Daily energy expenditure

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Thursday, March 17, 2016

Abstract: Big sentence  
Methods  
Results  
Implication  
250 words

## Introduction:

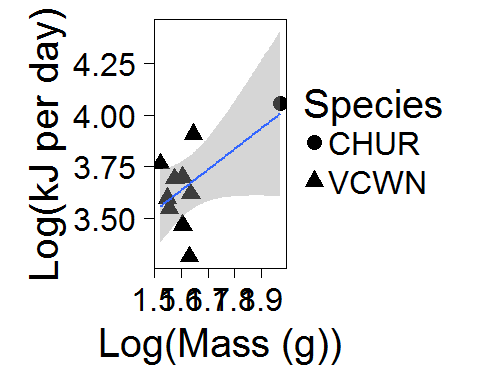
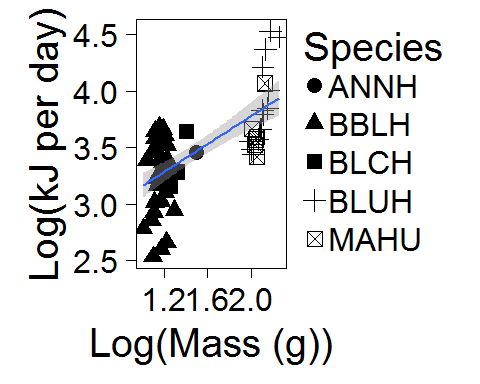
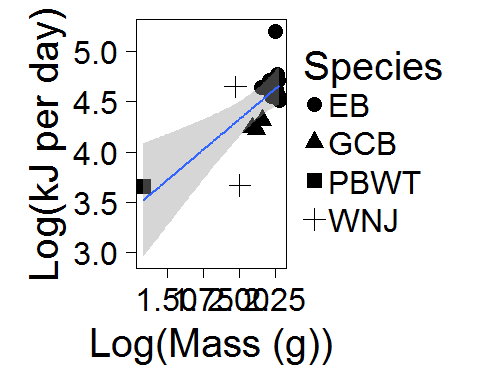
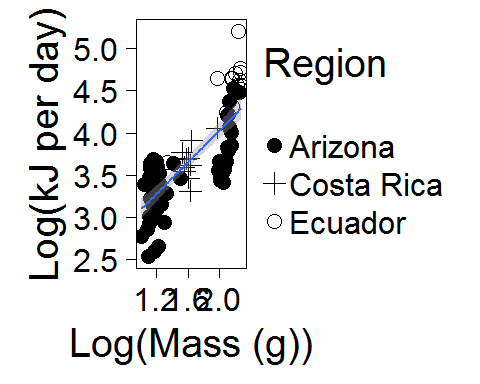
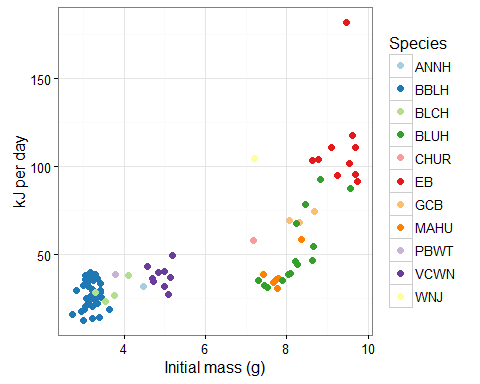
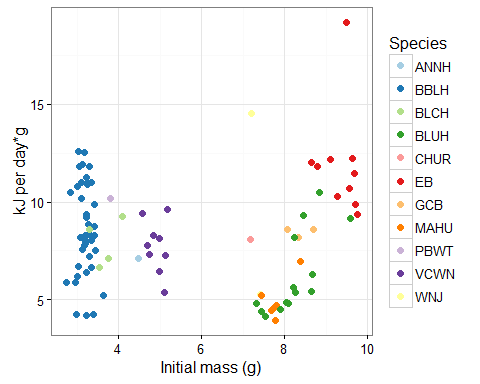
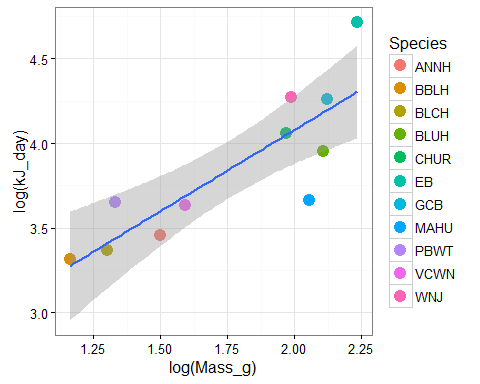
**Problem**: Organisms manage to survive by balancing their energy budgets. They usually do this with the help of fat reserves to buffer them if conditions get difficult. But some small organisms do not have much fat, and must deal with the variable energetic demands their environment places on them. I want to know what strategies hummingbirds use to manage their tight energy budgets. Is there a difference in how much energy birds spend in the tropics vs. temperate environments. e.g. birds migrate to temperate places because tropical environments don't have as many bursts of flowering events. Migration trade-offs: high mortality during trade-offs, but big gains at the other end. Do tropical hummingbirds have a higher EE than temperate, because resources are distributed in the tropics in such a way that birds spend more time foraging.

**Hurdle**: To answer this question in a useful way, we need daily energy expenditure measured in the wild, on free-living hummingbirds, not just on animals living in a cage. And we need this information in a variety of environmental conditions. Unfortunately, hummingbirds are too small to carry physiological sensors or GPS tags.

**Solution**: I used the doubly labeled water method to collect daily energy expenditure data from hummingbirds. Combining these data with daily activity budgets and estimates of energy spent on each activity, I will build an estimated daily energy budget for hummingbirds in North and South America.

**Benefit**: Hummingbirds are small endotherms with very high energetic demands, so they must manage their energy budgets carefully. They are always on the razor edge between life and death. Once we understand how they manage energy in changing environments, we can extend this energy budget model to other endotherms, such as those with large fat reserves. This will allow us to understand how endotherms will respond energetically to rapidly changing environmental conditions.

**Hypotheses**: 1. Whole animal daily energy expenditure will increase as mass increases 2. Daily energy expenditure will increase if daily temperatures vary more widely + Higher thermoregulatory costs (avg. daily temperatures are low) would contribute to increased DEE (both directly because of increased thermoregulatory costs, and indirectly because they would need to be more active to gain energy to deal with these increased costs) 3. Tropical resident species have a higher DEE than temperate long distance migrants 4. Territorial species

Plot of daily energy expenditure per gram bird, colored by species 

Plot of total daily energy expenditure per bird, colored by species (not mass-corrected)

##   
## Call:  
## lm(formula = log(kJ\_day) ~ log(Initial\_mass), data = dlw)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -0.65537 -0.25841 0.03412 0.25133 0.94224   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 2.16647 0.13276 16.32 <2e-16 \*\*\*  
## log(Initial\_mass) 0.93116 0.07984 11.66 <2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.342 on 88 degrees of freedom  
## Multiple R-squared: 0.6072, Adjusted R-squared: 0.6027   
## F-statistic: 136 on 1 and 88 DF, p-value: < 2.2e-16

##   
## Call:  
## lm(formula = log(kJ\_day) ~ log(Initial\_mass), data = dlw[dlw$Big\_site ==   
## "EC", ])  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -0.66219 -0.15843 0.02263 0.12887 0.57555   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 1.9120 0.6824 2.802 0.01413 \*   
## log(Initial\_mass) 1.2073 0.3191 3.784 0.00201 \*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.2866 on 14 degrees of freedom  
## Multiple R-squared: 0.5056, Adjusted R-squared: 0.4703   
## F-statistic: 14.32 on 1 and 14 DF, p-value: 0.002014

##   
## Call:  
## lm(formula = log(kJ\_day) ~ log(Mass\_g), data = dlw\_mean)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -0.46776 -0.09714 0.00693 0.13382 0.40697   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 2.1642 0.3626 5.969 0.00021 \*\*\*  
## log(Mass\_g) 0.9577 0.2015 4.753 0.00104 \*\*   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.2477 on 9 degrees of freedom  
## Multiple R-squared: 0.7151, Adjusted R-squared: 0.6834   
## F-statistic: 22.59 on 1 and 9 DF, p-value: 0.00104

##   
## Call:  
## lm(formula = log(kJ\_day) ~ log(Mass\_g) + Region, data = dlw\_mean)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -0.21710 -0.09355 0.00264 0.06574 0.24674   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 2.3103 0.2285 10.112 1.99e-05 \*\*\*  
## log(Mass\_g) 0.7646 0.1341 5.702 0.000734 \*\*\*  
## RegionCR 0.1748 0.1304 1.340 0.222004   
## RegionEC 0.4460 0.1105 4.035 0.004965 \*\*   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.1538 on 7 degrees of freedom  
## Multiple R-squared: 0.9145, Adjusted R-squared: 0.8779   
## F-statistic: 24.97 on 3 and 7 DF, p-value: 0.0004105