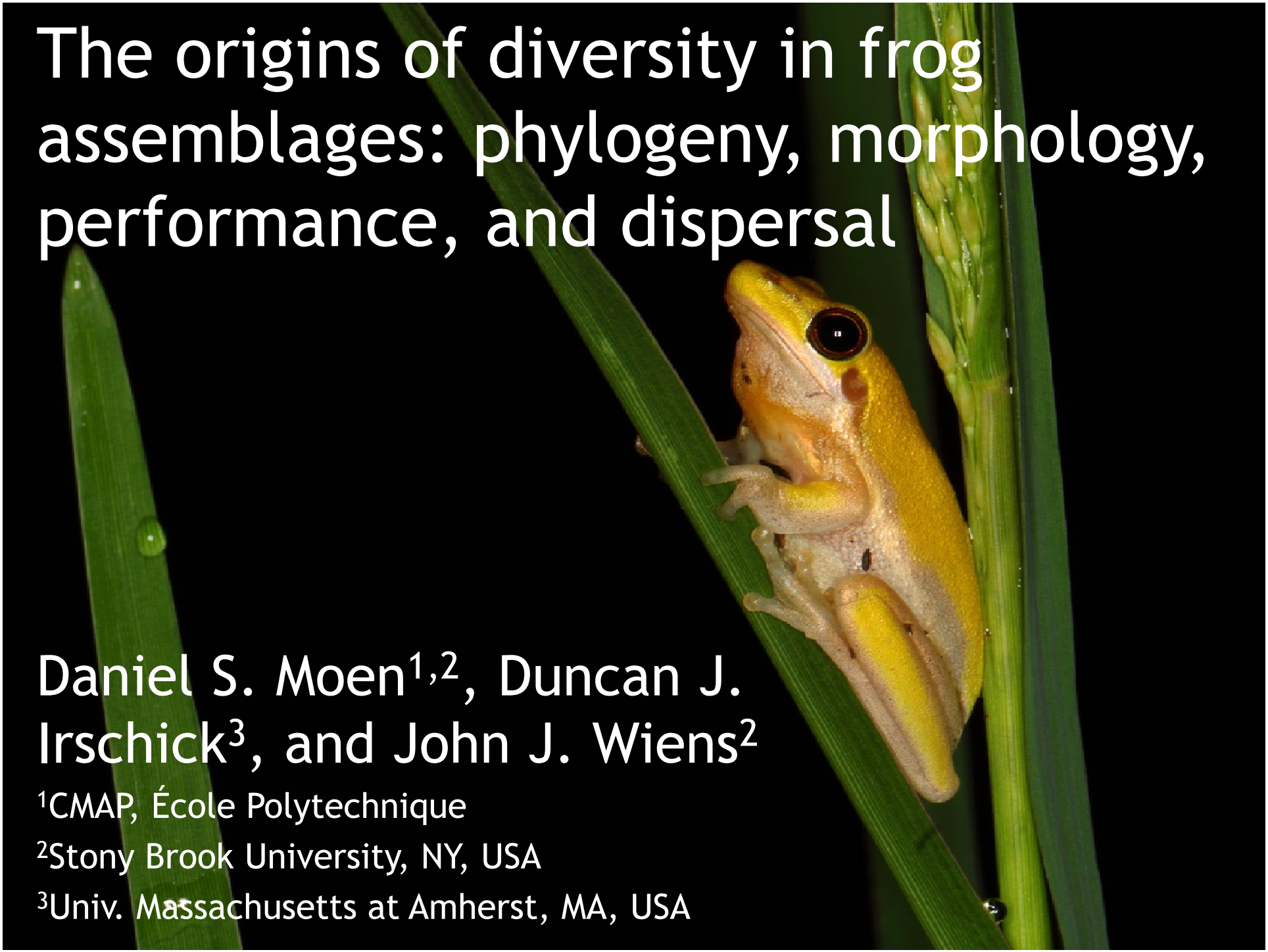
The origins of diversity in frog assemblages: phylogeny, morphology, performance, and dispersal



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Why do we see the phenotypic diversity that we see in a given assemblage?

(1) Environment

versus

Photo: International Polar Foundation

Why do we see the phenotypic diversity that we see in a given assemblage?

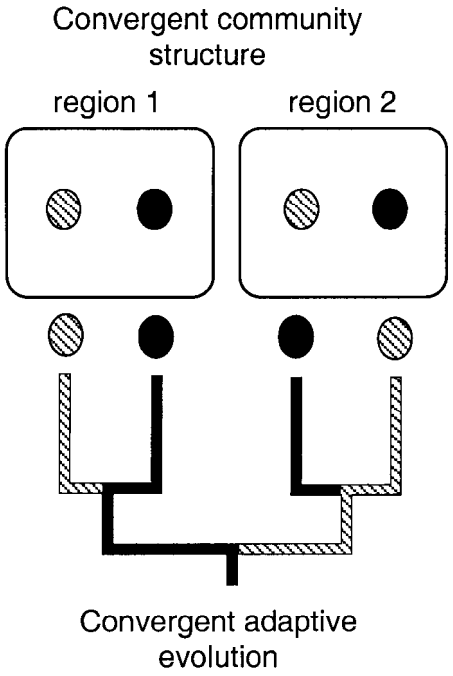
(1) Environment

(2) Import to consider how various aspects of the phenotype are related

- Ecology, morphology, and performance (Arnold 1983; Wainwright 1991)

(3) Historical biogeographic context is necessary to understand how assemblages developed (Losos 1996)

- Diversification within a given location (Schluter and McPhail 1993, Losos et al. 1998, Kornfield and Smith 2000)
- Biogeographic dispersal with little phenotypic change (Ackerly 2003, Stephens and Wiens 2004)



Diversification within a given location

Stephens and Wiens 2004

Convergent similarity across assemblages

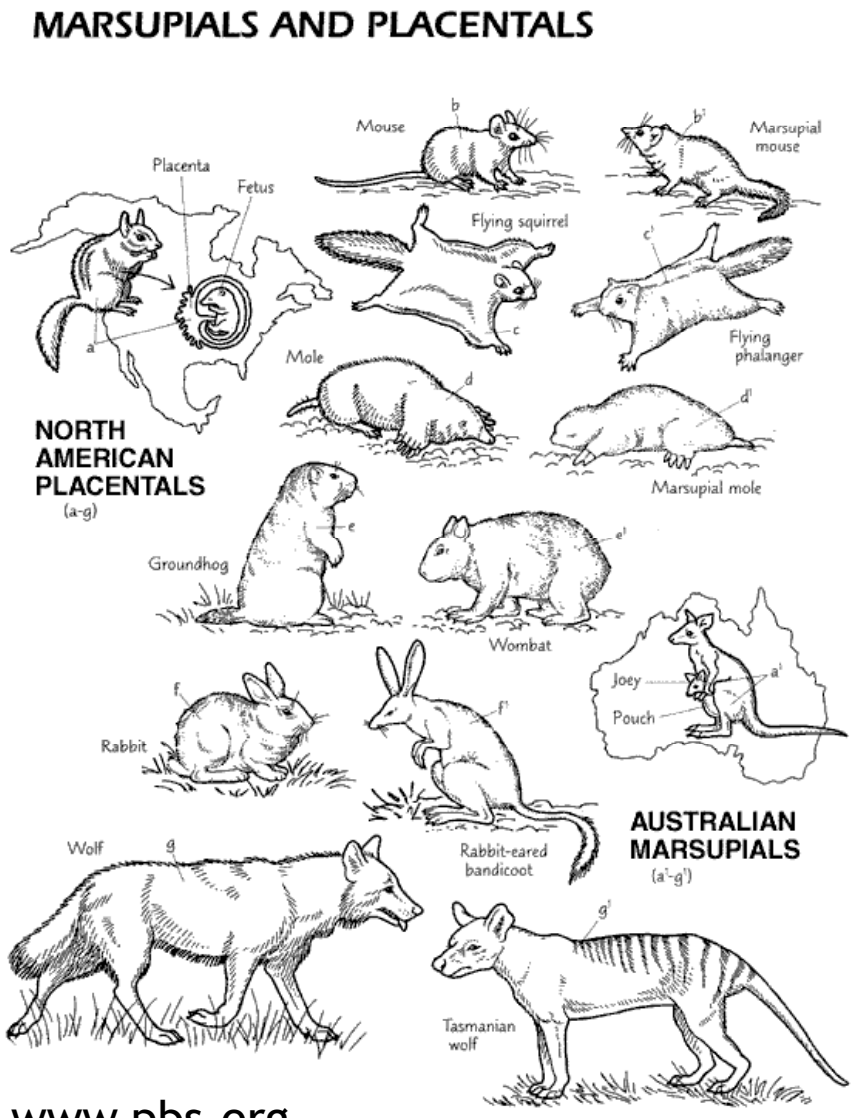


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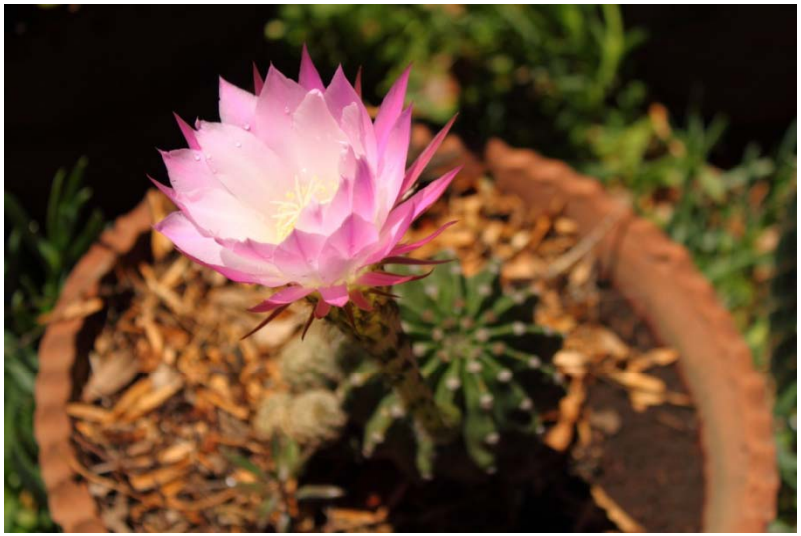
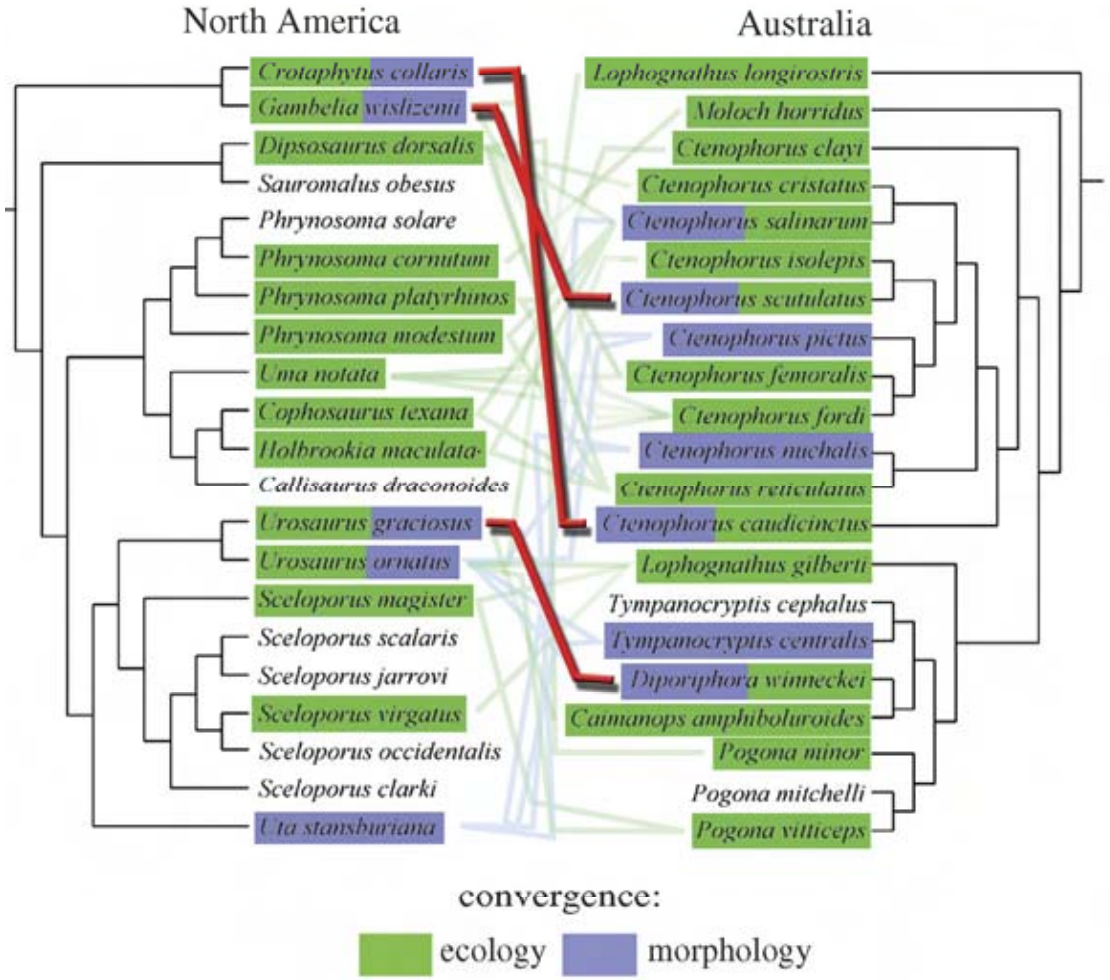
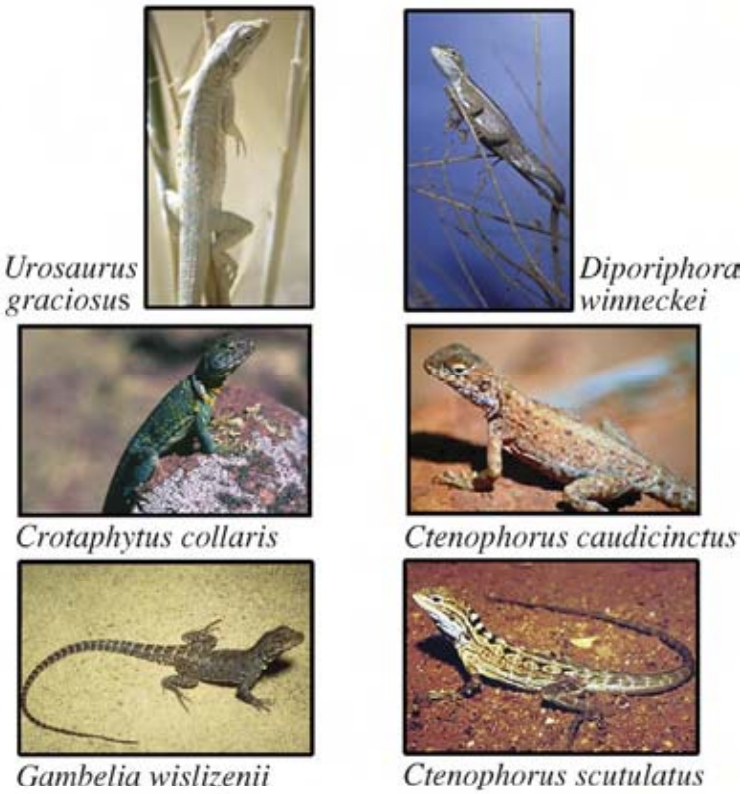
Photo: cactiguide.com

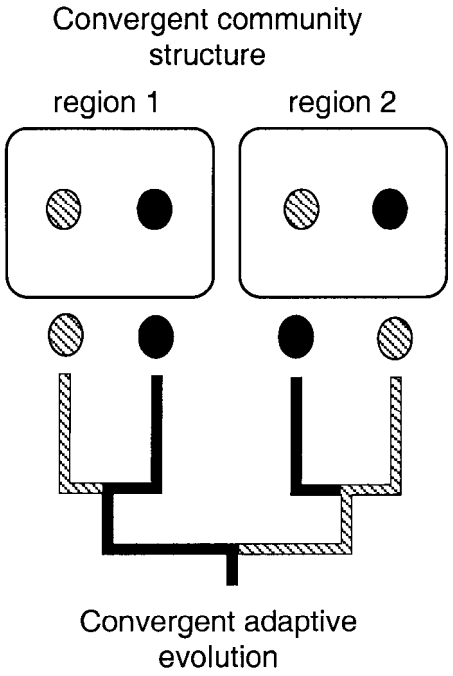


Convergent similarity across assemblages





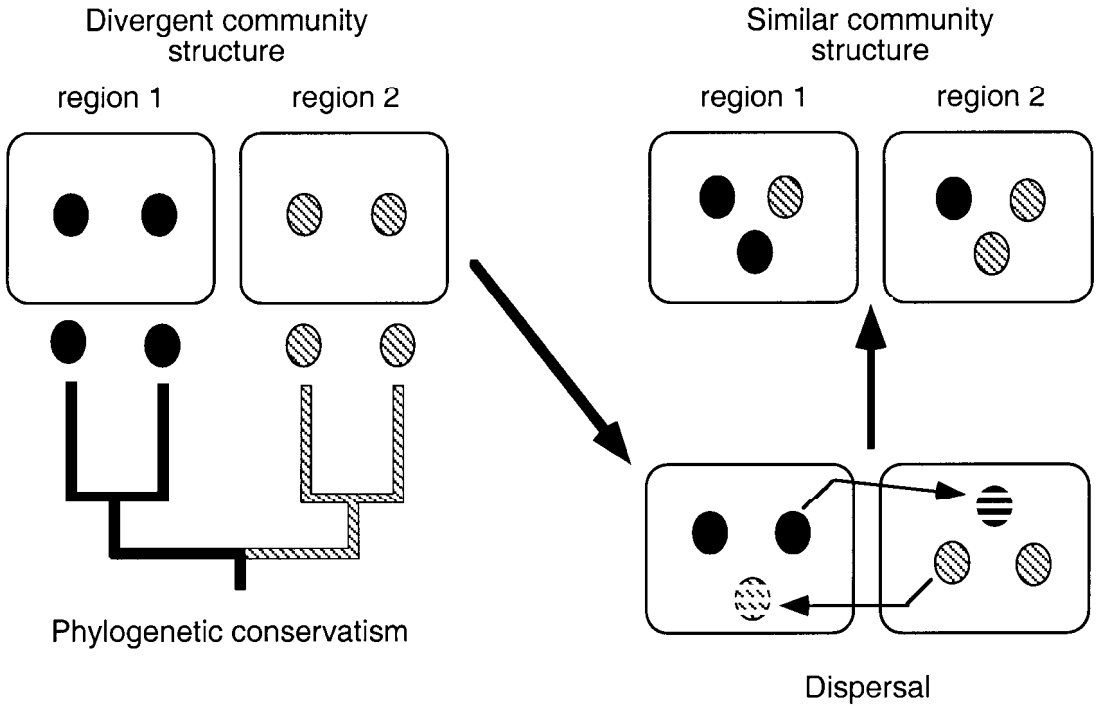
Melville et al. 2006



Diversification within a given location

?

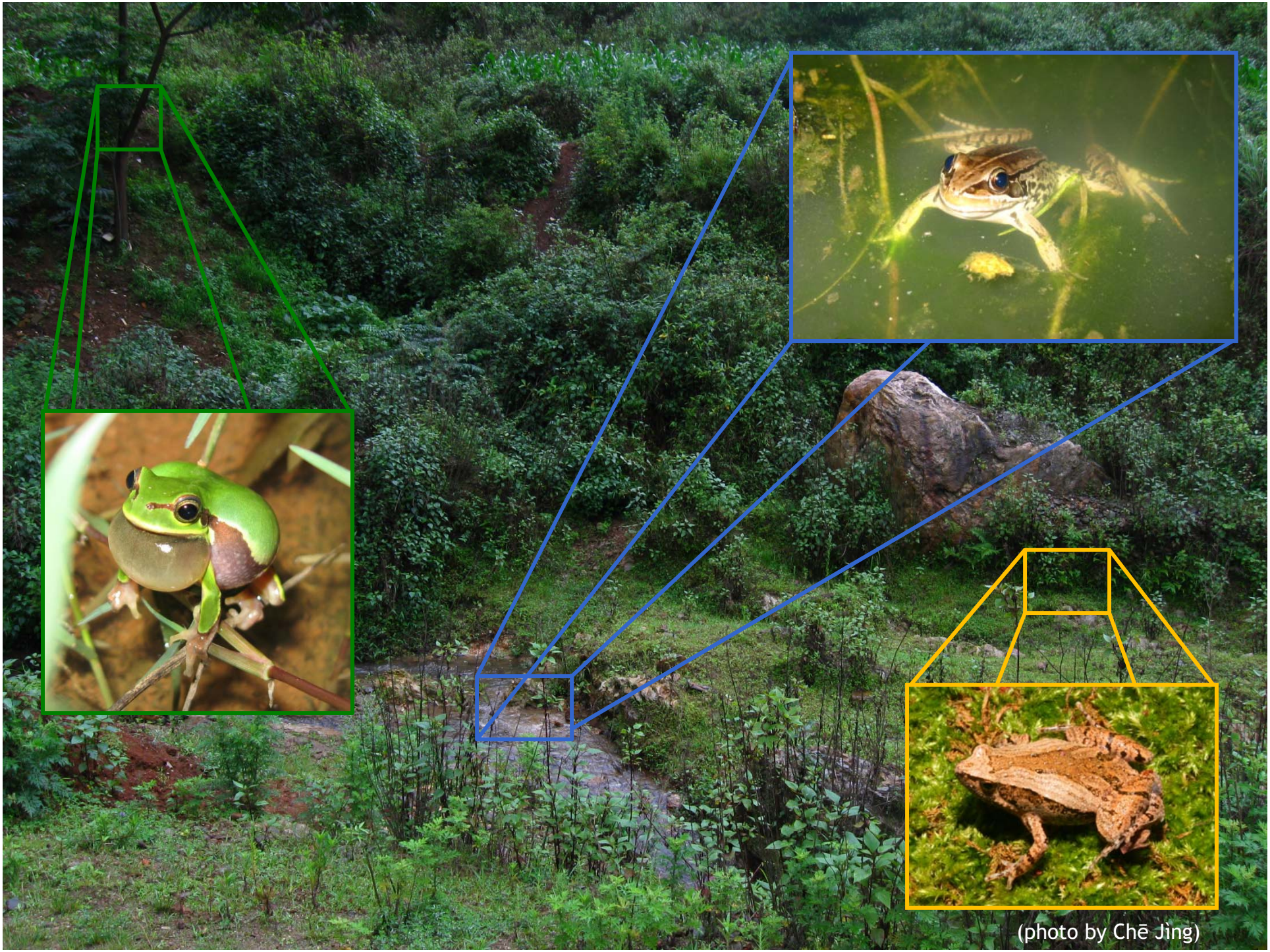
At the global scale?



?

Biogeographic dispersal with little phenotypic change

Stephens and Wiens 2004


(photo by Chē Jing)

Herein, I ask:

(1) Are species that use the same microhabitat around the world also similar in morphology and performance?

(2) Can species similarity at huge spatial and temporal scales be due to biogeographic dispersal and evolutionary conservatism?

(3) How do morphology and performance evolve in association with microhabitat transitions in an in situ radiation?

from 3 assemblages

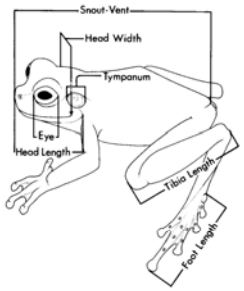
(1) Yunnan, China (near Baoshan)
(2) Amazonas, Colombia (near Leticia)
(3) Northern Territory, Australia (near Darwin)

Data: Summary

Performance

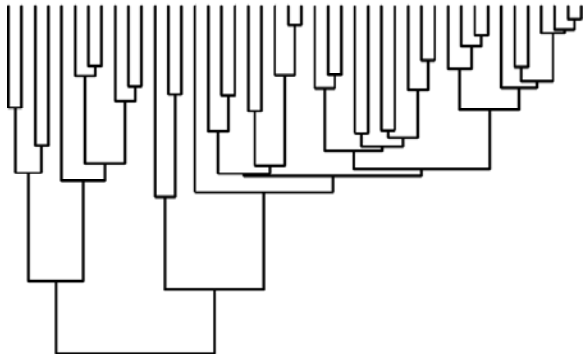
Microhabitat use

Morphology



Duellman 2001

Phylogeny



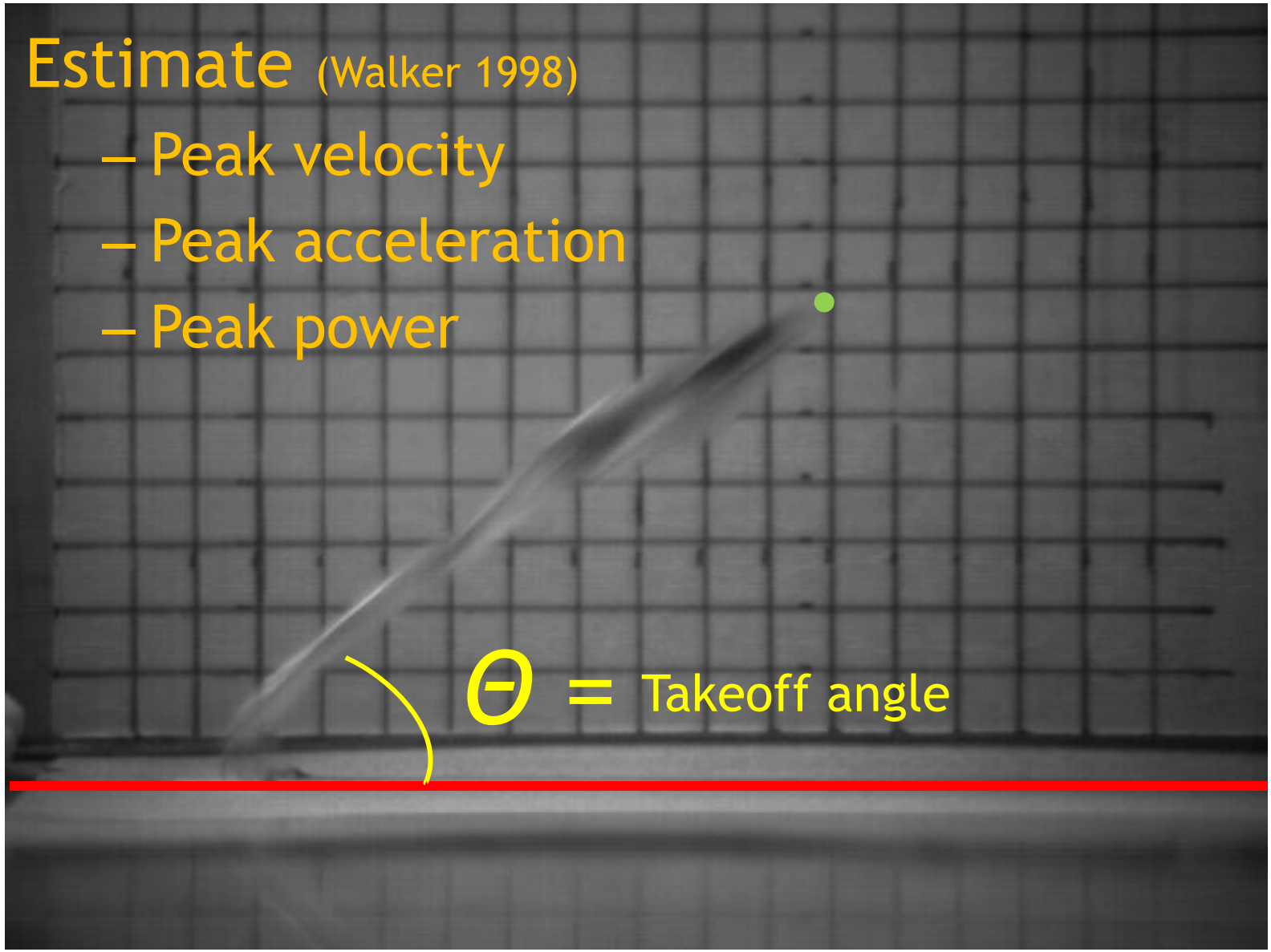
Performance data

- Examine the critical feature upon which natural selection acts
- What is important to frogs?
  - Jumping
  - Swimming
  - Clinging ability (to surfaces)
  - Terrestrial endurance
  - Burrowing ability

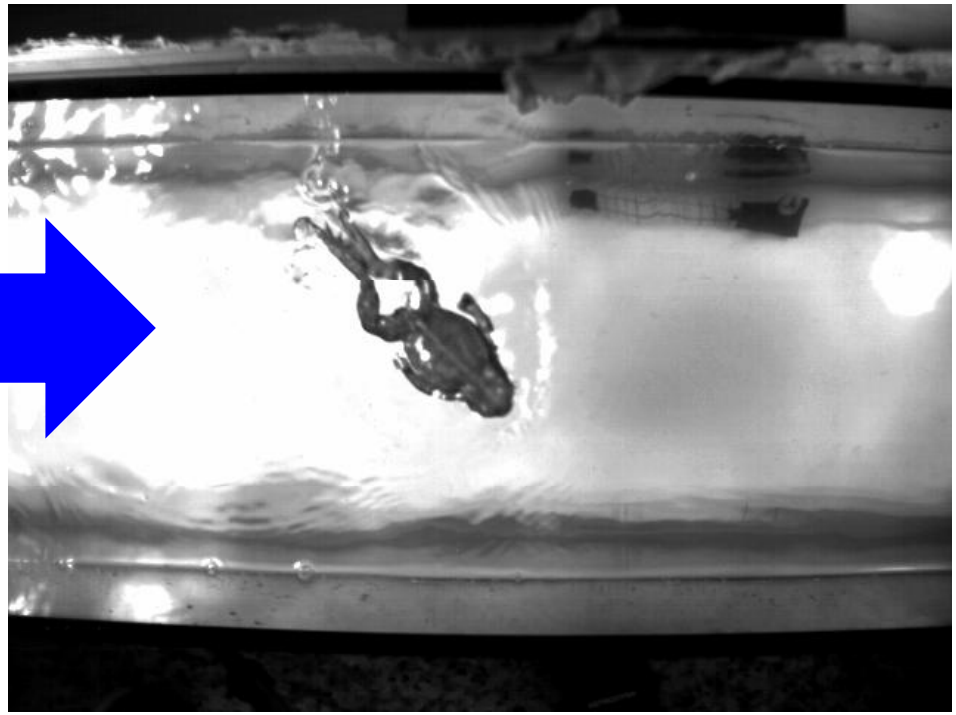
Photo: Bianca Lavies, National Geographic

Jumping

Measuring performance from videos



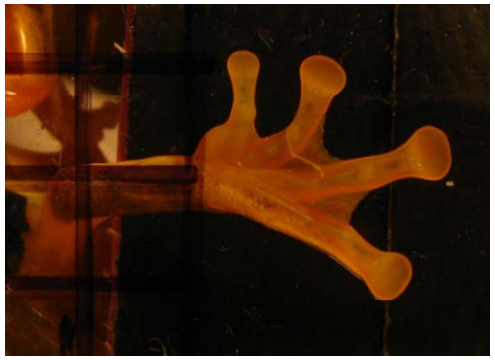
Swimming

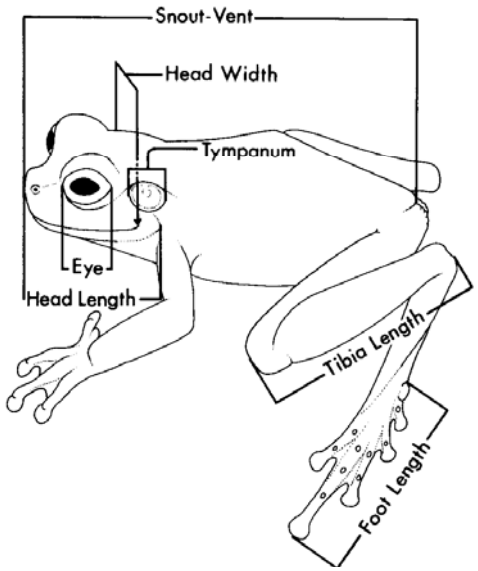


Peak velocity, acceleration, and power are likewise calculated from videos

Maximum clinging angle

Morphology





Duellman 2001

Phylogenetic Principal Components (Revell 2009)

PC1: size-related variation

Remaining PCs: size-independent variation

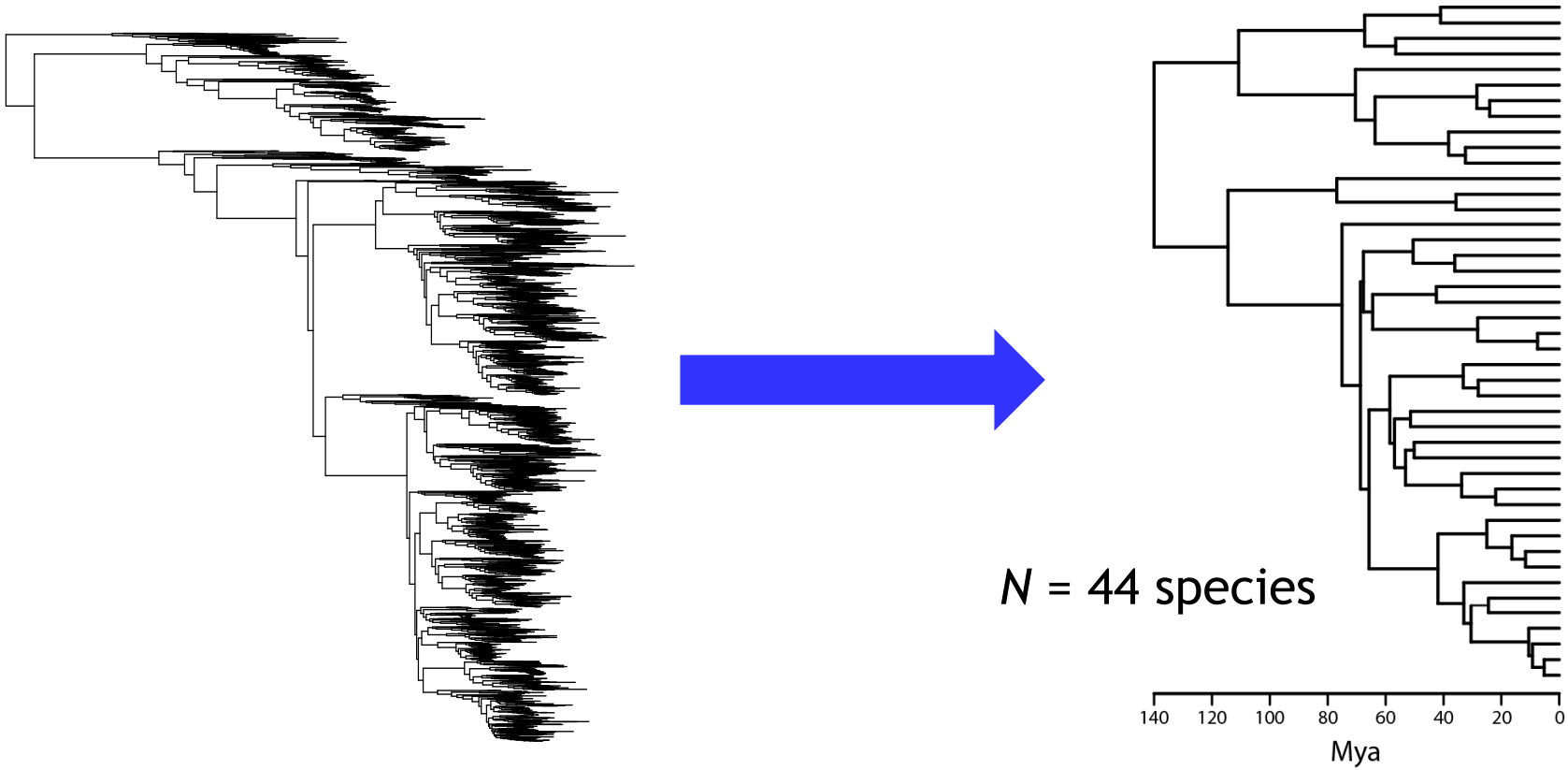
(both performance and morphology)

Loadings? Be patient…

Microhabitat use

Phylogeny (primary)

- Topology: Pyron and Wiens 2011
- Branch lengths: BEAST (Drummond and Rambaut 2007)



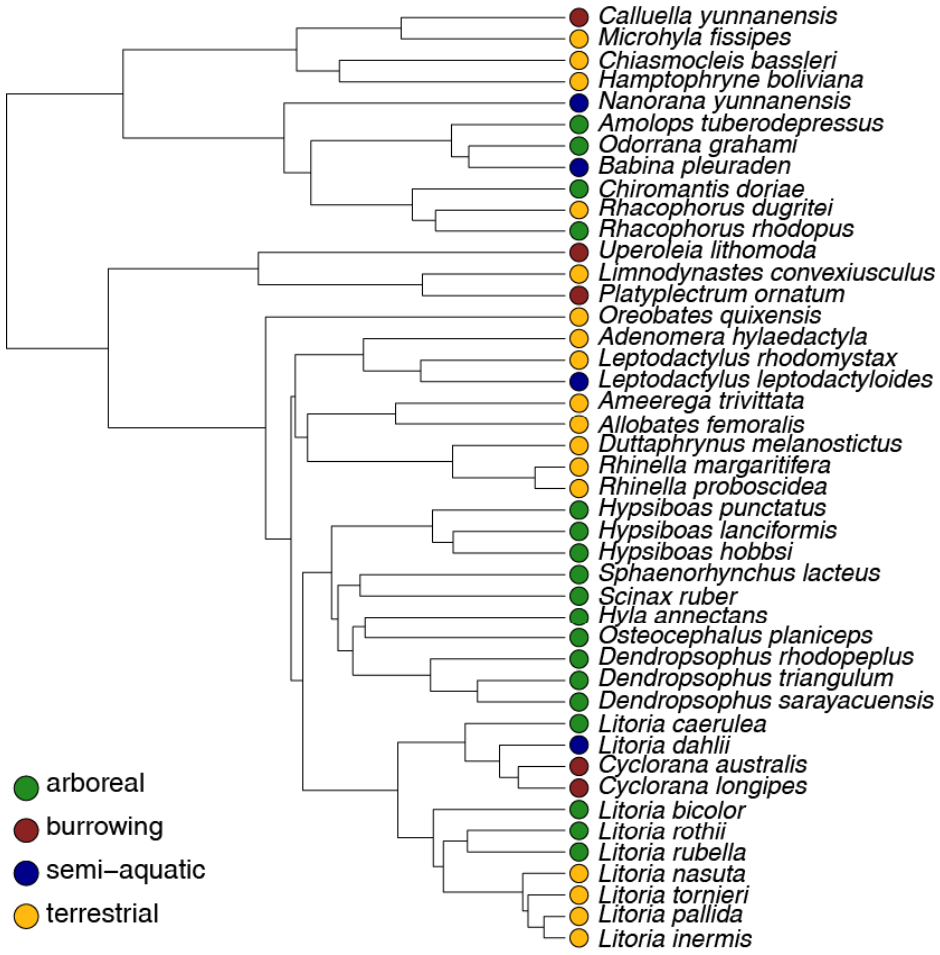
Outline of data analyses

(1) How is microhabitat use associated with morphology and performance?

(2) How do morphology and performance evolve when microhabitat is conserved despite great geographic distances?

(3) How do morphology and performance evolve in association with microhabitat transitions in an in situ radiation?

Are microhabitat specialists distinctive in morphology and performance?



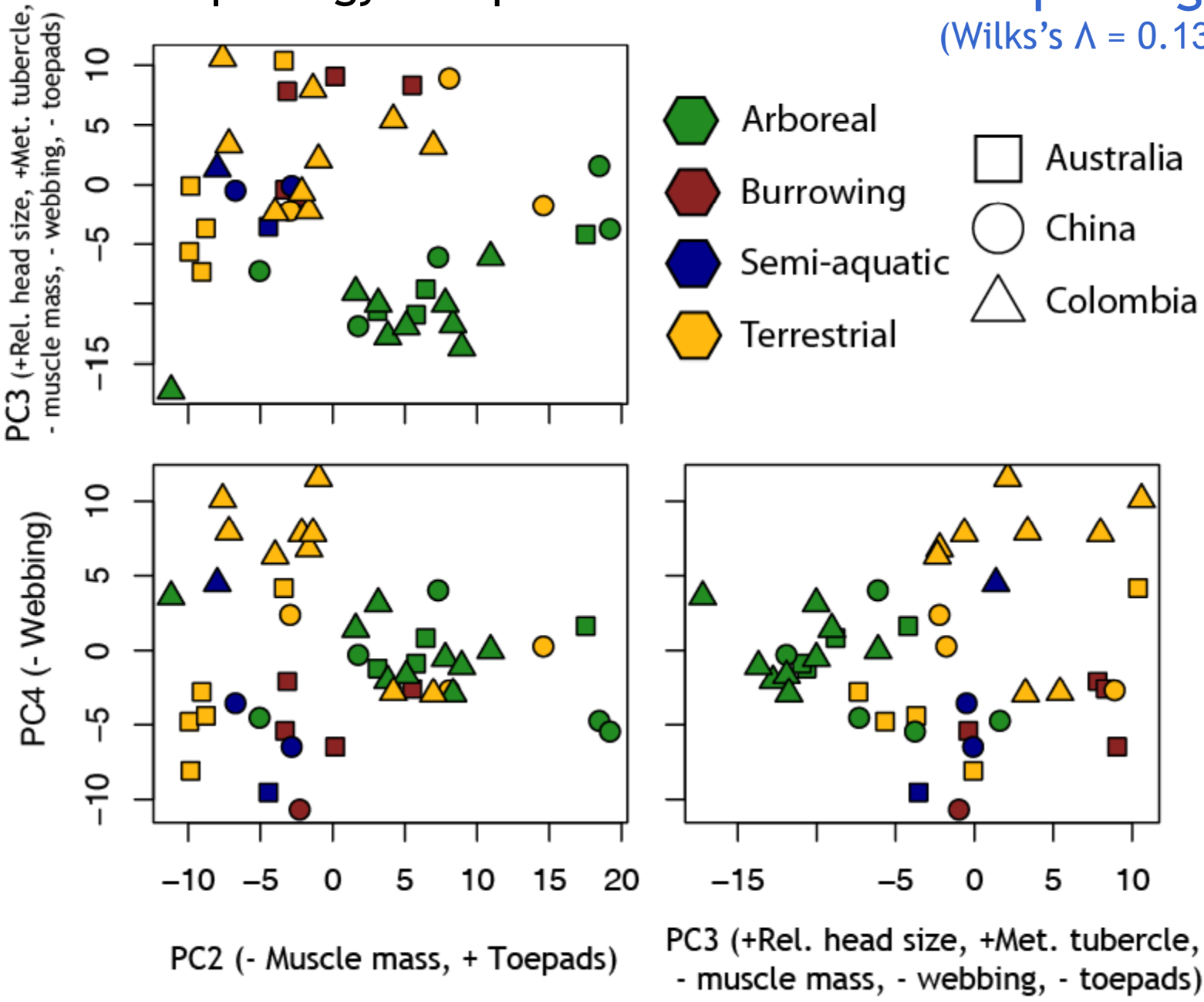
Multivariate Analysis of Variance (MANOVA)

- Phylogenetically transformed PCA data (Garland and Ives 2000; Blankers et al. 2012)
- Done separately for morphology and performance

Are microhabitat specialists distinctive in morphology and performance?

Morphology

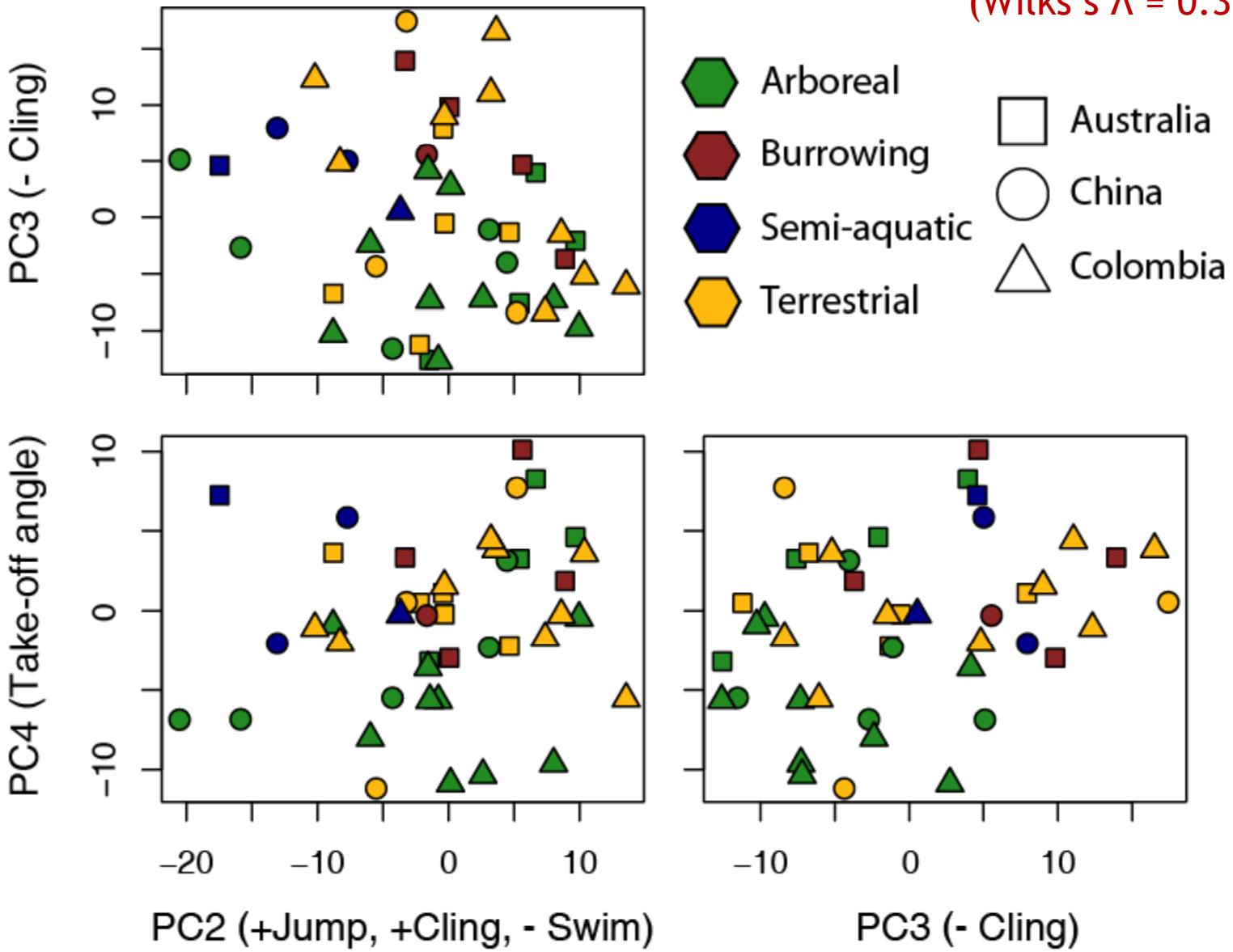
(Wilks's $\Lambda = 0.136$, $P < 0.001$)

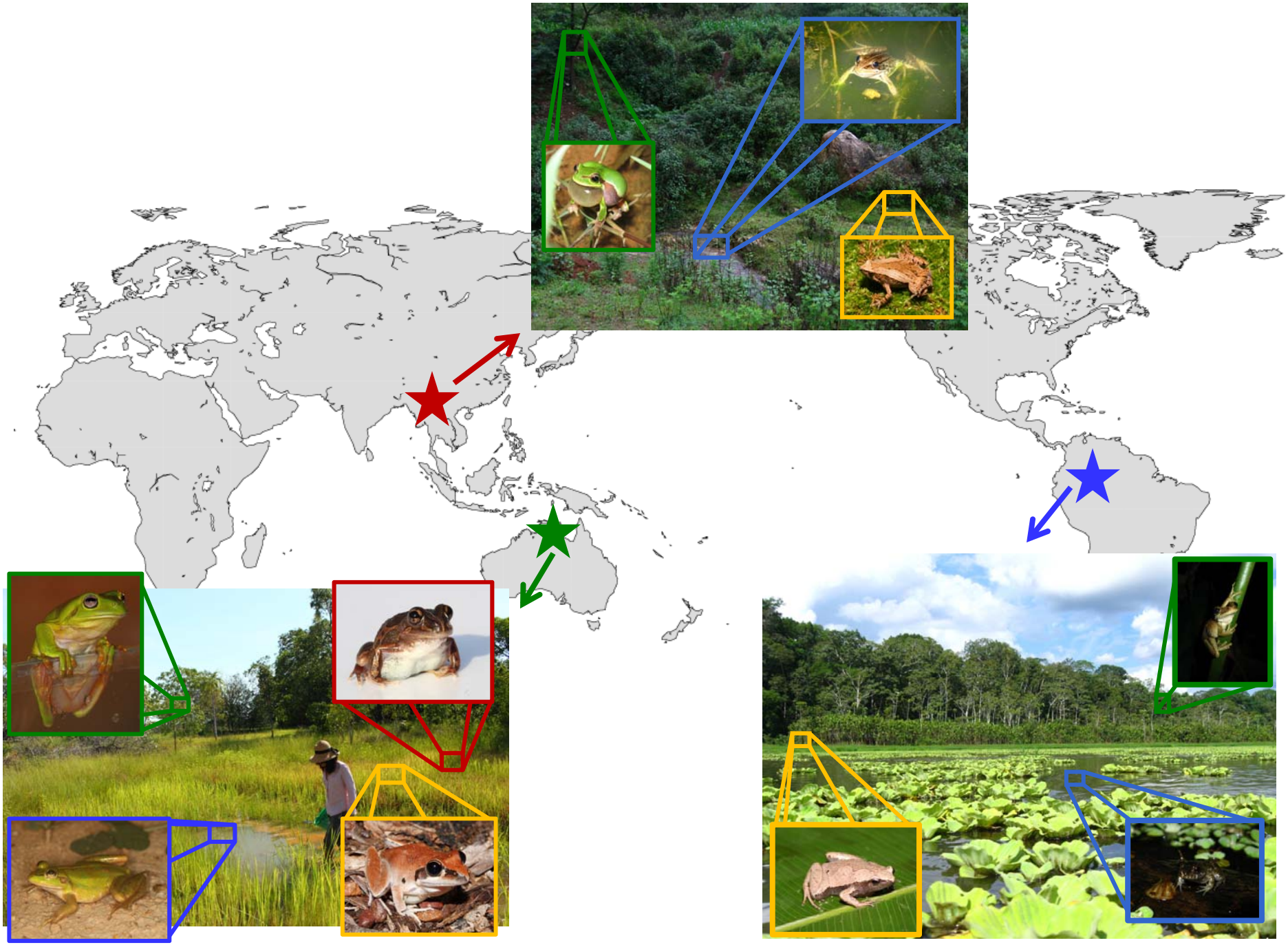


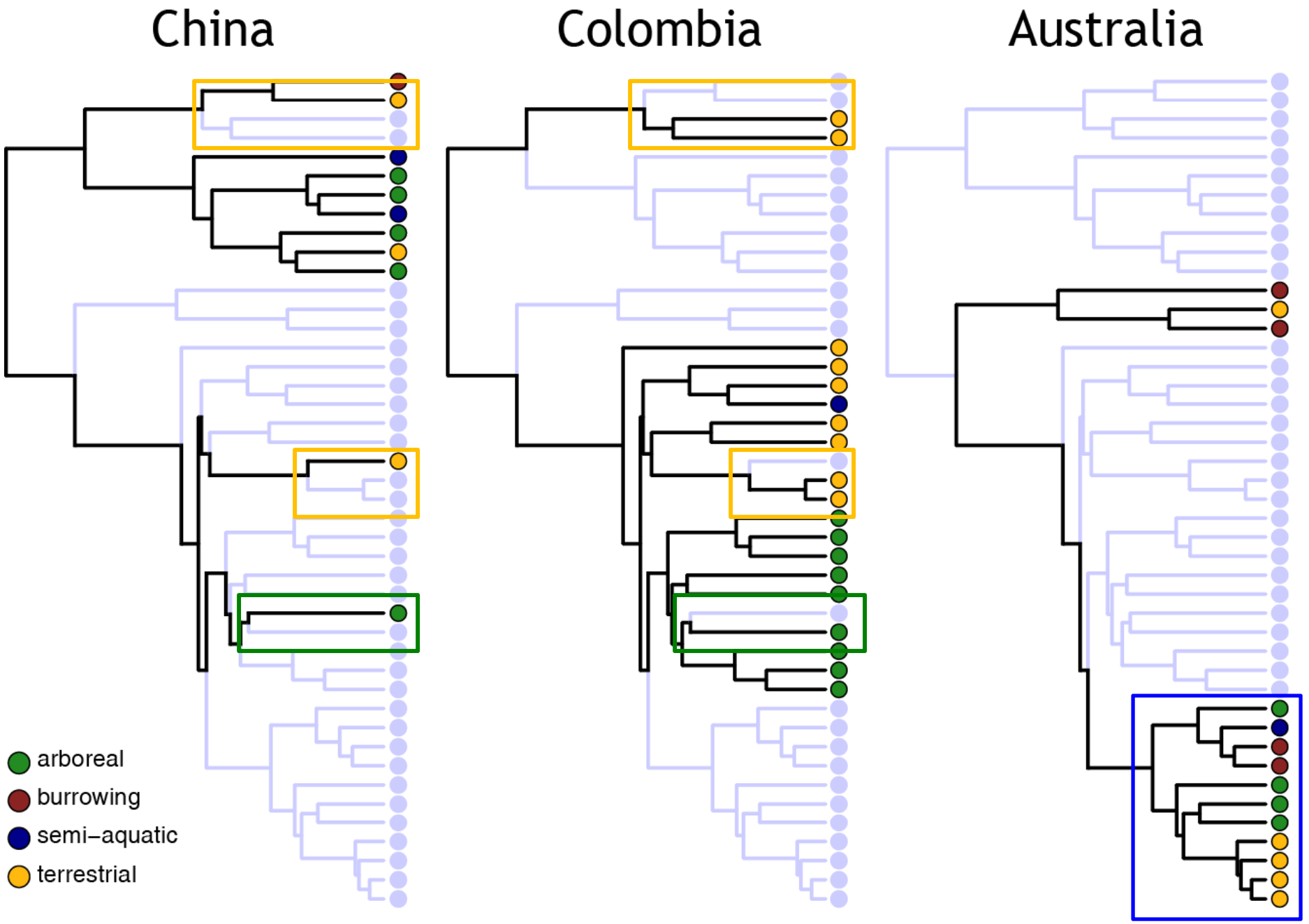
Are microhabitat specialists distinctive in morphology and performance?

Performance

(Wilks's $\Lambda = 0.319$, $P = 0.003$)






China
Colombia
Australia
arboreal
burrowing
semi–aquatic
terrestrial

Outline of data analyses

(1) How is microhabitat use associated with morphology and performance?

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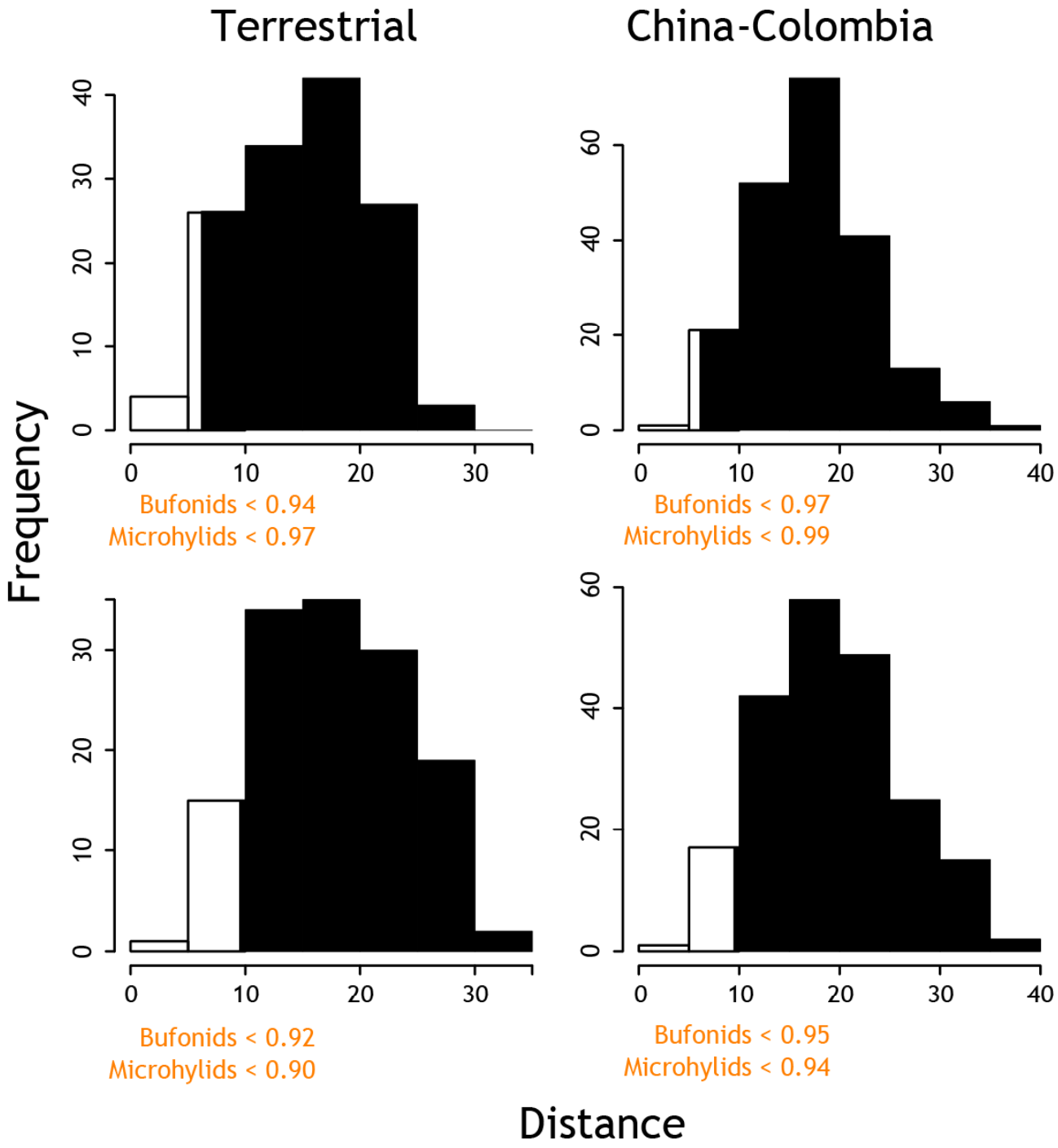
Same microhabitat use, geographically disparate

	Morph. distance	Perform. distance
Microhylidae	5.3	9.6
Bufonidae	6.2	9.1
Hylidae	21.1	12.0
Mean terrestrial	15.3	17.8
Mean arboreal	12.1	16.5
Mean China-Colombia	17.2	19.1

Morphological pairwise distances

Performance pairwise distances



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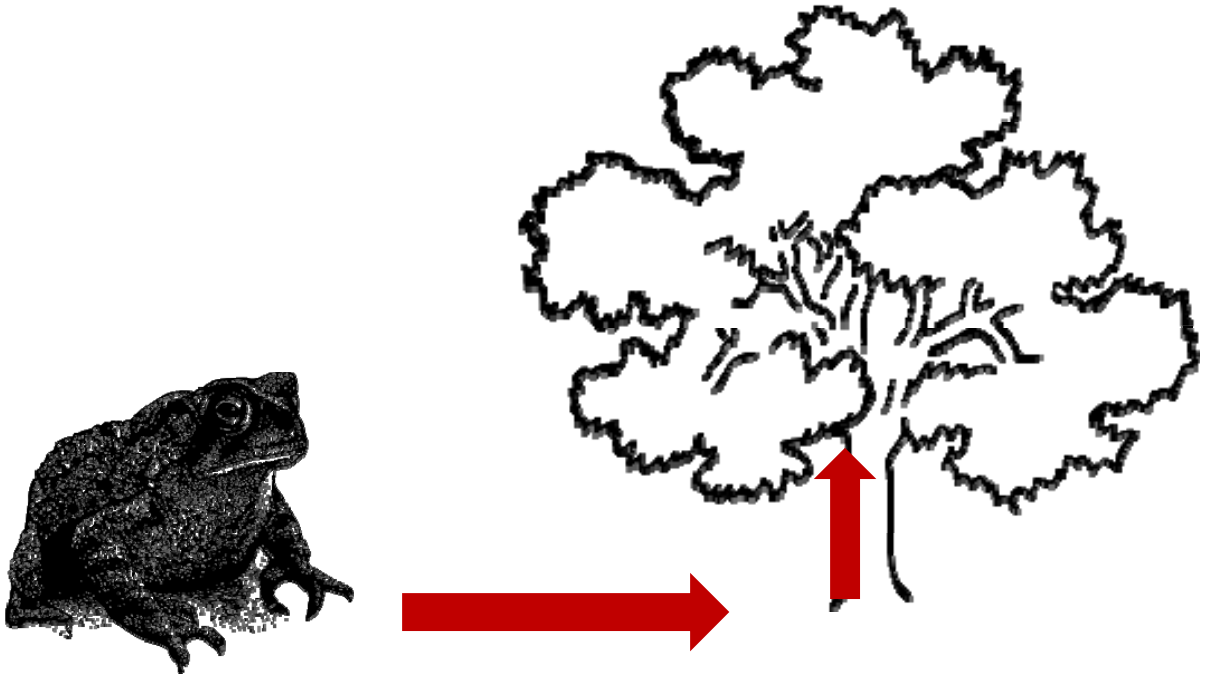
What is the role of prior evolutionary history? Does convergence completely erase any traces of history?



What is the role of prior evolutionary history? Does convergence completely erase any traces of history?

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Or does prior adaptation to an ancestral environment or resource may generally leave a footprint on subsequent evolutionary adaptation?

?

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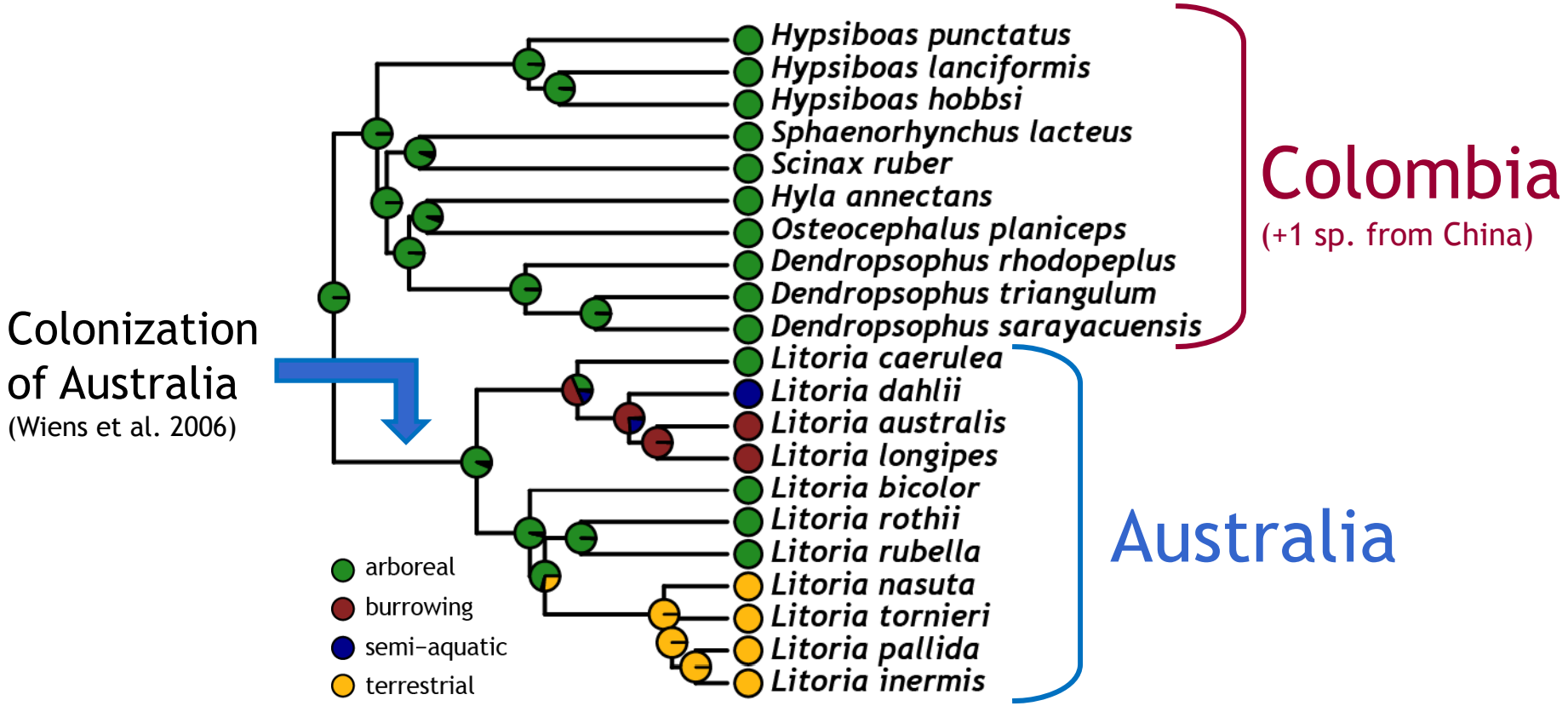
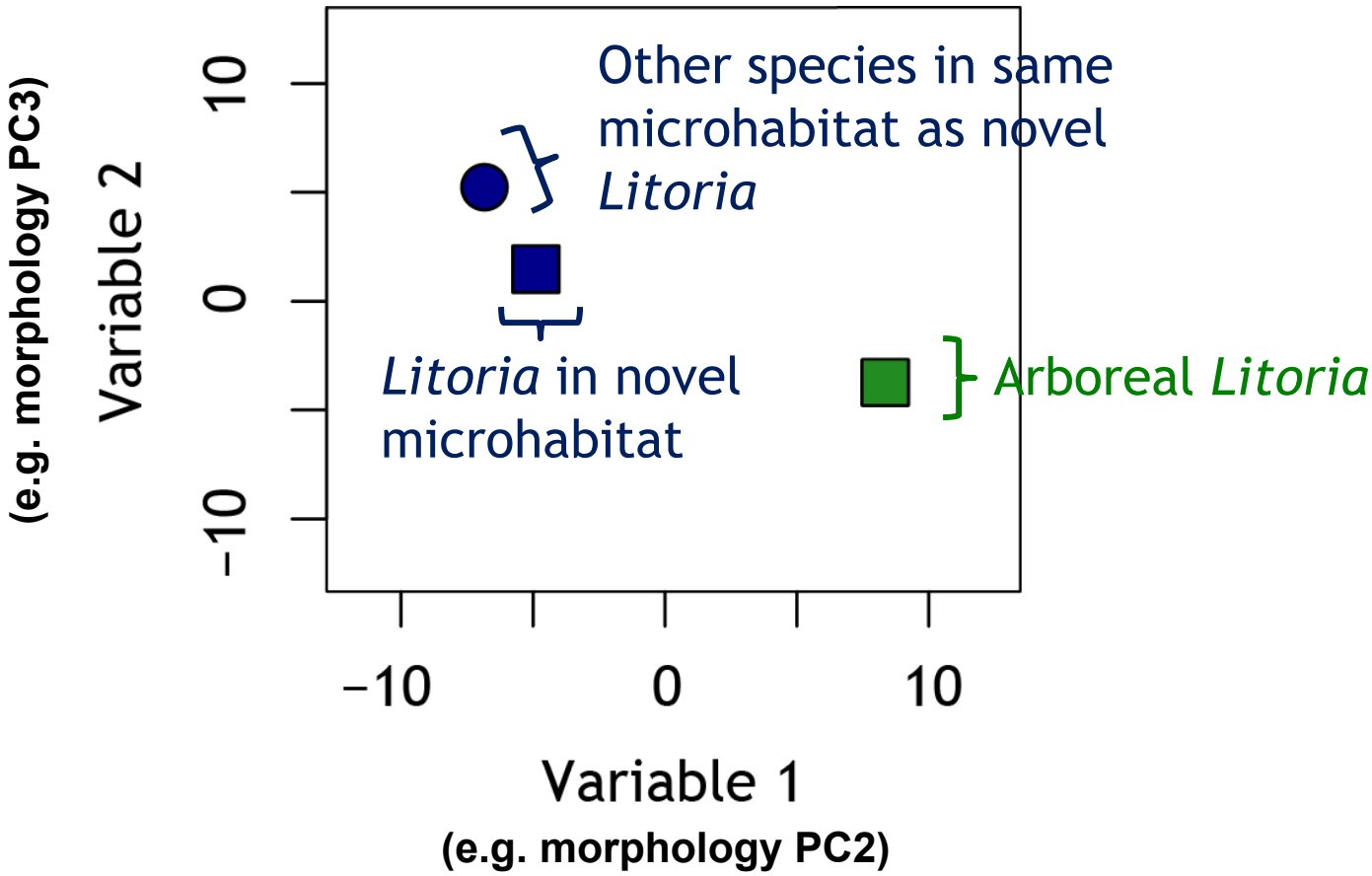


Given this diversification from an arboreal ancestor, how do these "new" microhabitat specialists in the genus *Litoria* compare to other species that are similar in ecology?

Are *Litoria* who are not arboreal more similar to their ancestral type or to other species who share a common ecology?



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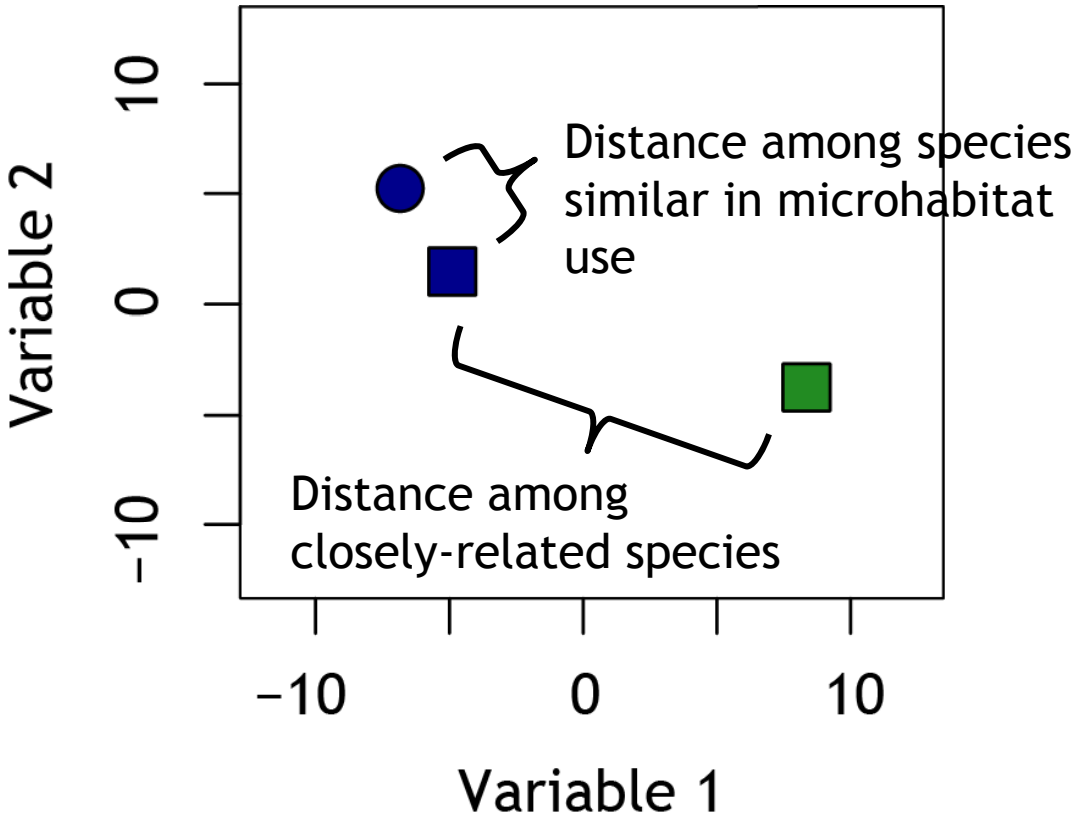
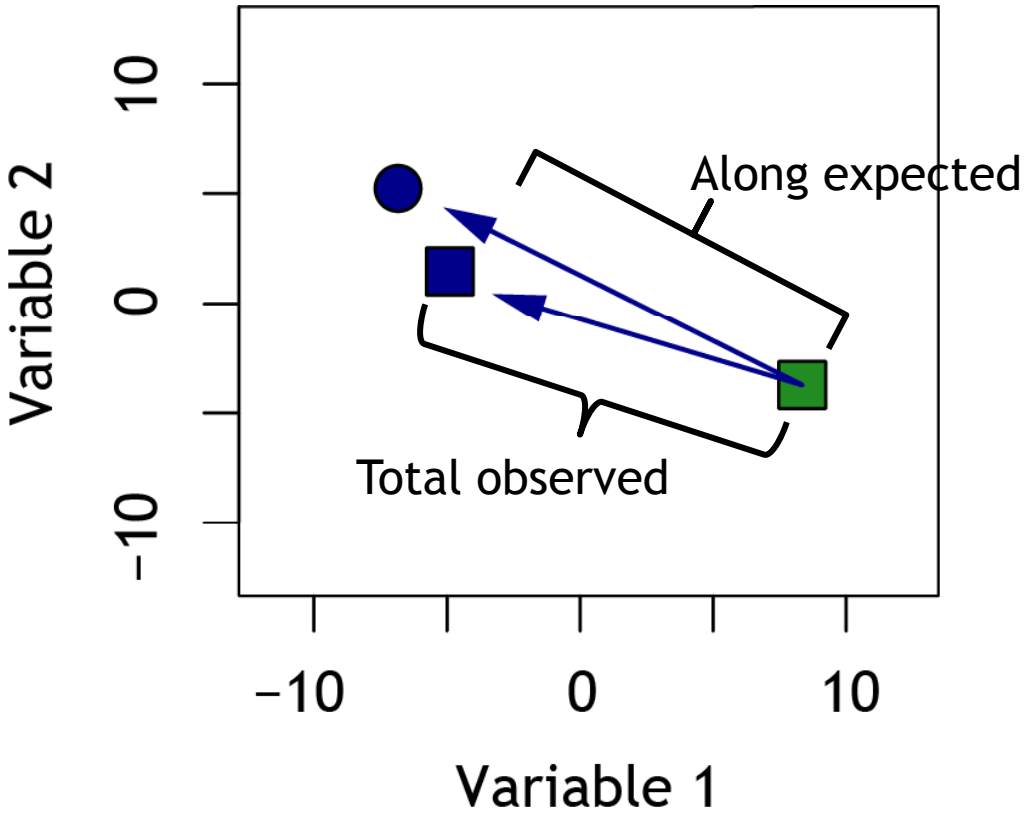


2 ways to compare

(1)Distance

Are *Litoria* who are not arboreal more similar to their ancestral type or to other species who share a common ecology?

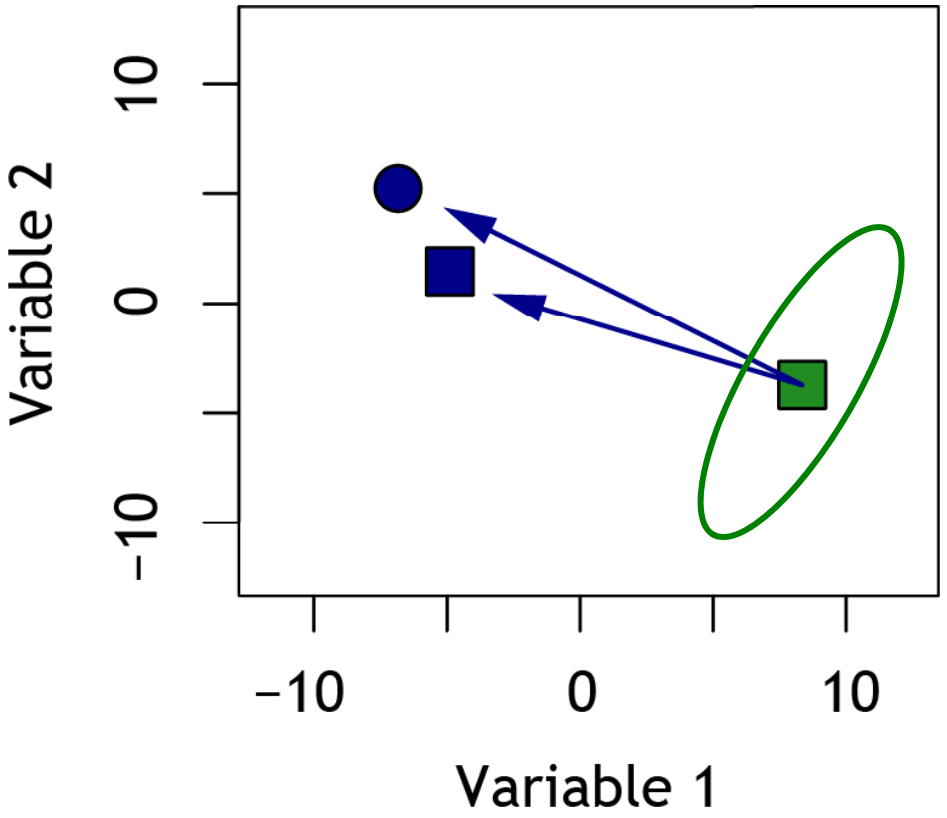


2 ways to compare

(1)Distance

(2)Proportion of divergence along expected trajectory relative to total observed divergence (p_{obs})

Are *Litoria* who are not arboreal more similar to their ancestral type or to other species who share a common ecology?



2 ways to compare

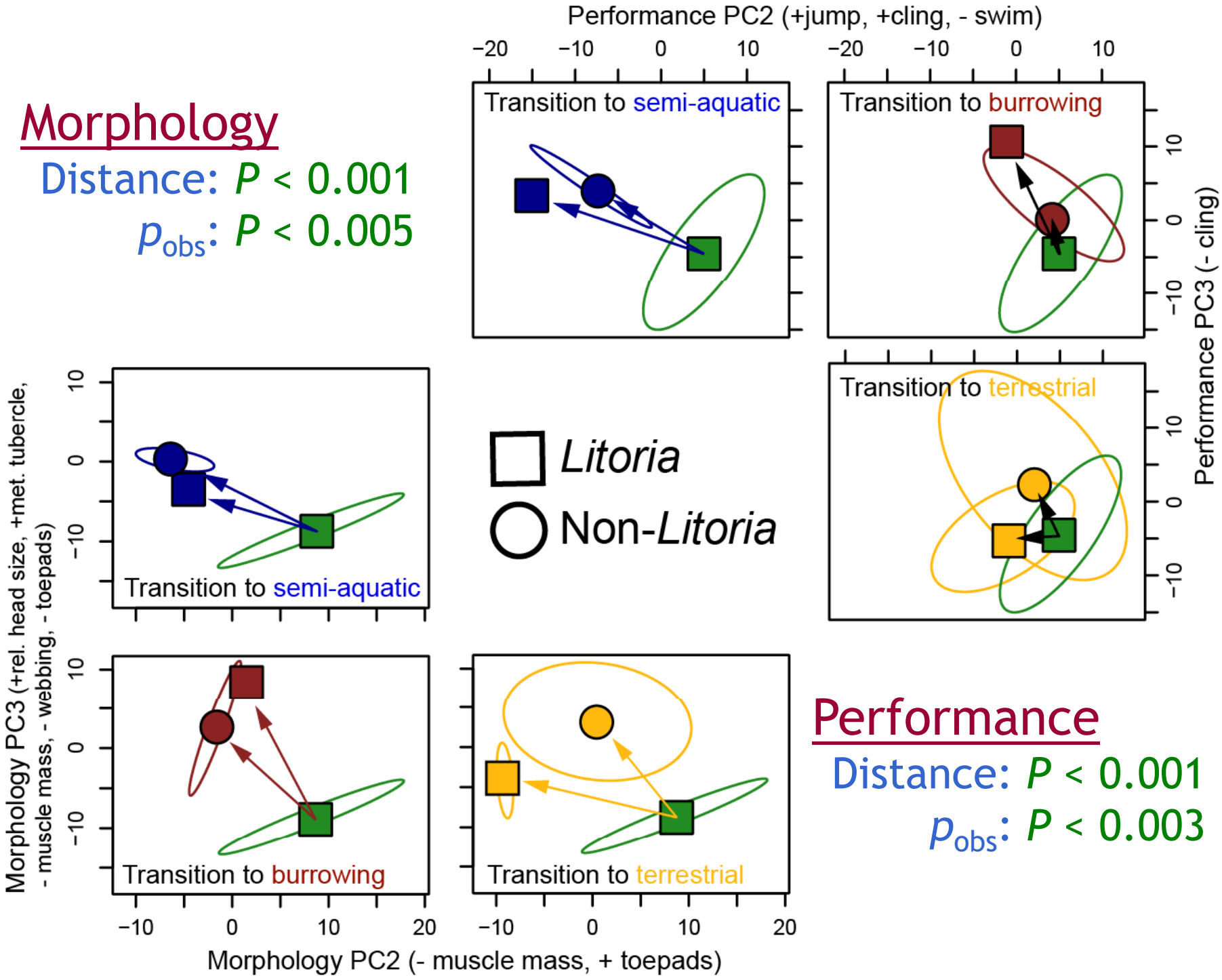
(1)Distance

(2)Proportion of divergence along expected trajectory relative to total observed divergence (p_{obs})

Morphology

Distance: $P < 0.001$

p_{obs}: $P < 0.005$

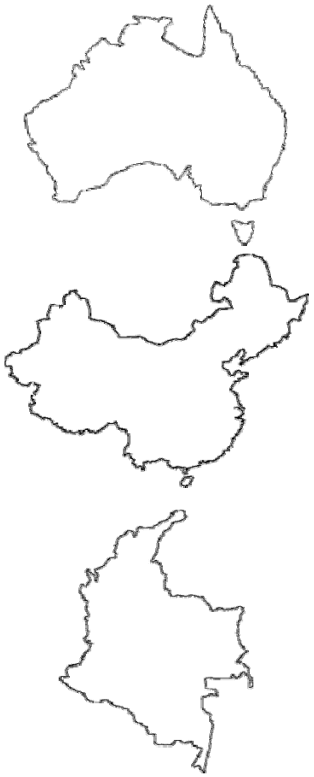


Performance

Distance: $P < 0.001$

p_{obs}: $P < 0.003$

So what about phenotypic diversity?

Morphological variance		Performance variance	
133.5		133.5	
137.8		172.9	P=0.015
132.1		144.8	

Understanding *why* we see the phenotypic diversity that we see in various assemblages – even at large geographic and temporal scales – depends on considering multiple pathways

Understanding *why* we see the phenotypic diversity that we see in various assemblages depends on considering both:

(1) No geographic change with much diversification

China

Australia

Understanding *why* we see the phenotypic diversity that we see in various assemblages depends on considering both:

(1) No geographic change with much diversification

(2) Geographic change with little diversification

China

Colombia

Microhylidae
(67 million years)

Bufonidae
(28 million years)

Take home message: the factors that we should study to understand phenotypic diversity across assemblages will depend on how that diversity developed over time

(1) No geographic change with much diversification

- How does adaptive radiation happen?
- What are the roles of competition, predation, mutualism, etc.?
- How common is sympatric speciation?

(2) Geographic change with little diversification

- What factors affect long-distance dispersal?
- Why do we see conservatism in some groups versus much evolution in others?
- What role does non-adaptive allopatric speciation play?

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