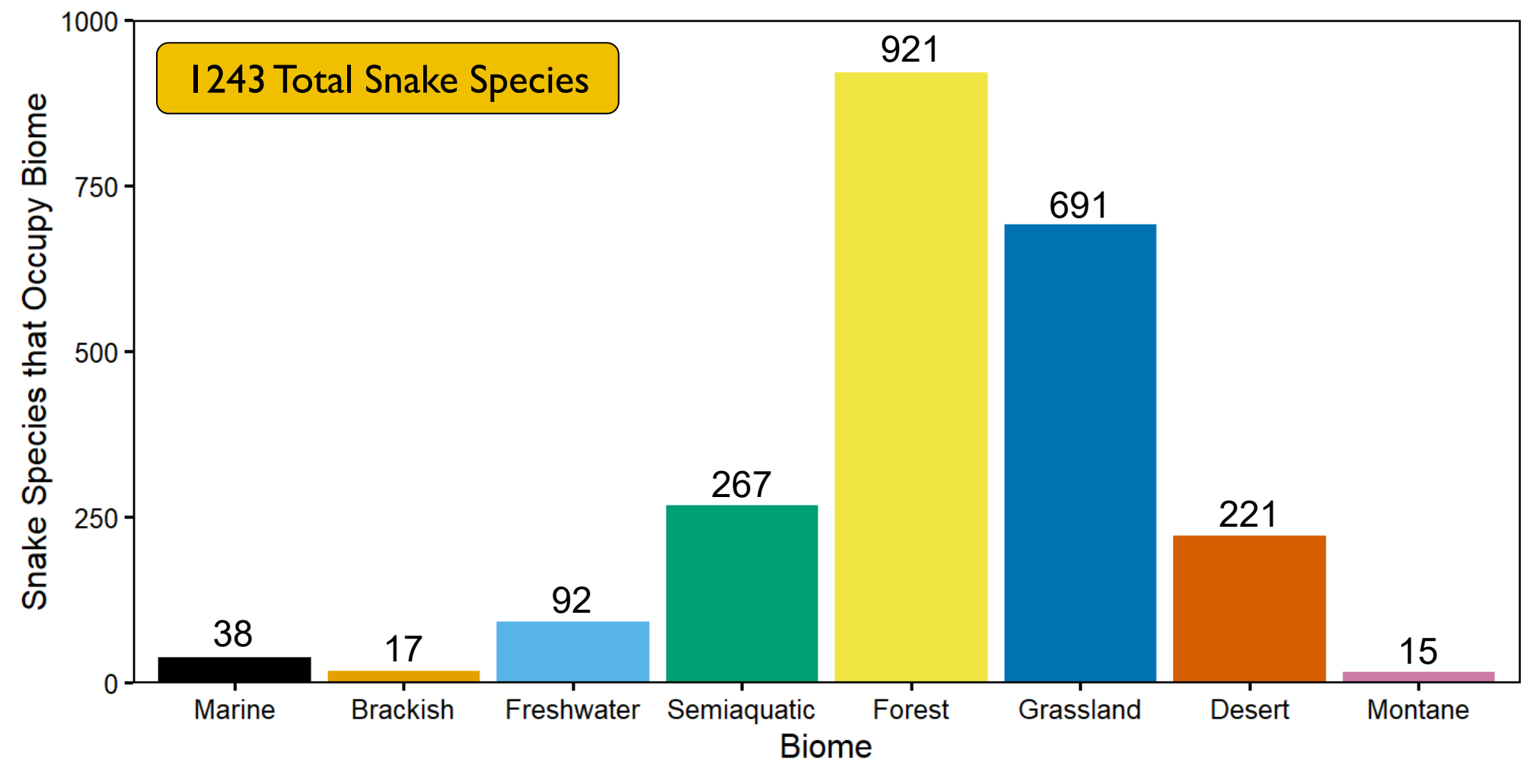
Modified from Gearty, Carrillo, and Payne 2021, *The American Naturalist*

EVOLUTION OF MARINE SNAKES

wikipedia.org

BIOME DATA COLLECTION

BIOME OCCUPANCY



OTHER DATA

Fully-sampled phylogenies of squamates reveal evolutionary patterns in threat status

João Filipe Riva Tonini [a,*], Karen H. Beard [b], Rodrigo Barbosa Ferreira [b,c], Walter Jetz [d], R. Alexander Pyron [a]

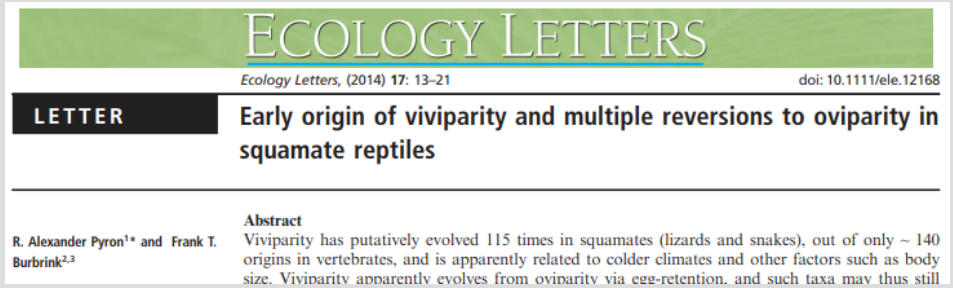
[a] Department of Biological Sciences, The George Washington University, 2029 G St NW, Washington, DC 20052, USA
[b] Department of Wildland Resources and the Ecology Center, Utah State University, Logan, UT 84322-5230, USA
[c] Laboratório de Ecologia de Populações e Conservação, Universidade Vila Velha, Rua Comissário José Dantas de Melo 21, Boa Vista, Vila Velha, ES 29102-920, Brazil
[d] Department of Ecology and Evolutionary Biology, Yale University, 165 Prospect Street, New Haven, CT 06520, USA

Global Ecology and Biogeography, (Global Ecol. Biogeogr.) (2016) **25**, 187–197

RESEARCH PAPER

Body sizes and diversification rates of lizards, snakes, amphisbaenians and the tuatara

Anat Feldman[1], Niv Sabath[2], R. Alexander Pyron[3], Itay Mayrose[2] and Shai Meiri[1]*



ECOLOGY LETTERS

Ecology Letters, (2014) **17**: 13–21 doi: 10.1111/ele.12168

LETTER

Early origin of viviparity and multiple reversions to oviparity in squamate reptiles

R. Alexander Pyron[1]* and Frank T. Burbrink[2,3]

Abstract

Viviparity has putatively evolved 115 times in squamates (lizards and snakes), out of only ~ 140 origins in vertebrates, and is apparently related to colder climates and other factors such as body size. Viviparity apparently evolves from oviparity via egg-retention, and such taxa may thus still

Global Ecology and Biogeography, (Global Ecol. Biogeogr.) (2015) **24**, 1433–1442

RESEARCH PAPER

The geography of snake reproductive mode: a global analysis of the evolution of snake viviparity

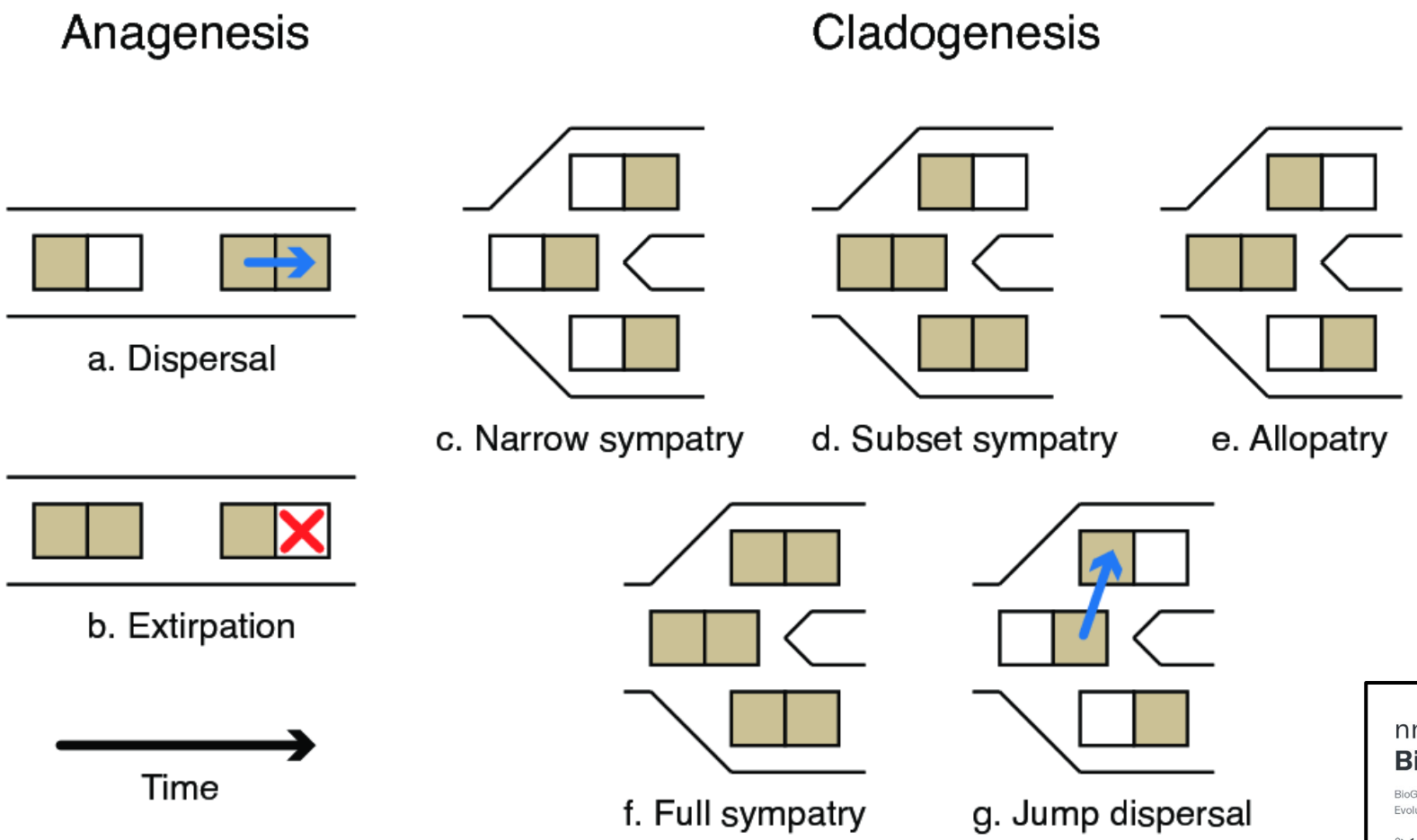
Anat Feldman[1]*, Aaron M. Bauer[2], Fernando Castro-Herrera[3], Laurent Chirio[4], Indraneil Das[5], Tiffany M. Doan[6], Erez Maza[1], Danny Meirte[7], Cristiano de Campos Nogueira[8], Zoltán Tamás Nagy[9], Omar Torres-Carvajal[10], Peter Uetz[11] and Shai Meiri[1]

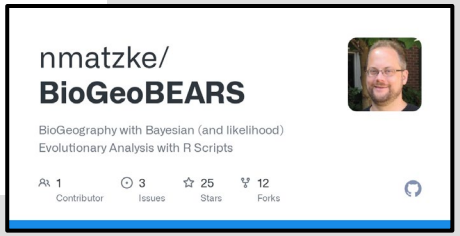
- Phylogeny (timescaled with fossil calibrations)
- Body mass
- Reproductive mode (eggs vs. live birth)
- Average temperature
- Average elevation

ESTIMATE ANCESTRAL BIOMES AND TRAITS

ESTIMATE ANCESTRAL BIOMES

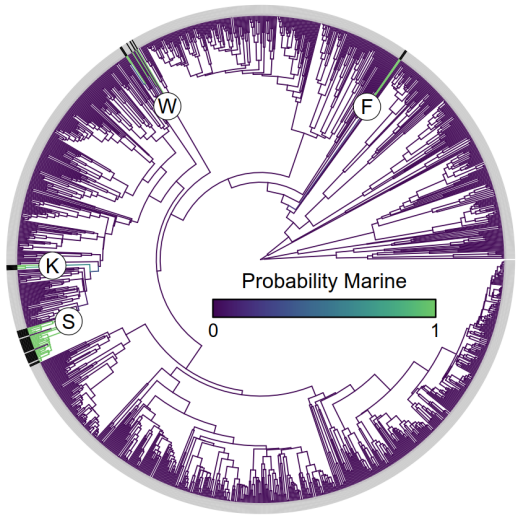
DEC MODEL

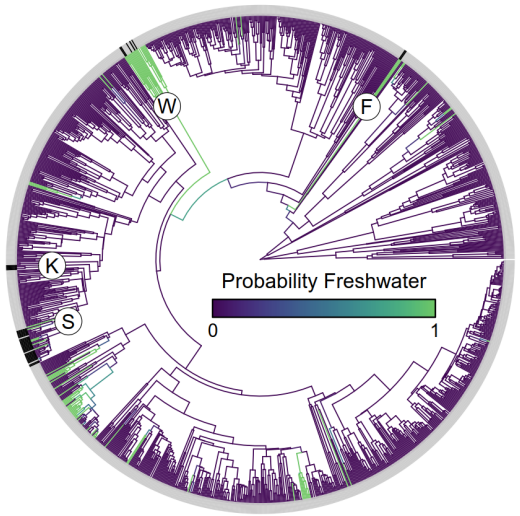


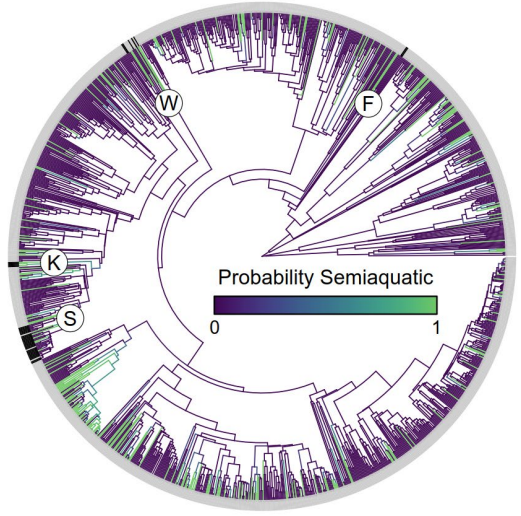


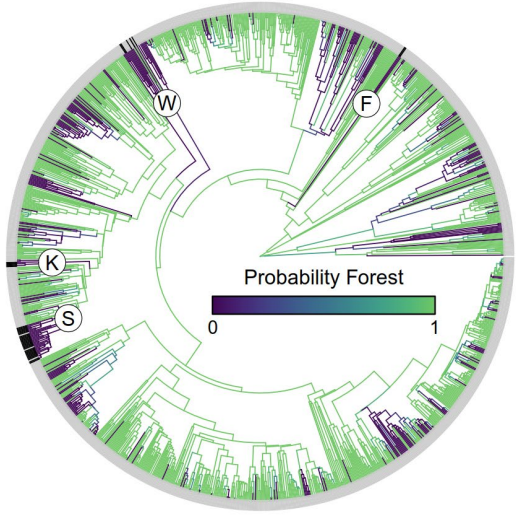
revbayes.github.io

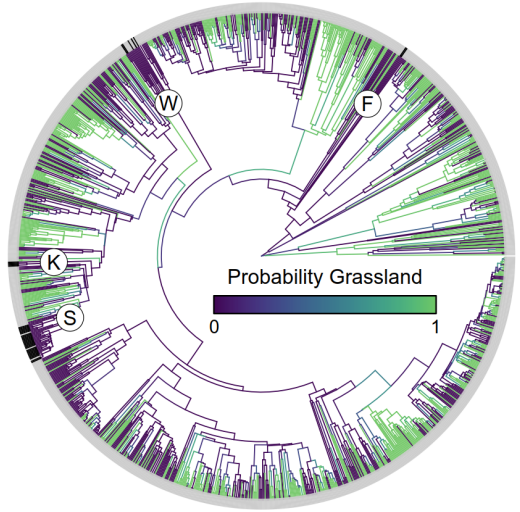
ESTIMATE ANCESTRAL BIOMES

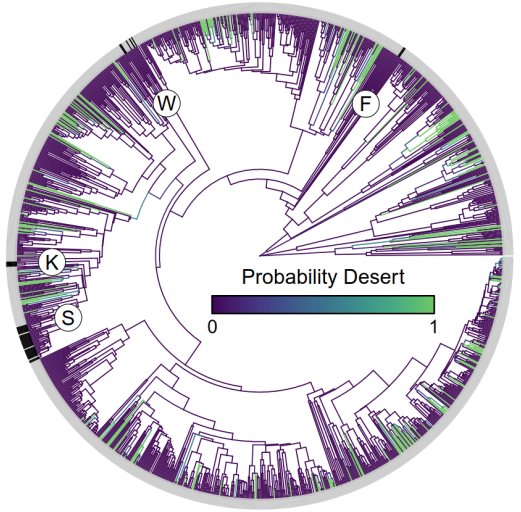












(F) File snakes

(W) Water snakes

(S) Sea snakes

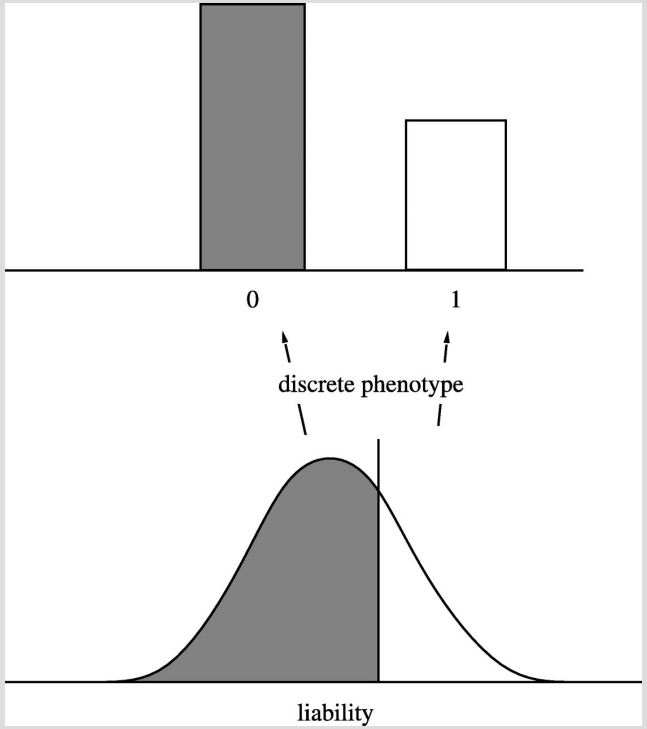
(K) Sea kraits

Gearty, Carrillo, and Payne 2021, *The American Naturalist*

JOINTLY ESTIMATE OTHER TRAITS AND ENVIRONMENTAL VARIABLES

threshml

- Jointly estimates discrete and continuous characters
- Threshold model for discrete characters
- Infers (and accounts for) covariances of characters



Felsenstein 2005, *Proceedings B*

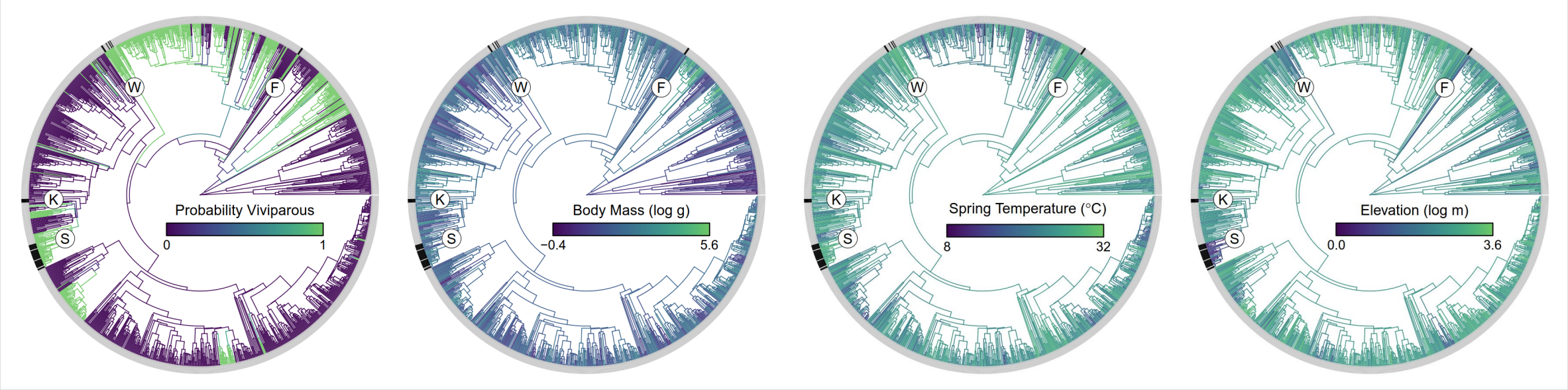
PHYLIP

VOL. 179, NO. 2 THE AMERICAN NATURALIST FEBRUARY 2012

A Comparative Method for Both Discrete and Continuous Characters Using the Threshold Model

Joseph Felsenstein*

JOINTLY ESTIMATE OTHER TRAITS AND ENVIRONMENTAL VARIABLES



(F) File snakes

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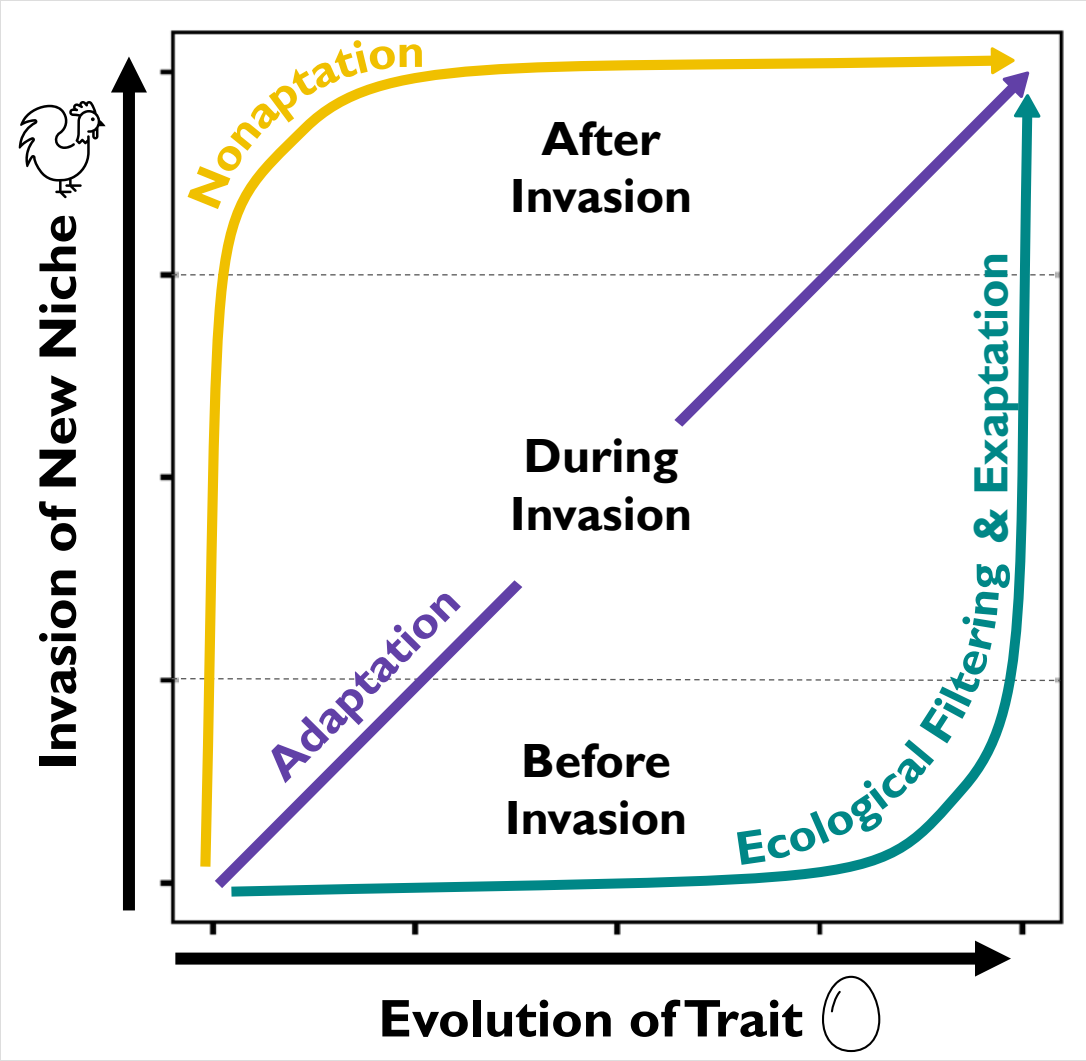
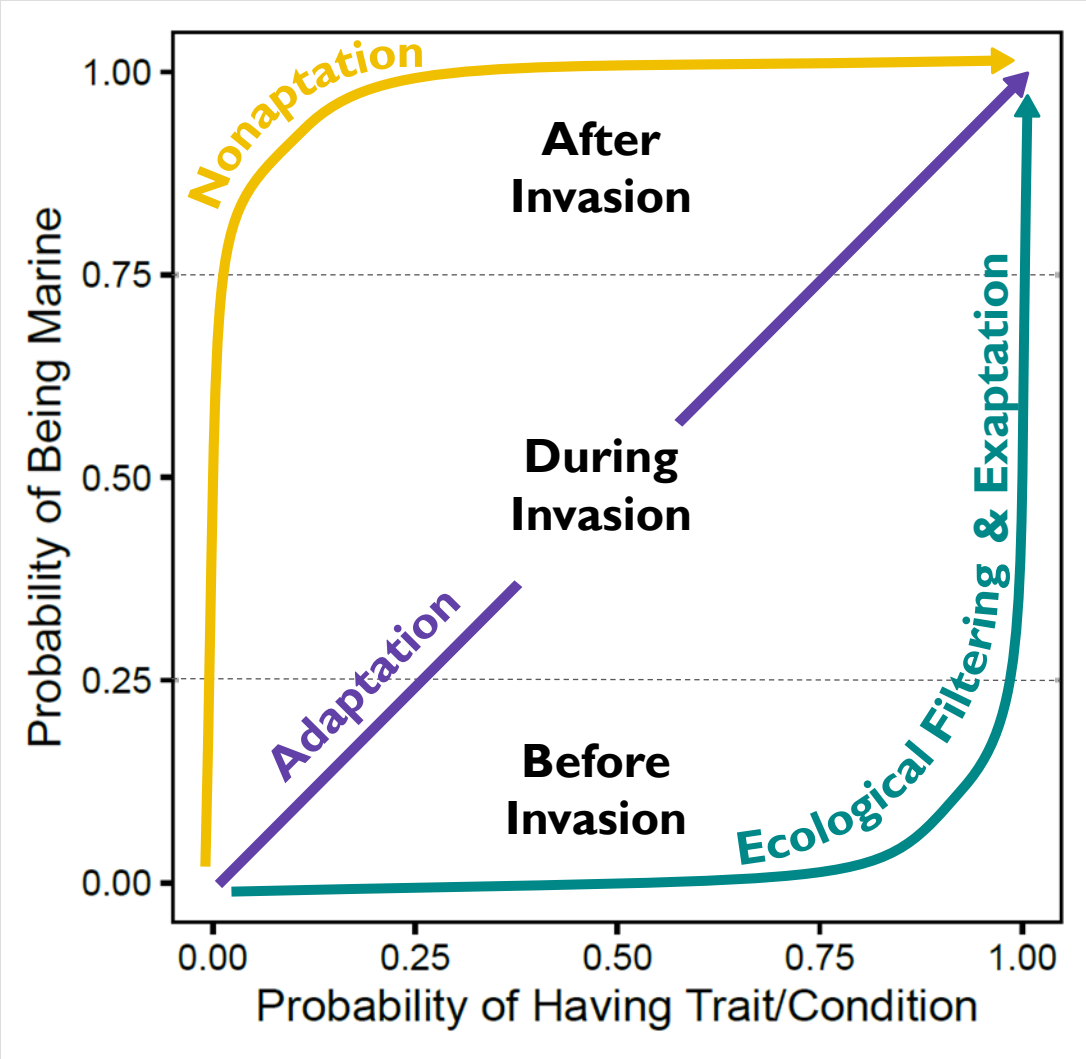
Gearty, Carrillo, and Payne 2021, *The American Naturalist*

TRAIT EVOLUTION ACROSS MARINE INVASIONS



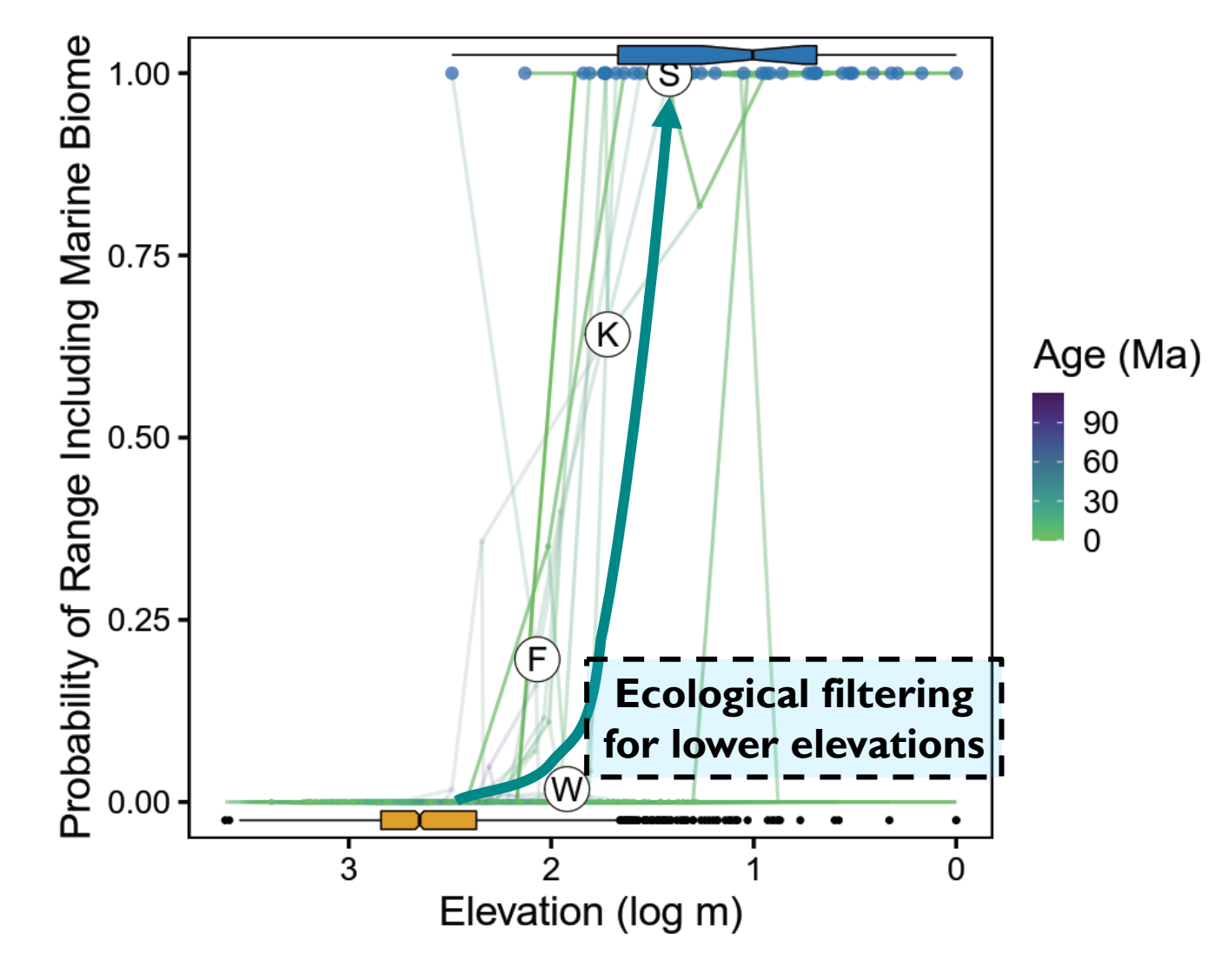
Modified from Gearty, Carrillo, and Payne 2021, *The American Naturalist*

TRAIT EVOLUTION ACROSS MARINE INVASIONS



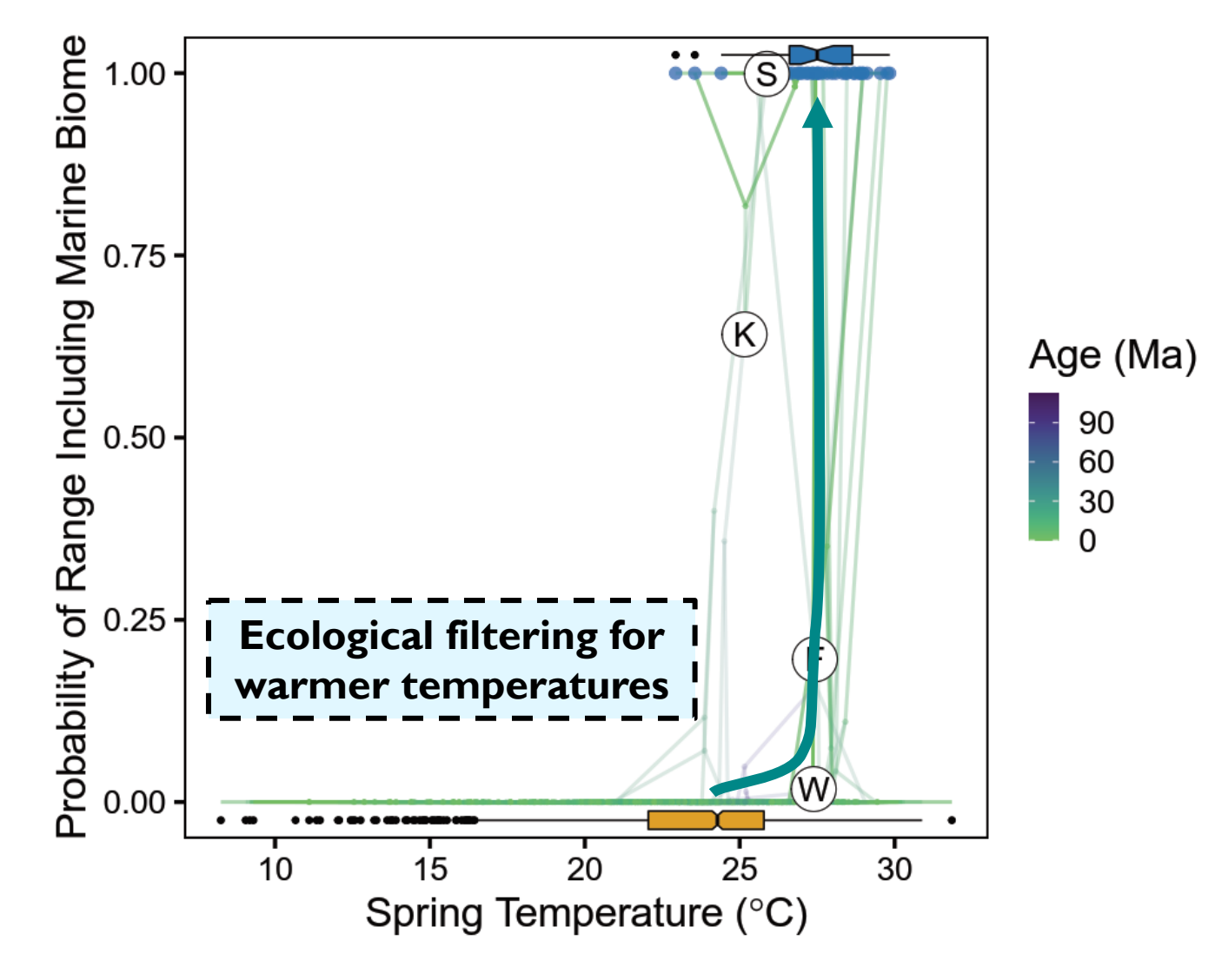
Modified from Gearty, Carrillo, and Payne 2021, *The American Naturalist*

ELEVATION



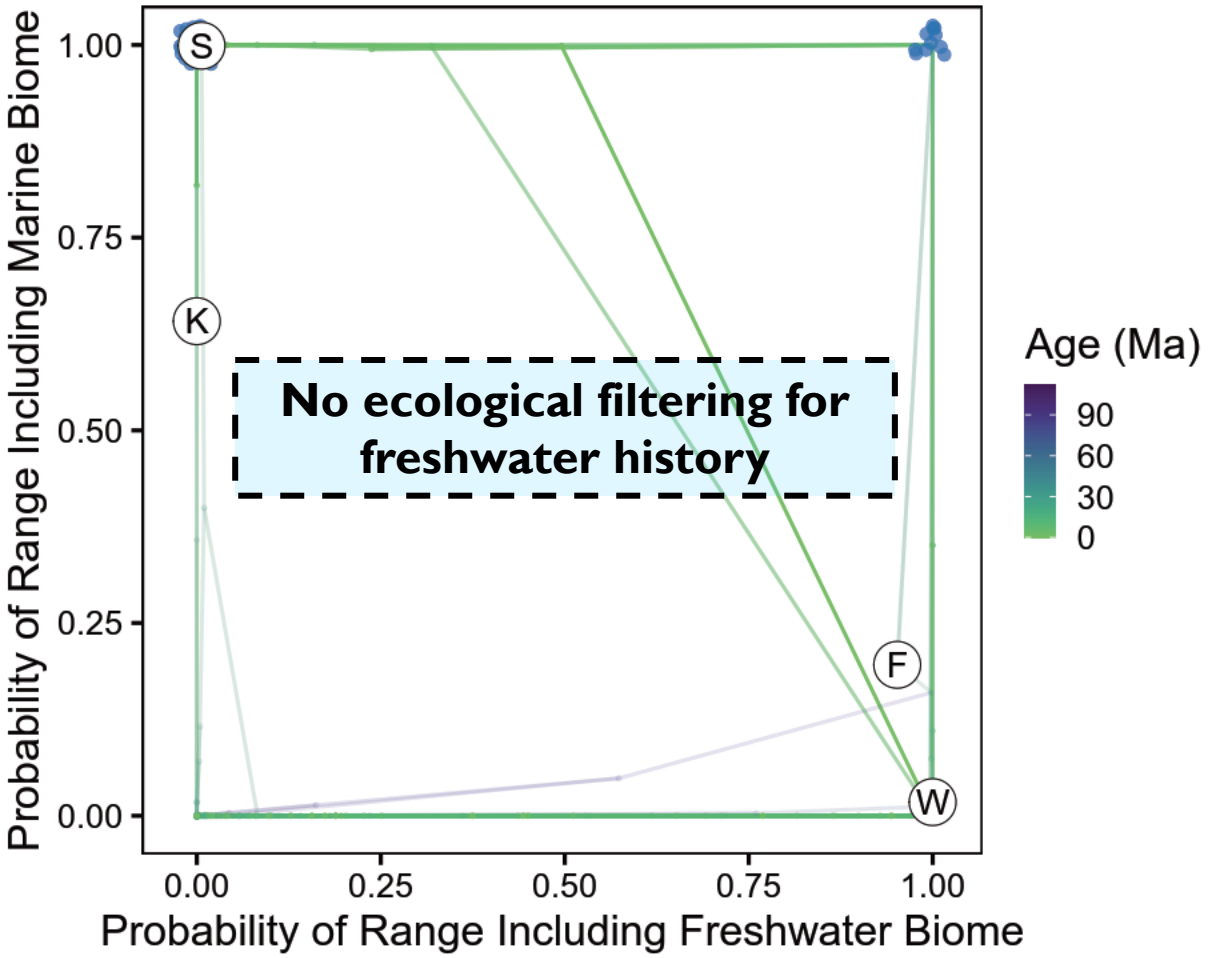
Gearty, Carrillo, and Payne 2021, *The American Naturalist*

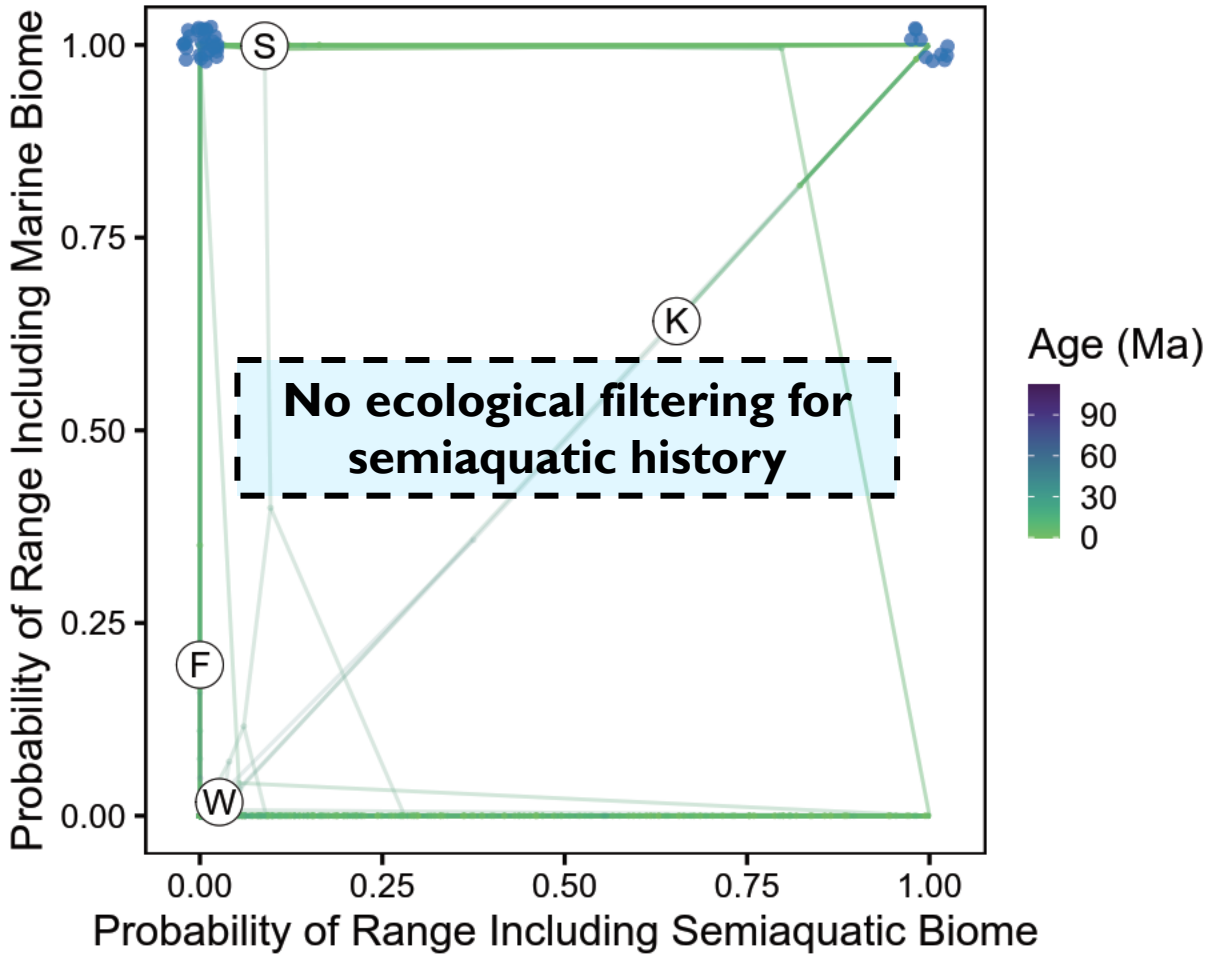
TEMPERATURE



Gearty, Carrillo, and Payne 2021, *The American Naturalist*

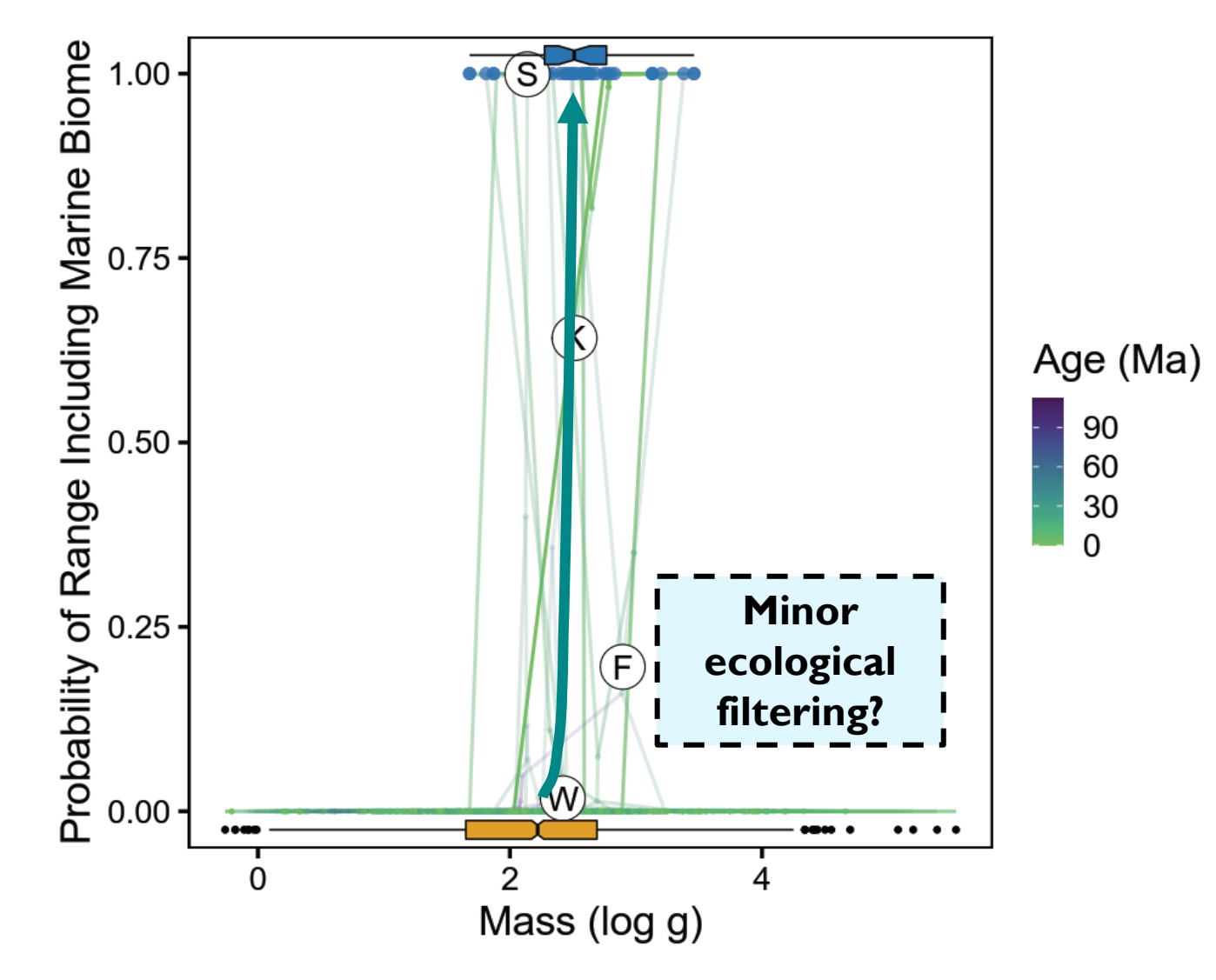
PREVIOUS AQUATIC HABITATS





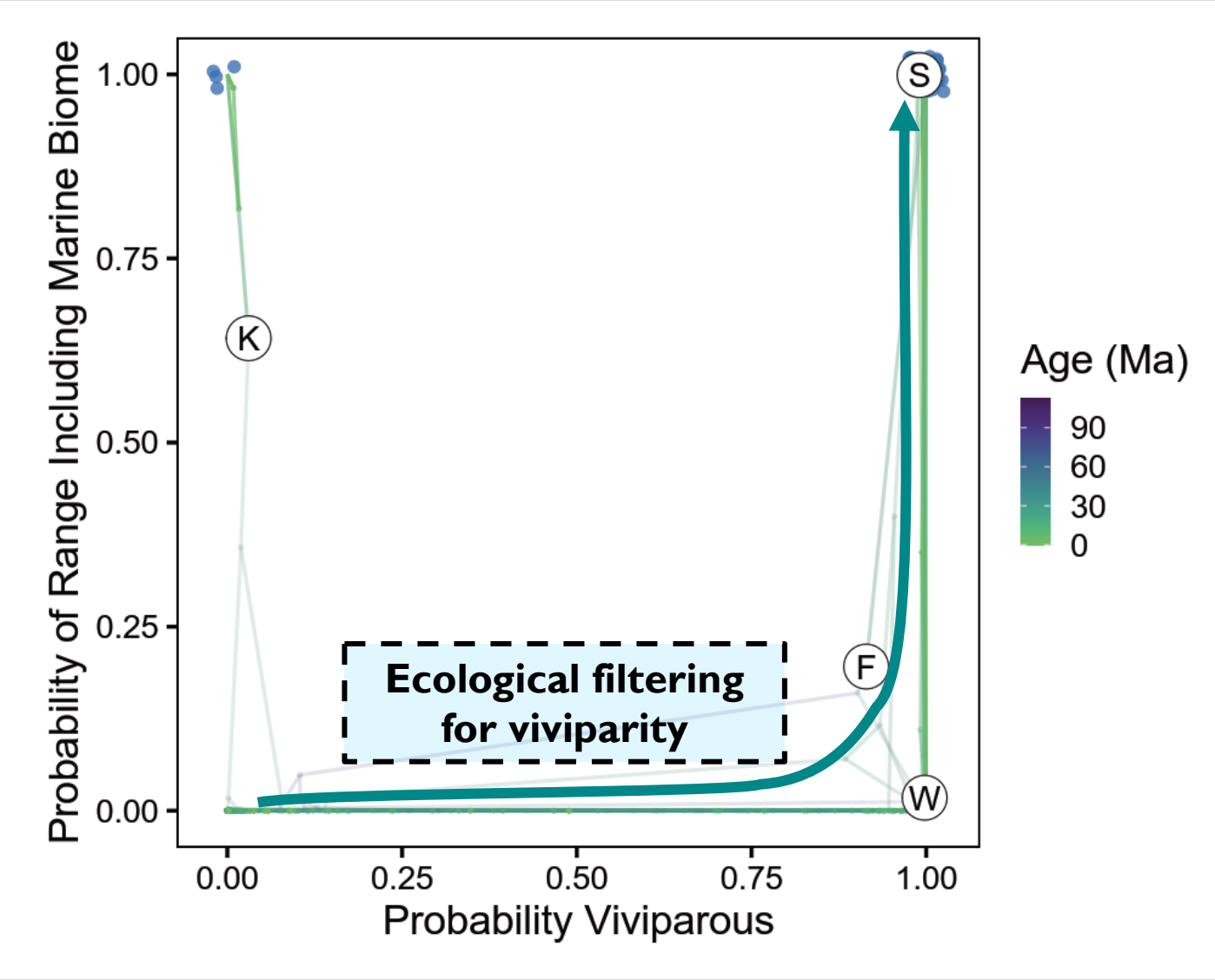
Gearty, Carrillo, and Payne 2021, *The American Naturalist*

BODY MASS



Gearty, Carrillo, and Payne 2021, *The American Naturalist*

VIVIPARITY



Gearty, Carrillo, and Payne 2021, *The American Naturalist*

TAKEAWAYS

- **Viviparity** may be the most important "preadaptation" to invading the marine realm for snakes
  - **Strong ecological filtering** in all but one invasion lineage
  - Previously evolved as an **adaptation** for **climate control** during development
  - **Exapted** for **preventing suffocation** during development
- Marine invasions originated from many different habitats
  - Former habitat **did not need to be aquatic**
  - Former habitat must have been in **tropical regions at low elevation**
    - This **reduces the need for larger body sizes** (although there is still some minor ecological filtering)

ACKNOWLEDGMENTS

Elsie Carrillo

Christianne Orsmby

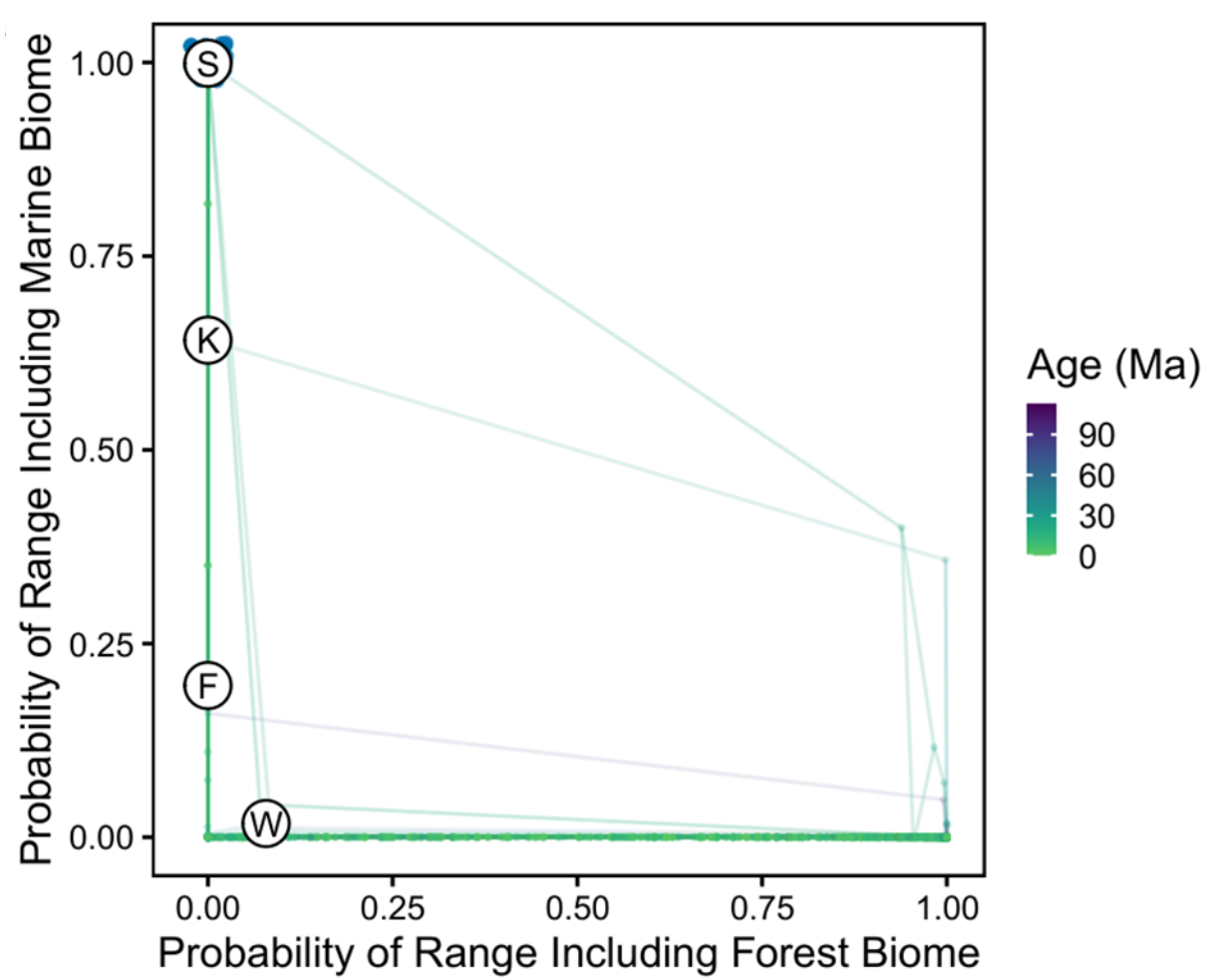
Jonathan Payne

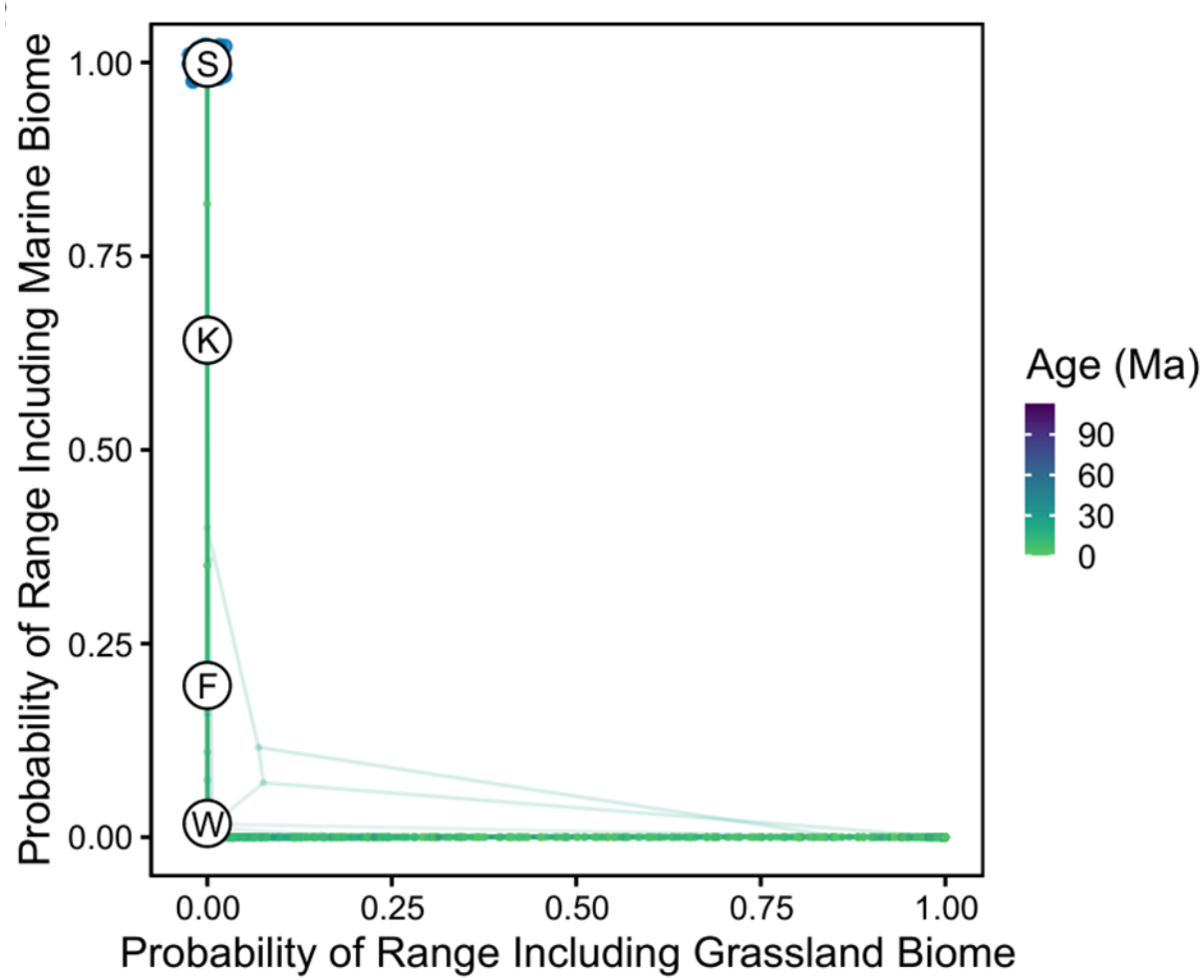
Payne Paleobiology Lab

Lyons Paleoecology Lab

Wagner Paleobiology Lab

OTHER BIOMES





Gearty, Carrillo, and Payne 2021, *The American Naturalist*