

Macroevolution of dimensionless life histories in amniotes

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Objectives

1. Use Charnov's dimensionless life history traits to visualize and quantify the life history strategies of amniotes
2. Compare life history strategies of birds, mammals, reptiles, and smaller clades by using hypervolumes
3. Investigate if these so-called invariant traits are actually invariant with body mass
4. Analyze the macroevolutionary patterns of the dimensionless traits and their components between clades

Charnov's Dimensionless Traits

3 dimensionless variables hypothesized to be invariant with body mass

1. **C·E = reproductive effort · average lifespan**
 - Fraction of body mass allocated to reproduction per unit death
 - Trade-off of reproductive effort and mortality rate
2. **E/α = average lifespan / age at female maturity**
 - Cost of aging to reproductive maturity relative to lifespan
 - Trade-off of reproductive age and overall lifespan
3. **I/m = mass at independence / adult body mass**
 - Size of independent offspring relative to adult
 - Trade-off of offspring size compared to adult size

Life History Hypervolumes

4-dimensional Gaussian hypervolumes

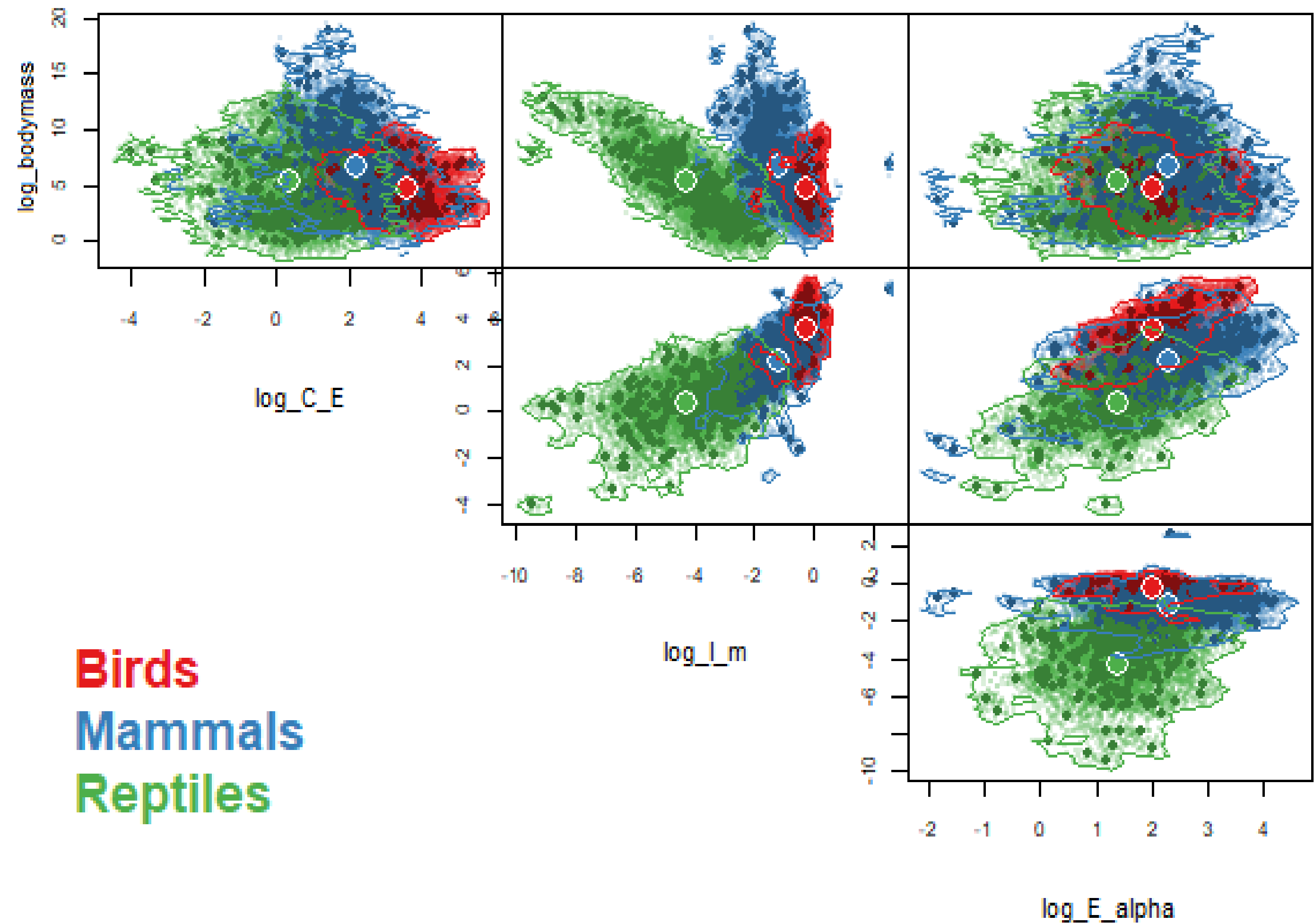


Figure 1. Hypervolumes for birds (n=171), mammals (n=849), and reptiles (n=516). Bird hypervolume volume is 29.25, mammal is 205.82, and reptile is 474.93.

Data

Used the Myhrvold *et al.* 2015 amniote database augmented with reptile data from Allen *et al.* 2017
849 mammals, 516 reptiles, and 171 birds with trait values for body mass and the invariants

Chiroptera: A Case Study

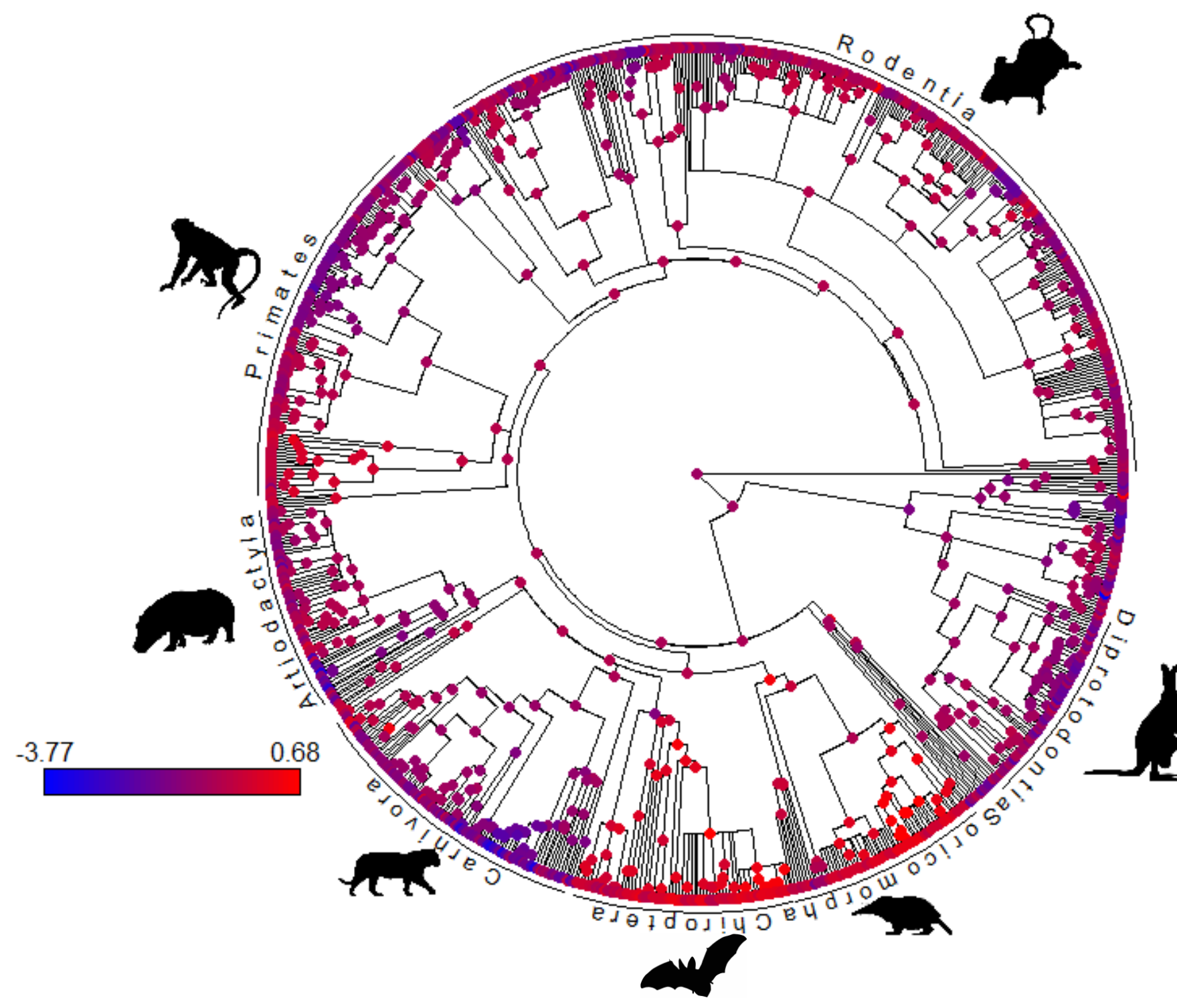


Figure 2. Extant and reconstructed $\log(I/m)$ values plotted on mammal supertree (Fritz *et al.* 2009). Reconstruction shown is a Pagel's lambda model ($\lambda=0.89$, $\sigma^2=0.0050$, $z_0=-1.42$).

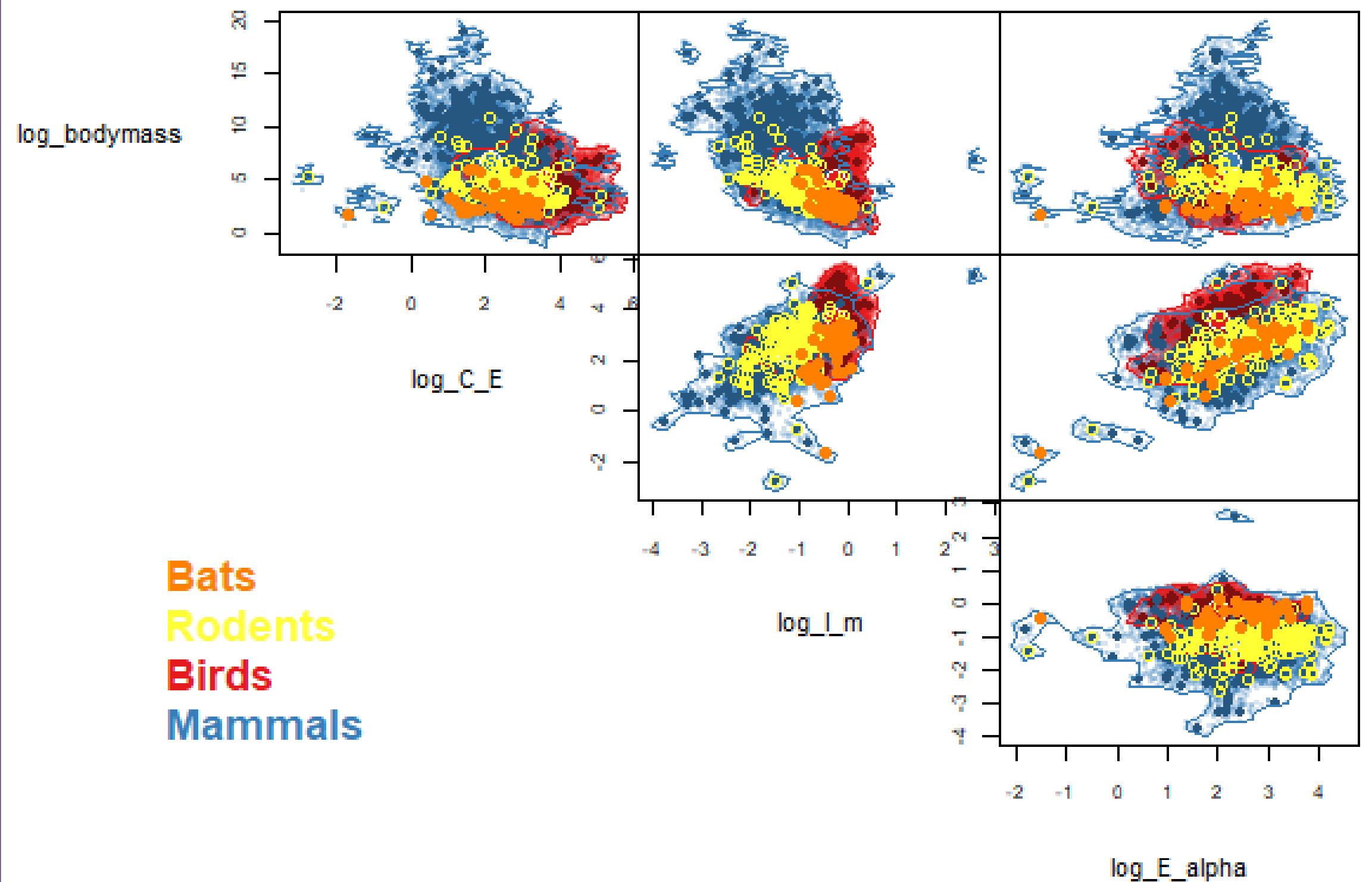
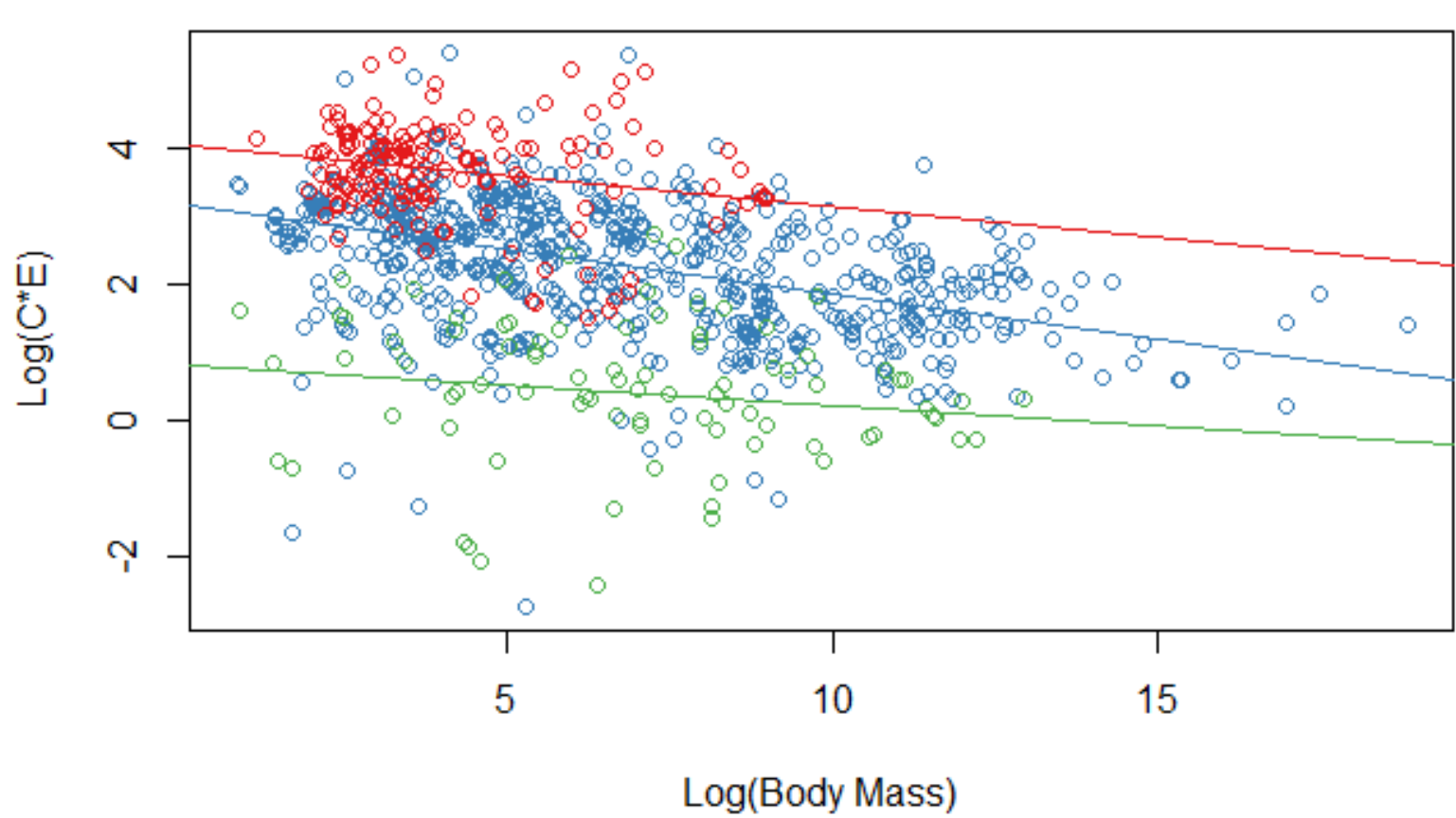


Figure 3. Bird and mammal hypervolumes displaying the positions of rodents and bats.

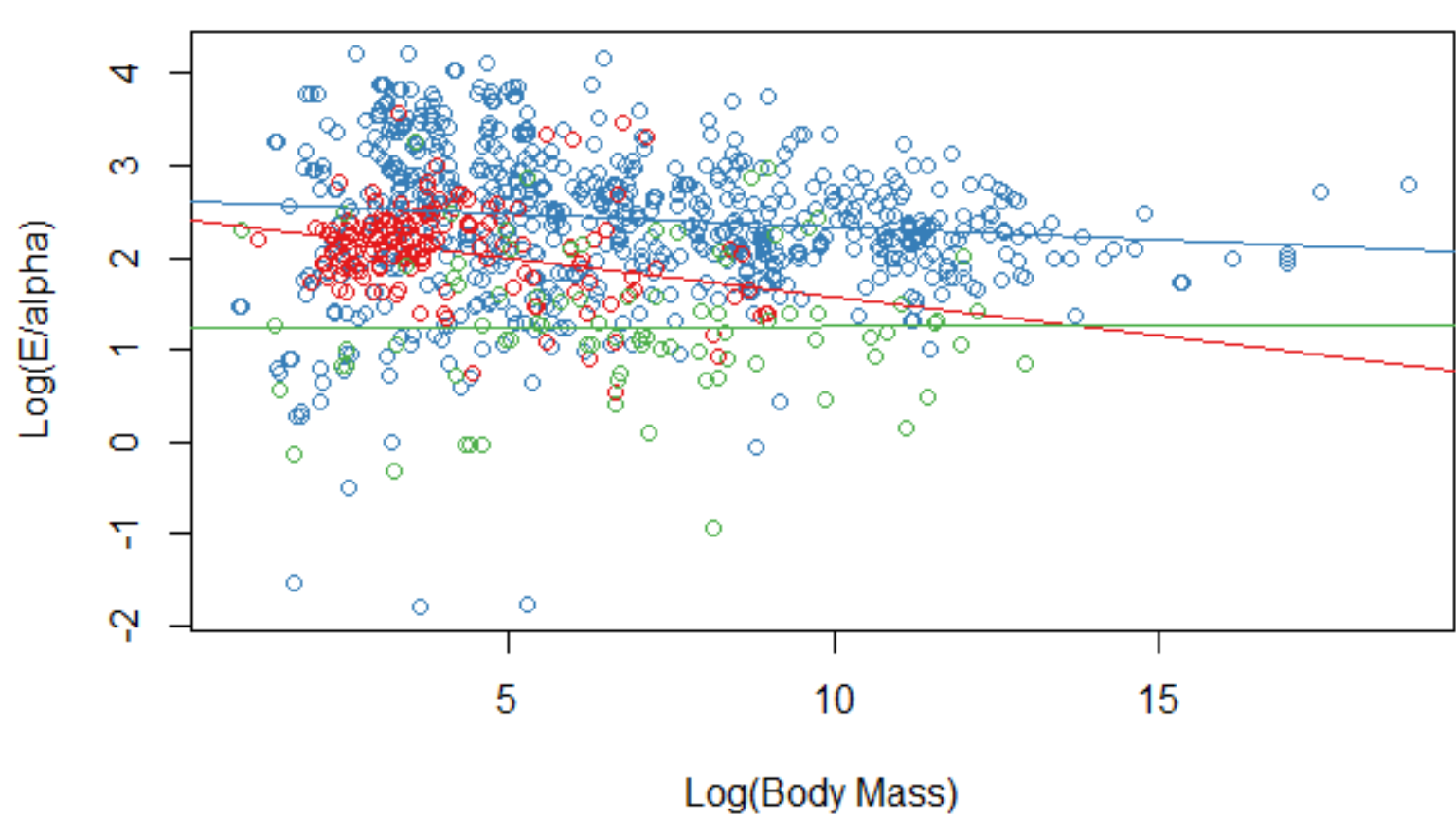
Are the invariants really invariant?

C·E



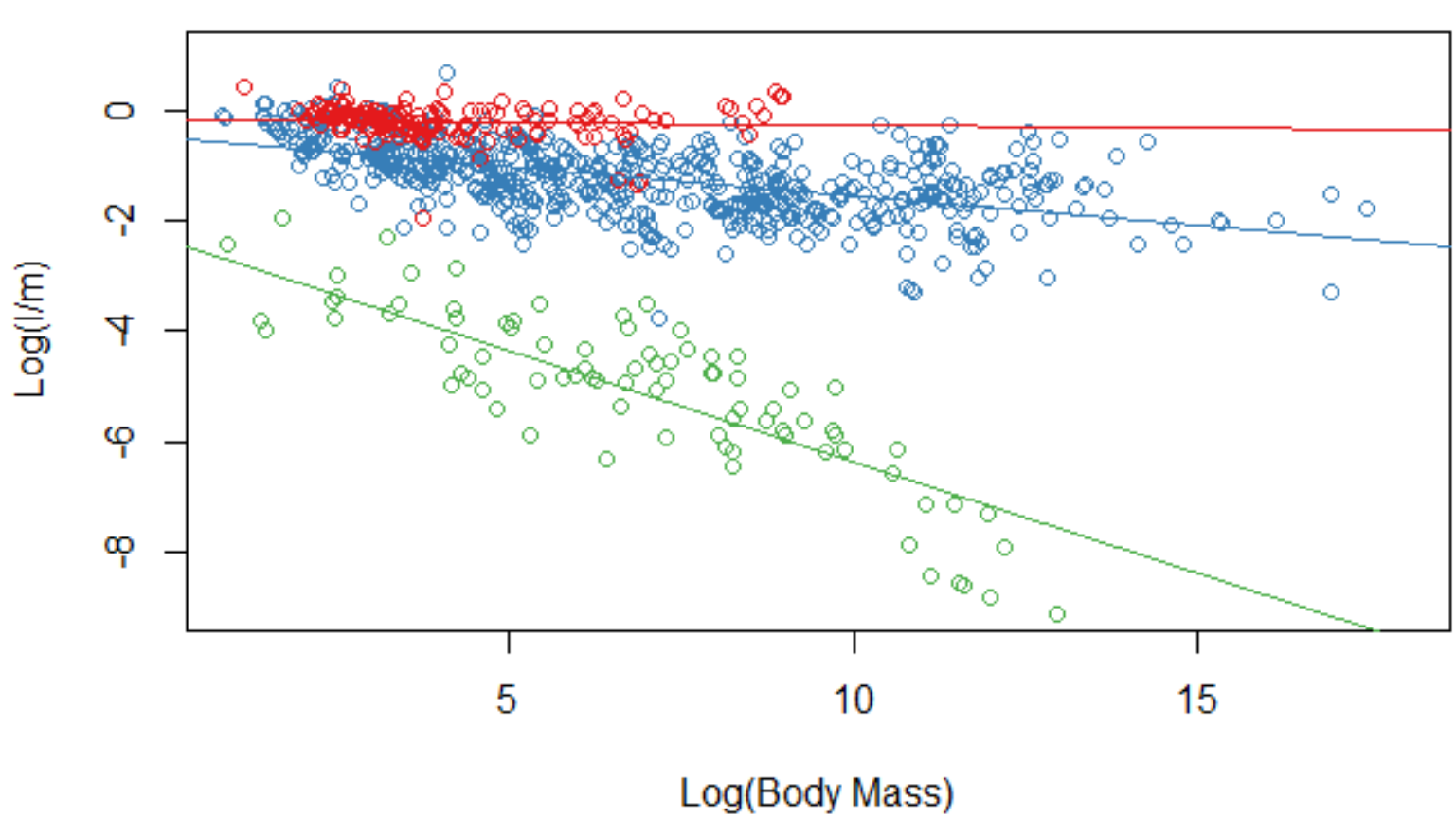
Class	P-value	R ²	Slope
Birds	0.003188	0.05242	-0.08924
Mammals	<2e-16	0.2048	-0.132068
Reptiles	0.11076	0.02197	-0.05874

E/α



Class	P-value	R ²	Slope
Birds	5.29e-05	0.09624	-0.08400
Mammals	0.00128	0.01239	-0.027678
Reptiles	0.954	2.907e-05	0.001521

I/m



Class	P-value	R ²	Slope
Birds	0.45649	0.003427	-0.009766
Mammals	<2e-16	0.2972	-0.106914
Reptiles	<2e-16	0.7138	-0.40072

Figure 4. Log-log regressions of the three invariant traits against body mass for the three classes of amniotes. Invariance can be measured using p-value, R², or slope of the linear regression.

Conclusions & Future Directions

1. Birds, mammals, and reptiles have very different constraints in life history space.
 2. Bats share characteristics with birds and mammals.
 3. Charnov's traits are not always invariant with body mass.
- Does coevolution of life history traits result in invariance?
What differs in clades that do not exhibit invariance?

Acknowledgments

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