

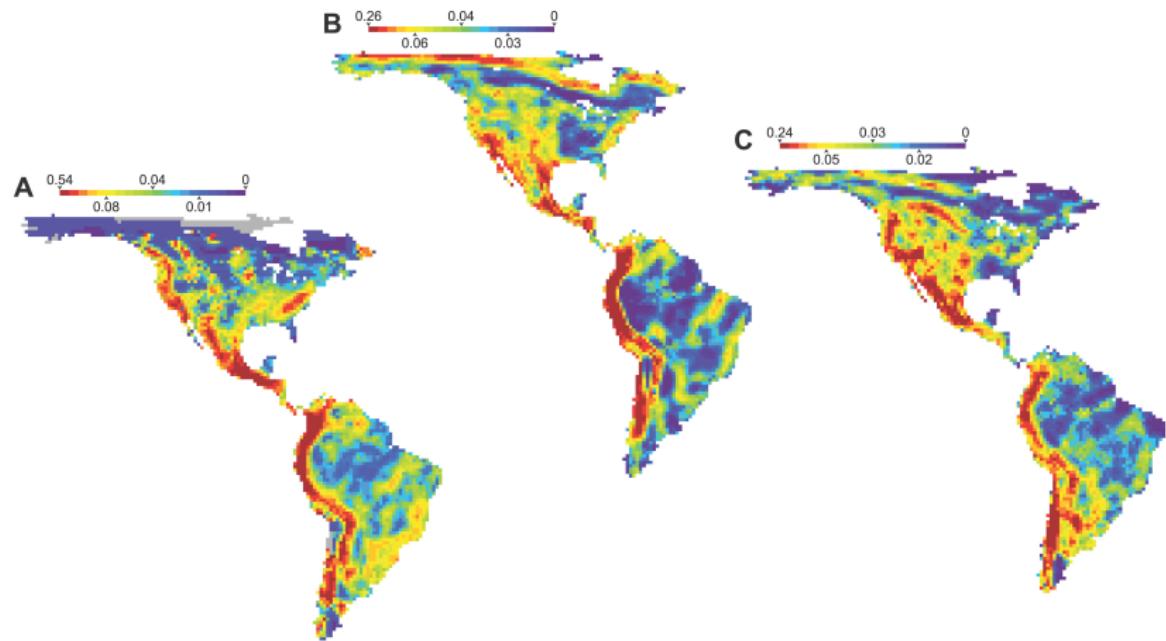


The evolution of elevational specialization (and why studying it is hard)

Ethan B. Linck

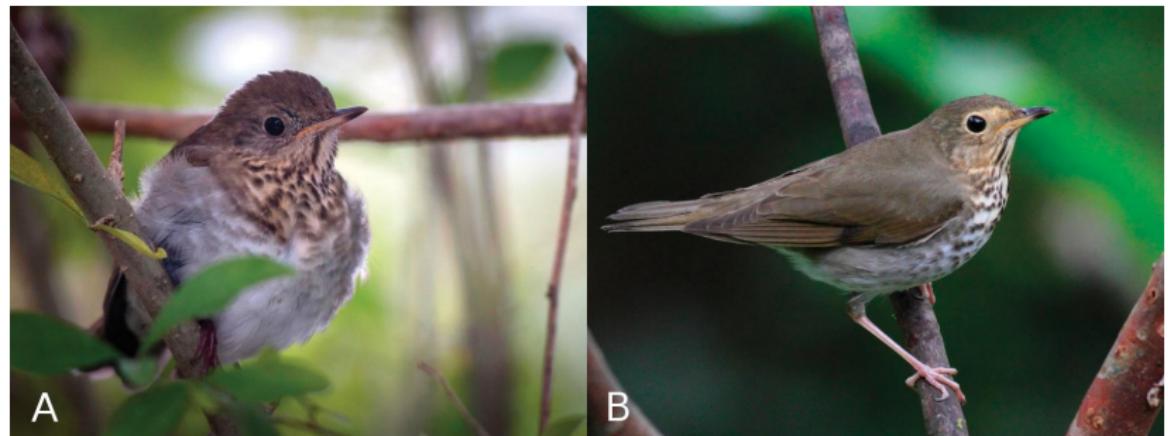
University of New Mexico
Department of Biology & Museum of Southwestern Biology

Big Pattern: β diversity and elevation



(McKnight et al. 2007)

Elevational specialization



(Freeman & Montgomery 2015)

Big Questions

- ▶ What are the evolutionary *causes* of elevational specialization?
- ▶ What are its possible *consequences*?
- ▶ (Why is this such a hard question to study?)

Littler Question 1: Does parapatric speciation generate β diversity?

Acknowledgements:

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- ▶ **Funding:** NSF DDIG #1701224, NSF DEB #0108247, and NDSEG and WRF-Hall Fellowships

Elevational replacements

FEATURES OF THE EASTERN HIGHLANDS

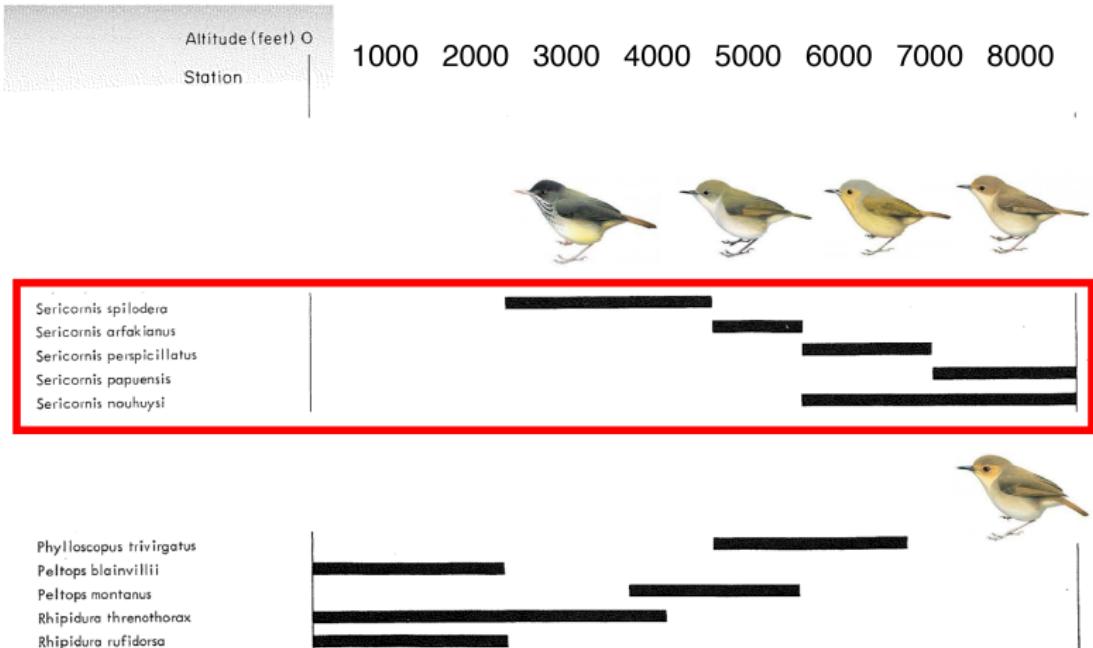
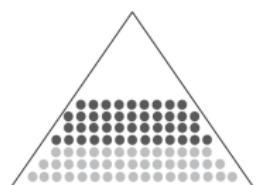
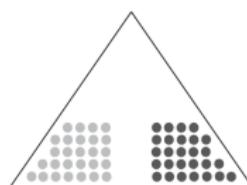
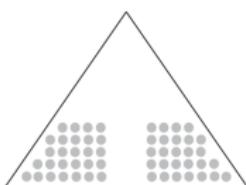
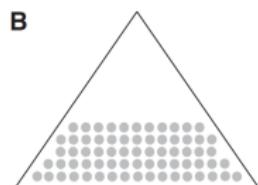
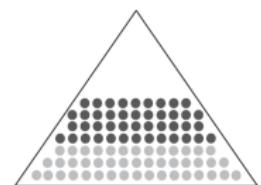
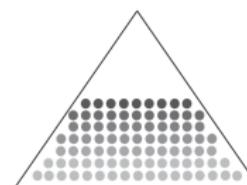
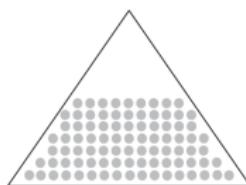
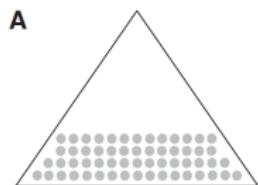


FIG. 4 (cont.). Altitudinal ranges of 166 species in the Karimui area.

(Diamond 1972)

Alternate paths to the same result

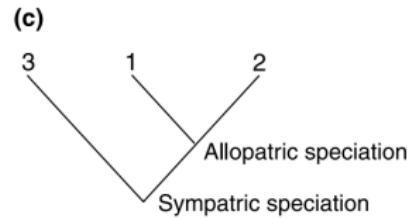
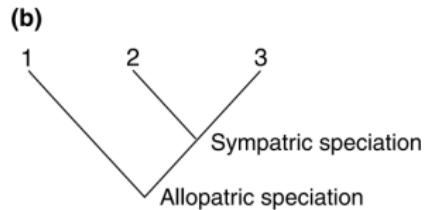
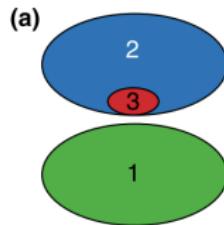


common ancestor

intermediate divergence

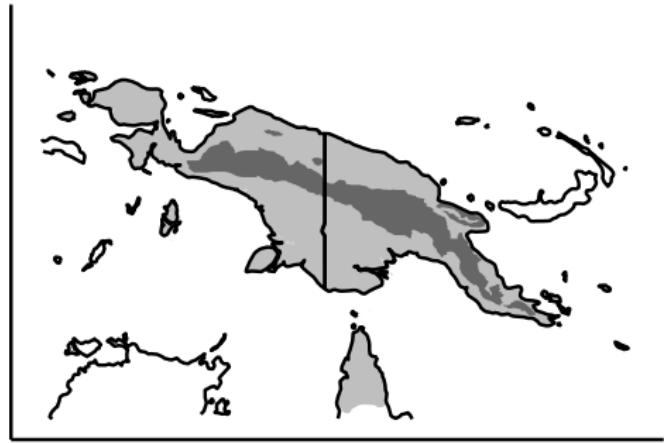
speciation

Phylogeny and the geography of speciation



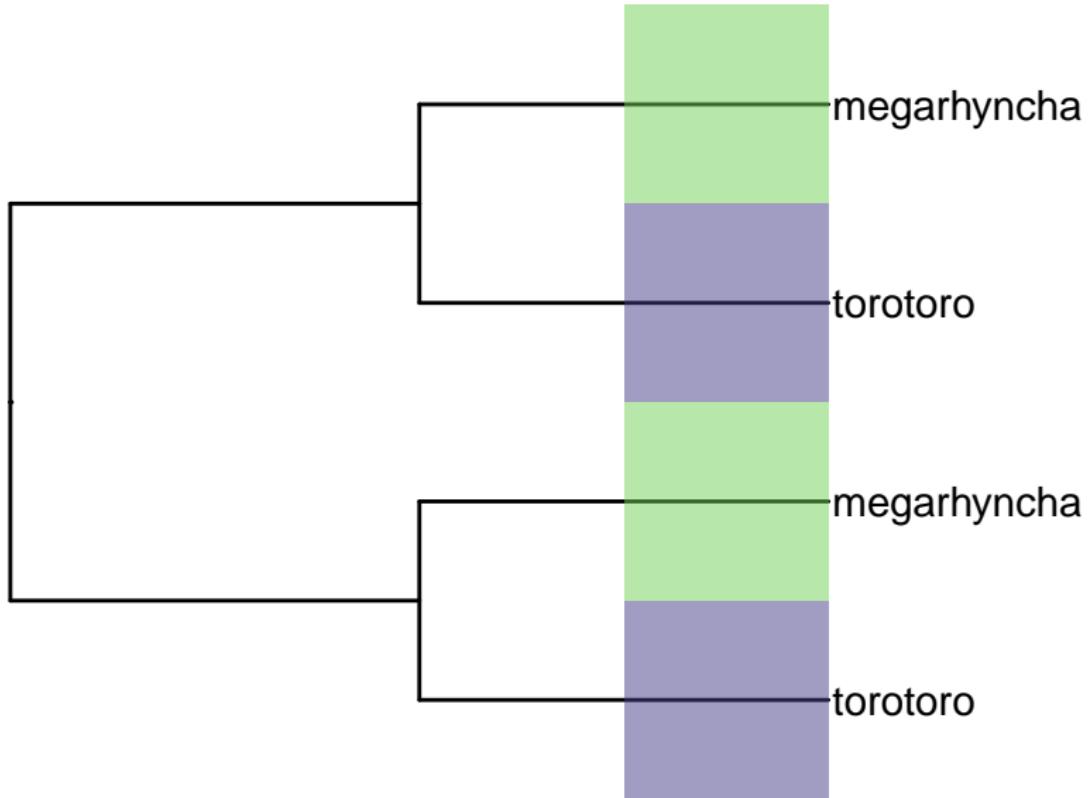
(Losos & Glor 2003)

Syma kingfishers as natural experiment



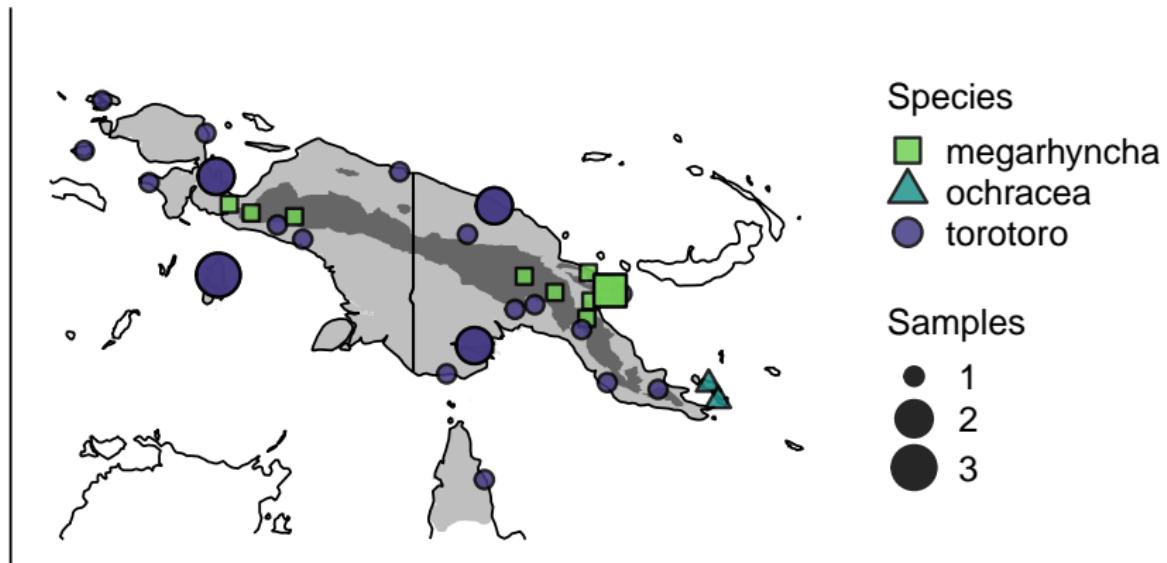
(art by Kevin Epperly)

H_1 : Parallel parapatric speciation

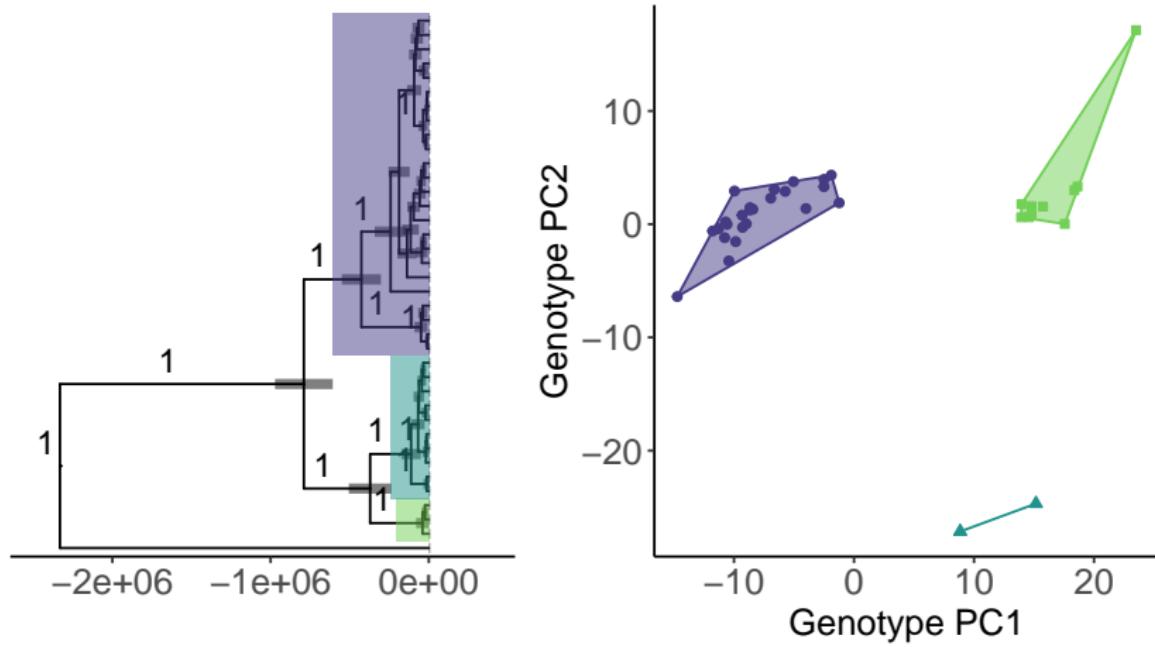


Methods

- ▶ mtDNA and nuclear DNA from fresh and historic tissues
- ▶ phylogenetic inference, clustering, and demographic modeling



No evidence for parallel parapatric speciation



(Linck, Freeman, & Dumbacher 2020)

We conclude: speciation in allopatry is more likely (but parapatric speciation is possible, and gene flow was involved)

Why it's unsatisfying:

"Formal hypotheses generally cannot usefully be posed in a way that allows meaningful disproof of a finite number of discrete possibilities" (Quinn & Dunham 1983, "On Hypothesis Testing in Ecology and Evolution", *The American Naturalist*)

Why it's unsatisfying, part 2:

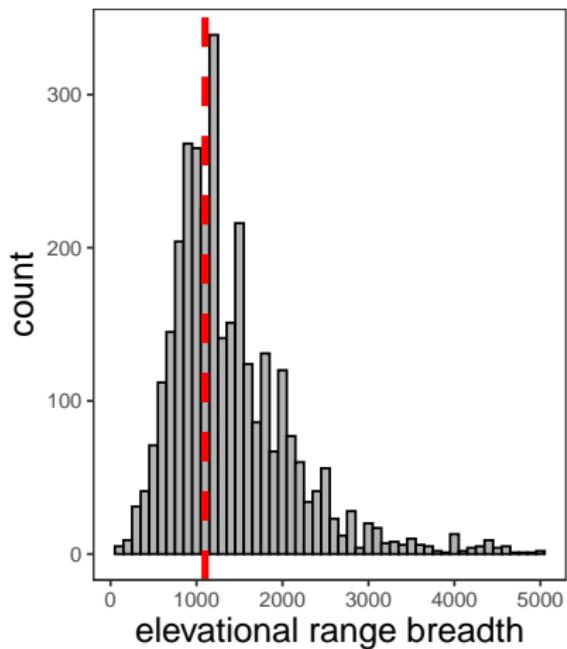
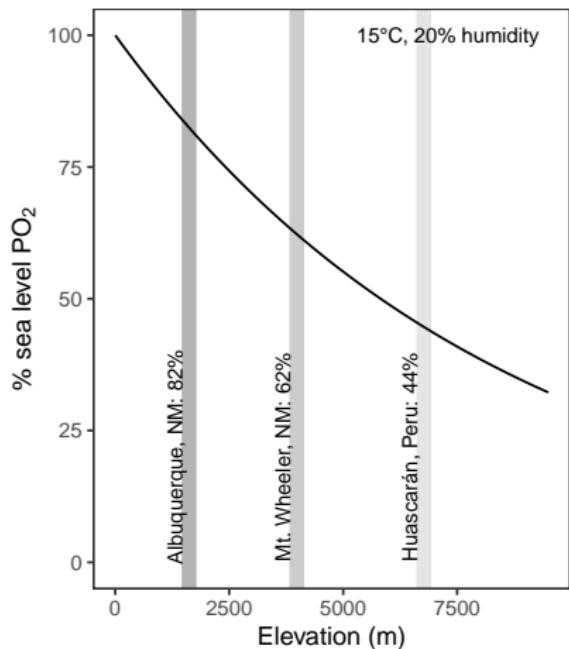
"Physicists and chemists often have genuine difficulty in understanding the biologist's stress of the unique... individuality [is] so characteristic of the organic world, where all individuals are unique; all stages in the life cycle are unique; all populations are unique; all species and higher categories are unique; all interindividual contacts are unique; all natural associations of species are unique; and all evolutionary events are unique"
(Mayr 1961, "Cause and Effect in Biology", *Science*)

Littler Question 2: Does physiology limit elevational ranges?

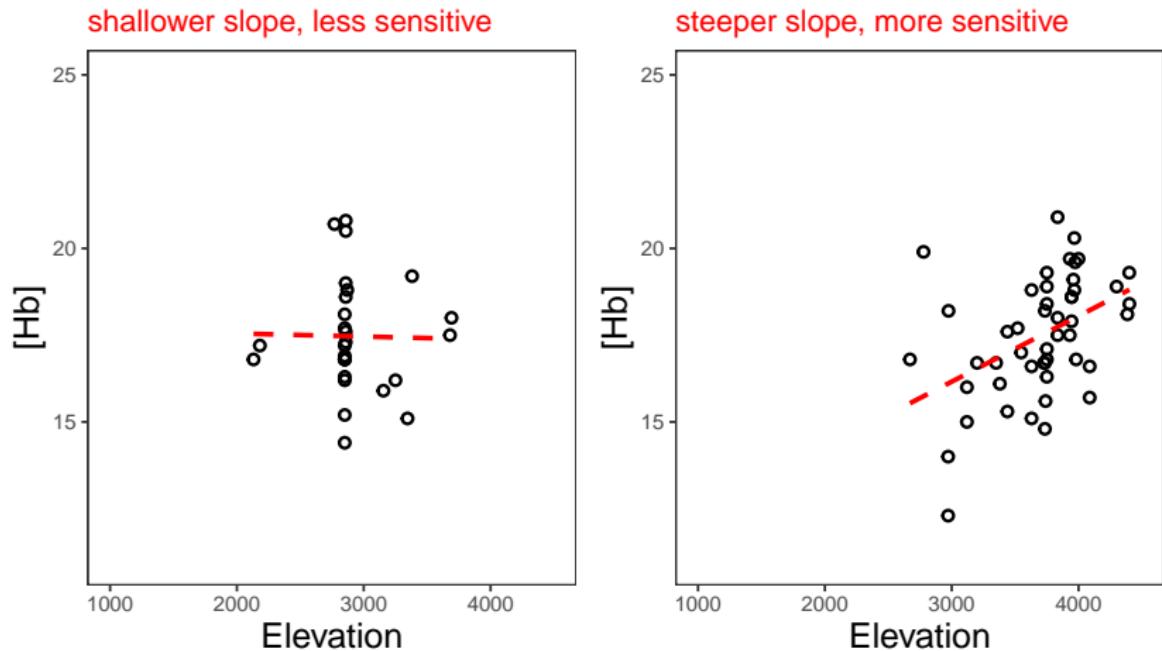
Acknowledgements:

- ▶ **Collaborators and Coauthors:** Jessie L. Williamson, Emil Bautista, Elizabeth J. Beckman, Phred M. Benham, Shane G. DuBay, L. Monica Flores, Chauncey R. Gadek, Andrew B. Johnson, Matthew R. Jones, Jano Núñez-Zapata, Alessandra Quiñonez, C. Jonathan Schmitt, Dora Susanibar, Jorge Tiravanti C., Karen Verde-Guerra, Natalie A. Wright, Thomas Valqui, Jay F. Storz, Christopher C. Witt
- ▶ **Funding:** NSF DBI #1907353, DEB #1146491, and DEB #0543556

Blood O_2 -carrying capacity and elevational specialization



Respiratory “plasticity” (sensitivity)

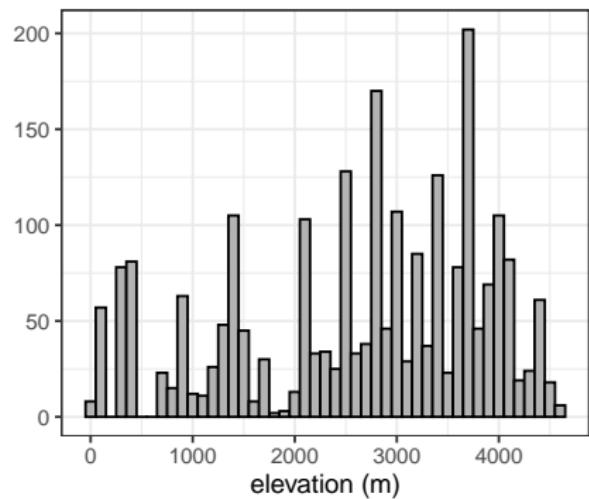
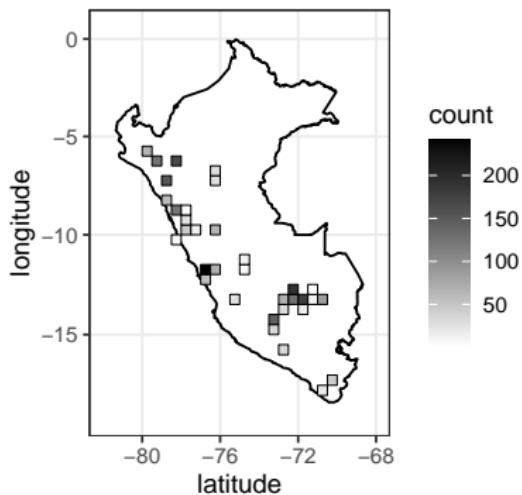


H_1 : Respiratory sensitivity facilitates niche breadth

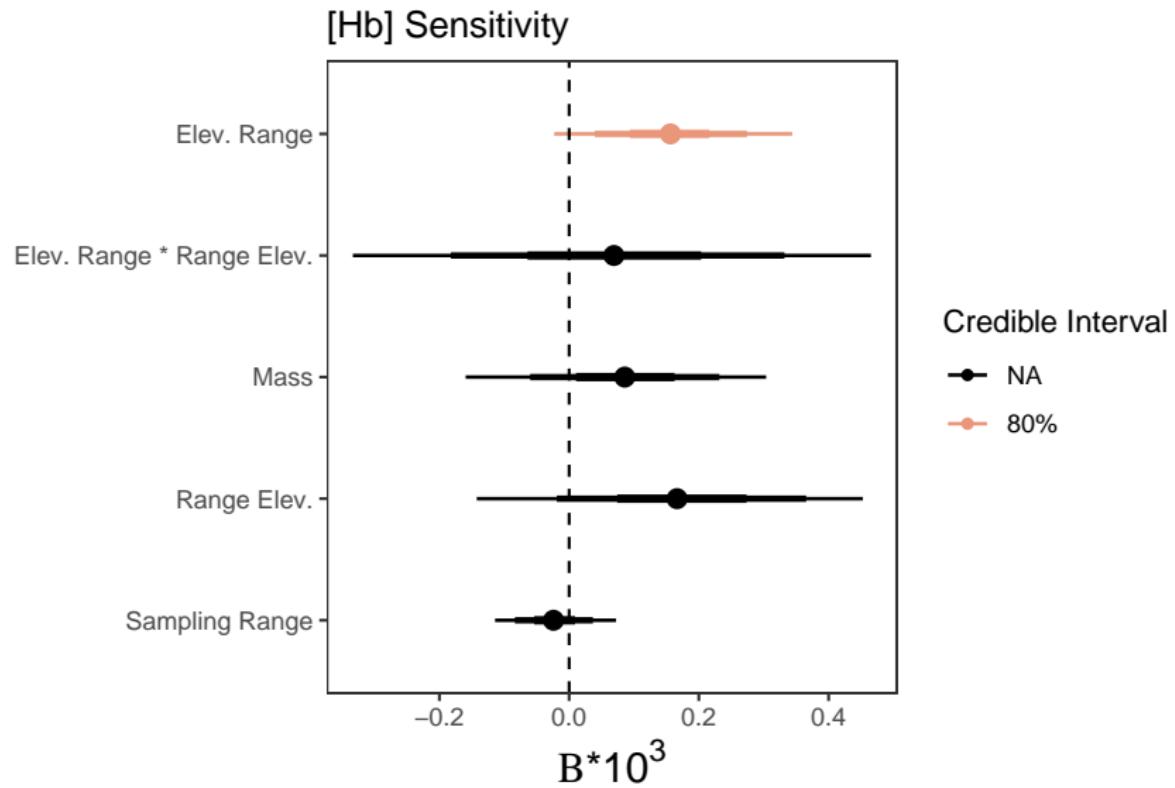


Methods

- ▶ [Hb] from 2367 individuals of 137 species
- ▶ Bayesian multivariate linear models



Elevational generalists are more sensitive



(Linck et al. *In review*)

We conclude: respiratory sensitivity may facilitate elevational range expansion—even if broad elevational ranges aren't stable in the long term
(Gadek et al. 2017)

Why it's unsatisfying:

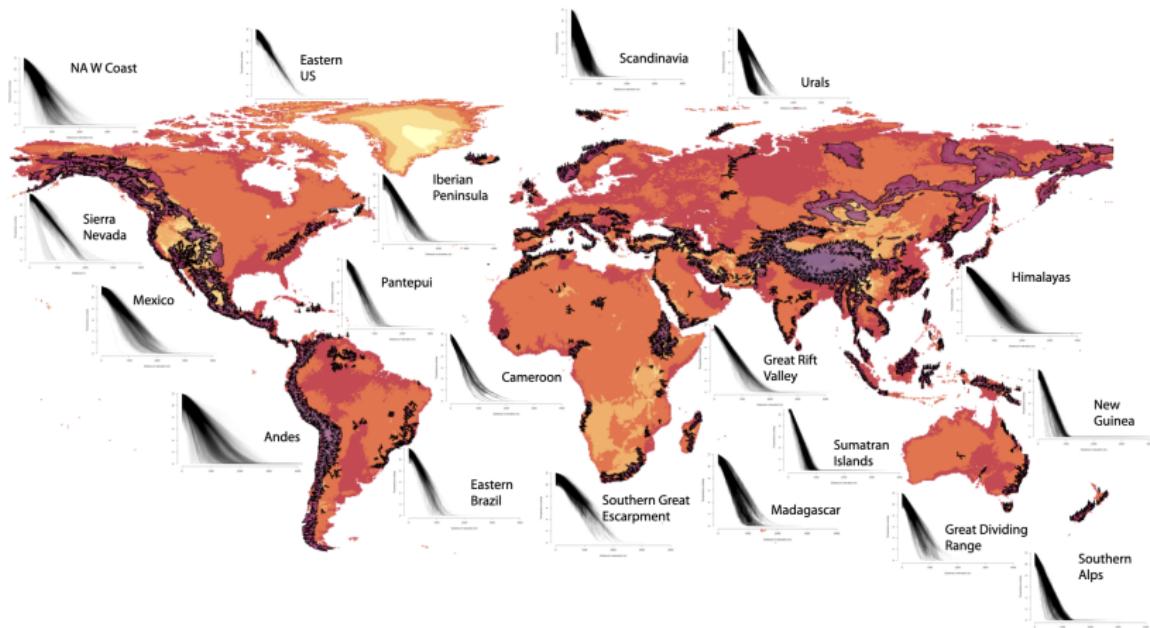
"However if many causes contribute to an observed pattern, none will be eliminated from consideration by a properly designed experiment... The objective of investigation in cases of this sort is not to determine the single cause of a pattern, as no such cause exists, but rather to assign relative importances to the contributions of, and interactions between, a number of processes, all known or reasonably suspected of operating to some degree" (Quinn & Dunham 1983)

What does the evolution of elevational specialization tell us about adaptation to climate change?

Acknowledgements:

- ▶ **Collaborators and Coauthors:** Daniel Cadena, Cameron Ghalambor, Ben Freeman, Ignacio Quintero, Juan Parra
- ▶ **Funding:** NSF DBI #1907353, IOS-1457383, DEB-1754821; Banting Postdoctoral Fellowship #379958; University of British Columbia Biodiversity Research Centre Fellowship

Seasonality and conservatism across the globe

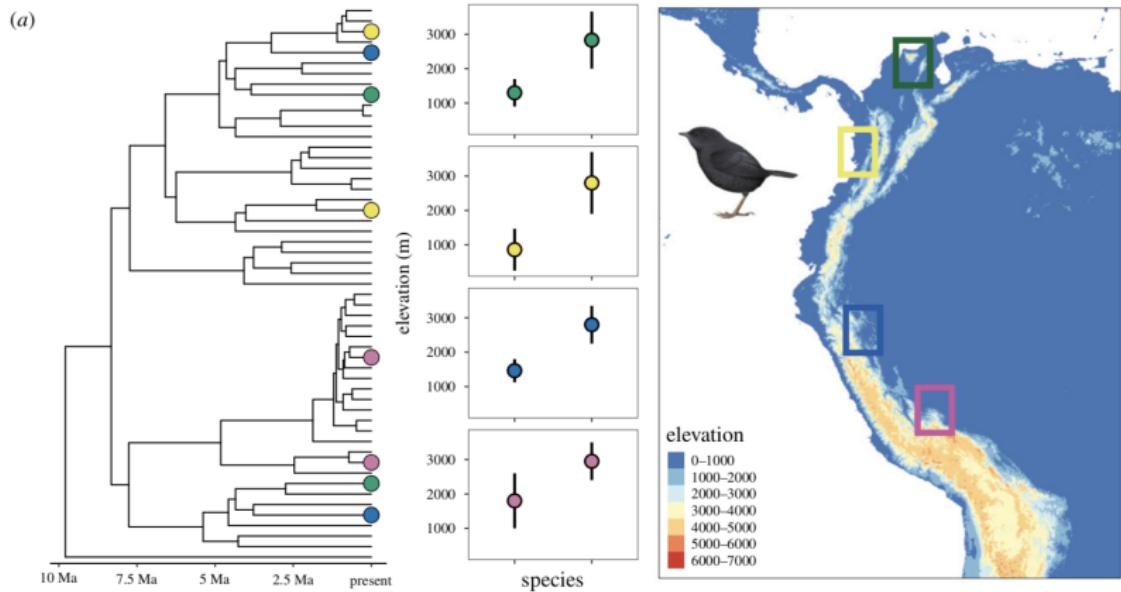


Cadena et al. *In prep*

Possible lines of evidence

- ▶ **Evolutionary rate of elevational niche shifts**
- ▶ Responses to past climatic changes
- ▶ Rate of upslope movement across latitude

Niche shifts take time



(Cadena & Céspedes 2020; Linck et al. 2021)

We infer: if elevational range shifts take millions of years in tropical birds, adaptation to new climate niches also a slow process

Why it's unsatisfying:

"A theory can predict to the extent to which it can describe and explain." It is evident [the source of this quote] is a physicist; no biologist would have made such a statement. The theory of natural selection can describe and explain phenomena with considerable precision, but it cannot make reliable predictions, except through such trivial and meaningless circular statements" (Mayr 1961)

Biology progresses through incrementally better questions

- ▶ How often do elevational replacements hybridize?
- ▶ What role does genetics play in blood trait plasticity?
- ▶ Are there other genetic constraints on elevational ranges?
- ▶ How do rates of elevational niche evolution compare to geographic range evolution more broadly?
- ▶ What forces lead to niche conservatism?

Thanks!



(Yellow-breasted satinbird, 625-2000m)

Resources

- ▶ slides & code:
https://github.com/elinck/andean_range_limits/
- ▶ website: <https://elinck.org/>
- ▶ twitter: @ethanblinck