## D13C - Initial Analysis

### Species Differences

#### Boxplot

* Most negative d13C (highest MR):
  + E. Antarctica
  + G. braueri
  + K. andersoni
* Least negative d13C (lowest MR):
  + E. carlsbergi
  + G. nicholsi
  + P. bolini

#### Kruskal-Wallis Test

* Significant difference between species.
  + Chi-squared = 82.414
  + Df = 5
  + p-value = 2.61 x 10^-16

#### Dunn Test (from dunn.test package)

* Bonferroni correction

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | E. antarctica | E. carlsbergi | G. braueri | G. nicholsi | P. bolini | K. anderssoni |
| E. Antarctica |  | <0.01 | N/S | <0.01 | <0.01 | N/S |
| E. carlsbergi | <0.01 |  | <0.01 | N/S | N/S | <0.01 |
| G. braueri | N/S | <0.01 |  | <0.01 | <0.01 | N/S |
| G. nicholsi | <0.01 | N/S | <0.01 |  | N/S | <0.01 |
| P. bolini | <0.01 | N/S | <0.01 | N/S |  | <0.05 |
| K. anderssoni | N/S | <0.01 | N/S | <0.01 | <0.05 |  |

* Supports three groups as seen in boxplot

### Log10\_Weight vs. d13C

#### Plot

* Decrease in d13C with weight with E. carlsbergi and G. nicholsi as outliers.
  + Decrease in mass specific metabolic rate with weight (expected).

#### Spearman’s Rank Test

* No significant correlation between d13C and log10\_Weight.
  + Rho = -0.0292
  + P = 0.7637

### D18O vs. d13C

#### Plot

* Decrease in d13C with increase in d18O. H
  + Higher metabolic rate at lower temperatures (counter-intuative).

#### Spearman’s Rank Test

* Significant negative correlation.
  + Rho = -0.6721
  + P = 1.695 x 10^-15

### D13C with Depth

* Nothing interesting on the metabolic side.
* E. carlsbergi and G. braueri mostly caught shallow (>250m).

## D13C – Sherwood & Rose & My Data Comparison

### Species Comparisons

* E. Antarctica – same value as *Chaetodon ulietensis* (Pacific double-saddle butterflyfish, Chaetodontidae).
* G. braueri – same value as *Oncorhynchus nerka* (sockeye salmon, Salmonidae).
* K. andersoni – same value as *Maena maena* (now *Spicara maena,* blotched picarel, Centracanthidae).
* E. carlsbergi – same values as *Clupea pallasii* (Pacific herring, Clupeidae).
* G. nicholsi – same values as *Beryx splendens* (splendid alfonsino, Berycidae) and *Osmerus mordax* (rainbow smelt, Osmeridae).
* P. bolini – between *Centrolophus niger* (rudderfish, Centrolophidae) and *Merluccius merluccius* (European hake, Gadidae).
* Possible action?: run data against known RMR and compare.

### K\_caud vs. d13C

#### Spearman’s Rank Analysis

* Significant negative correlation between K\_caud and d13C.
  + Rho = -0.66
  + P = 1.79 x 10^-11

#### Bayesian Analysis (without n as a random factor)

* All species, except G. nicholsi, plot outside 95% HDPI, but within range of other species.
  + Lower d13C than expected given K\_caud.
  + High metabolic rate for activity level.
  + C. maderensis is also below the line.

### D18O vs. d13C

#### Spearman’s Rank Analysis

* Significant positive relationship between d18O and d13C.
  + Rho = 0.52
  + P = 8.26 x 10^-7
  + Increasing MR with increasing temperature.

#### Bayesian Analysis (without n as a random factor)

* Higher d18O than Sherwood & Rose fishes.
  + At lower temperatures.
* G. nicholsi and E. carlsbergi plot within 95% HDPI.
* K. anderssoni, E. Antarctica and G. braueri (and P. bolini, just) all plotting below the line.
  + Lower d13C than expected given d18O.
  + High metabolic rate for temperature.
  + But C. maderensis plots outside HDPI as well.
  + Not metabolic cold adaptation, or it would affect all of them?
* Possible action?: look into metabolic cold adaptation.
* Note: cannot do against weights as they are max. weights and missing for many species.

## M-Values – Initial Analysis

* 0.14 – 0.30
  + 95% HDI range of 10,000 replicates: 0.01-0.04

### Species Differences

#### Boxplot

* E. Antarctica, G. braueri and K. andersoni all have high M values.
* G. nicholsi and E. carlsbergi have low M values, with P. bolini straddling but on lower end.

#### Kruskal-Wallis Test

* Repeated 1000 times
* Significant difference between species.
  + Chi-squared = 49.82 (95% HDI 39.84 – 61.35)
  + Df = 5
  + P = 2.44 x10^-9 (95% HDI 6.43 x 10^-13 – 1.01 x 10^-07)

#### Dunn Test

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | E. antarctica | E. carlsbergi | G. braueri | G. nicholsi | P. bolini | K. anderssoni |
| E. Antarctica |  | <0.01 | N/S | <0.01 | <0.01 | N/S |
| E. carlsbergi | <0.01 |  | <0.01 | N/S | N/S | <0.01 |
| G. braueri | N/S | <0.01 |  | <0.01 | <0.01 | N/S |
| G. nicholsi | <0.01 | N/S | <0.01 |  | N/S | <0.01 |
| P. bolini | <0.01 | N/S | <0.01 | N/S |  | <0.05 |
| K. anderssoni | N/S | <0.01 | N/S | <0.01 | <0.05 |  |

* Supports three groups as seen in boxplot

With multiple repeats

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | E. antarctica | E. carlsbergi | G. braueri | G. nicholsi | P. bolini | K. anderssoni |
| E. Antarctica |  | <0.05 | N/S | <0.01 | <0.01 | N/S |
| E. carlsbergi | <0.05 |  | <0.1 | N/S | N/S | <0.01 |
| G. braueri | N/S | <0.01 |  | <0.01 | <0.02 | N/S |
| G. nicholsi | <0.01 | N/S | <0.01 |  | N/S | <0.01 |
| P. bolini | <0.01 | N/S | <0.02 | N/S |  | <0.01 |
| K. anderssoni | N/S | <0.01 | N/S | <0.01 | <0.01 |  |

### Log10\_Weight vs. M

#### Plot

* No discernible relationship, apart from GYN (with largest weight) having lowest M.

#### Spearman’s Rank Test

* 1000 repeats
* Significant negative correlation between M and log10\_Weight.
  + Rho = -0.22 (95% HDI -0.32 to -0.13)
  + P = 1.03 x 10 ^-2 (95% HDI 2.61 x 10^-5 to 1.52 x 10^-1)

### Temperature vs. Species

* Temperature range from -3.43C to 3.88C (95% HDI 1.17-1.34).
* Seems low – may be due to parameters being derived from cod data.

#### Plot

* E. carlsbergi (2.76 mean) and G. nicholsi (2.31 mean) found at highest temps.
* G. braueri at lowest temps (mean -1.65).

#### K-W Test

* 1000 repeats
* Significant difference between species.
  + Chi = 53.43 (95% HDI 42.27 to 64.00)
  + P = 3.45 x 10^-10 (95% HDI 5.65 x 10^-14 to 2.01 x 10^-8)

## Model Comparison – Myctophids Only

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Model** | **Model Type** | **a** | **b** | **R-Squared** | **p-Value** | **AIC** |
| **M ~ Temperature** | LM | 0.22 (0.22 to 0.23) | -0.01 (-0.01 to -0.00) | 0.10 (0.03 to 0.19) | 4.45 x 10^-4 (1.84 x 10^-9 to 2.85 x 10^-02) | -367 (-390 to -344) |
| **M ~ Temperature + (1|Species)** | LMM | 0.21 (0.21 to 0.22) | 0.00 (-0.01 to 0.00) | 0.50 (0.40 to 0.62) | 0.13 (4.25 x 10^-4 to 0.94) | -383 (-407 to -352) |
| **M ~ log10(Weight)** | LM | 0.23 (0.22 to 0.24) | -0.01 (0.03 to 0.00) | 0.16 (0.11 to 0.23) | 2.71 x 10^-6 (3.56 x 10^-9 to 2.66 x 10^-4) | -374 (-397 to -350) |
| **M ~ log10(Weight) + (1|Species)** | LMM | 0.21 (0.20 to 0.23) | 0.00 (-0.02 to 0.01) | 0.53 (0.42 to 0.62) | 0.24 (0.56 to 0.98) | -379 (-408 to -355) |
| **M ~ Temperature \* log10(Weight)** | LM | 0.23 (0.22 to 0.24) | **T**  0.00 (-0.01 to 0.00) | 0.18 (0.10 to 0.28) | **T**  0.11 (6.08 x 10^-4) | -377 (-401 to -350) |
| **W**  -0.01 (-0.03 to 0.00) | **W**  0.01 (3.30 x 10^-4 to 4.31 x 10^-1) |
| **T\*W**  -0.01 (-0.01 to -0.00) | **T\*W**  0.01 (1.94 x 10^-07 to 6.2 x 10^-1) |
| **M ~ Temperature \* log10(Weight) +(1|Species)** | LMM | 0.22 (0.20 to 0.23) | **T**  0.00 (-0.01 to 0.00) | 0.49 (0.34 to 0.66) | **T**  0.11 (0.00 to 0.93) | -361 (-392 to 337) |
| **W**  0.00 (-0.02 to 0.01) |
| **W**  0.64 (0.07 to 1) |
| **T\*W**  0.00 (-0.01 to 0.01) | **T\*W**  0.74 (0.08 to 1) |