Meta-analysis Manuscript Wrangling

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```
## Warning: 1 components of `...` were not used.
##
## We detected these problematic arguments:
## * `method`
##
## Did you misspecify an argument?
```

Motivation and Hypotheses

Variability has been identified as important to organismal success and ecosystem dynamics (Vasseur et al 2014). To further understand the impacts of variability of performance, we conducted to analyses on data that explicitly accounted for acclimation (Acclimation model) and studies focuses solely on non-linear averaging (Non-linear averaging model).

H-Acclimation: If reared in fluctuating environments, when exposed to different thermal environments, organisms with larger fluctuation ranges will perform worse than those reared in constant environments. Additional covariates, such as age, size, and expsoure temperature will be correlated negative responses.

H-Non-linear averaging: Organisms will perform better in constant environments than fluctuating environments. Additional covariates, such as age, size, and large fluctuation range will be correlated negative responses.

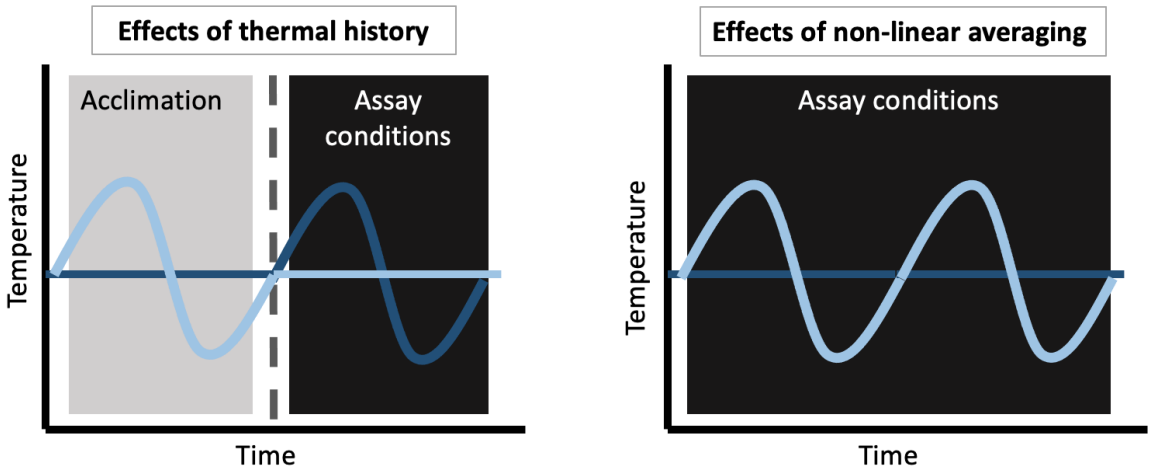


Figure 1: Conceptual figure demonstrating how acclimation and non-linear averaging account for different aspects of performance.

Acclimation Model

This data and analysis accounts for the temperatures at which organisms are reared and how their performance compares when exposed to different temperature. The results from this model has very similar results from the model I originally ran for my thesis...

Acclimation with temperature modifiers

```
##
## Multivariate Meta-Analysis Model (k = 332; method: REML)
##
## Variance Components:
##
##             estim    sqrt  nlvls  fixed                              factor
## sigma^2.1  0.0000  0.0002     11     no                            study_id
## sigma^2.2  0.4359  0.6602     33     no               study_id/experiment_id
## sigma^2.3  0.2693  0.5190     61     no  study_id/experiment_id/response_id
##
## Test for Residual Heterogeneity:
## QE(df = 328) = 3625.8727, p-val < .0001
##
## Test of Moderators (coefficients 2:4):
## QM(df = 3) = 122.6186, p-val < .0001
##
## Model Results:
##
##                              estimate      se     zval    pval    ci.lb
## intrcpt                        4.9972  0.9940   5.0274  <.0001   3.0490
## flux_range                    -0.4634  0.0989  -4.6872  <.0001  -0.6572
## mean_temp_reared              -0.2538  0.0439  -5.7870  <.0001  -0.3398
## flux_range:mean_temp_reared    0.0220  0.0044   5.0383  <.0001   0.0135
##                                ci.ub
## intrcpt                       6.9454  ***
## flux_range                   -0.2696  ***
## mean_temp_reared             -0.1678  ***
## flux_range:mean_temp_reared   0.0306  ***
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Acclimation with trait modifiers

```
## Warning: Rows with NAs omitted from model fitting.

## Warning: Redundant predictors dropped from the model.

##
## Multivariate Meta-Analysis Model (k = 331; method: REML)
##
## Variance Components:
##
##             estim    sqrt  nlvls  fixed                              factor
```

```
## sigma^2.1  0.0000  0.0001     11     no                              study_id
## sigma^2.2  0.4994  0.7067     33     no                study_id/experiment_id
## sigma^2.3  0.2272  0.4767     60     no  study_id/experiment_id/response_id
##
## Test for Residual Heterogeneity:
## QE(df = 327) = 3704.6953, p-val < .0001
##
## Test of Moderators (coefficients 2:4):
## QM(df = 3) = 3.6051, p-val = 0.3074
##
## Model Results:
##
##                estimate      se     zval    pval    ci.lb   ci.ub
## intrcpt          0.9898  0.9078   1.0904  0.2755  -0.7894  2.7690
## exp_age         -0.1968  0.3207  -0.6137  0.5394  -0.8254  0.4317
## size            -0.7382  0.4090  -1.8047  0.0711  -1.5399  0.0635  .
## exposure_temp    0.0010  0.0031   0.3254  0.7449  -0.0050  0.0070
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Acclimation with all modifiers

```
## Warning: Rows with NAs omitted from model fitting.

## Warning: Redundant predictors dropped from the model.

##
## Multivariate Meta-Analysis Model (k = 331; method: REML)
##
## Variance Components:
##
##             estim    sqrt  nlvls  fixed                              factor
## sigma^2.1  0.0000  0.0001     11     no                            study_id
## sigma^2.2  0.4698  0.6854     33     no                study_id/experiment_id
## sigma^2.3  0.2474  0.4974     60     no  study_id/experiment_id/response_id
##
## Test for Residual Heterogeneity:
## QE(df = 324) = 3580.2892, p-val < .0001
##
## Test of Moderators (coefficients 2:7):
## QM(df = 6) = 127.0957, p-val < .0001
##
## Model Results:
##
##                              estimate      se     zval    pval    ci.lb
## intrcpt                        6.0093  1.3387   4.4889  <.0001   3.3855
## flux_range                    -0.4757  0.0991  -4.7983  <.0001  -0.6700
## mean_temp_reared              -0.2595  0.0440  -5.9001  <.0001  -0.3457
## exp_age                       -0.0836  0.3184  -0.2626  0.7929  -0.7078
## size                          -0.6691  0.4072  -1.6432  0.1003  -1.4671
## exposure_temp                  0.0032  0.0031   1.0098  0.3126  -0.0030
## flux_range:mean_temp_reared    0.0226  0.0044   5.1550  <.0001   0.0140
```

```
##                                ci.ub
## intrcpt                       8.6331  ***
## flux_range                   -0.2814  ***
## mean_temp_reared             -0.1733  ***
## exp_age                       0.5405
## size                          0.1290
## exposure_temp                 0.0093
## flux_range:mean_temp_reared   0.0312  ***
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Effects of non-linear averaging

This uses the full dataset from my thesis (with more data from the additional search). Interesting that this time, mean temp is the only significant predictor?

Non-linear averaging model with temperature modifiers

```
##
## Multivariate Meta-Analysis Model (k = 366; method: REML)
##
## Variance Components:
##
##             estim    sqrt  nlvls  fixed                              factor
## sigma^2.1  0.0000  0.0008     28     no                            study_id
## sigma^2.2  0.2561  0.5061     45     no               study_id/experiment_id
## sigma^2.3  0.6116  0.7821    100     no  study_id/experiment_id/response_id
##
## Test for Residual Heterogeneity:
## QE(df = 362) = 6776.0661, p-val < .0001
##
## Test of Moderators (coefficients 2:4):
## QM(df = 3) = 95.1905, p-val < .0001
##
## Model Results:
##
##                               estimate      se     zval    pval    ci.lb
## intrcpt                         1.1548  0.3148   3.6686  0.0002   0.5378
## flux_range                     -0.0207  0.0221  -0.9397  0.3474  -0.0640
## mean_temp_constant             -0.0465  0.0127  -3.6559  0.0003  -0.0714
## flux_range:mean_temp_constant   0.0012  0.0010   1.2075  0.2272  -0.0007
##                                ci.ub
## intrcpt                       1.7718  ***
## flux_range                    0.0225
## mean_temp_constant           -0.0216  ***
## flux_range:mean_temp_constant 0.0031
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Non-linear averaging model with trait modifiers

```
## Warning: Rows with NAs omitted from model fitting.

##
## Multivariate Meta-Analysis Model (k = 359; method: REML)
##
## Variance Components:
##
##             estim    sqrt  nlvls  fixed                              factor
## sigma^2.1  0.0000  0.0004     27     no                            study_id
## sigma^2.2  0.2846  0.5335     44     no               study_id/experiment_id
## sigma^2.3  0.4882  0.6987     98     no  study_id/experiment_id/response_id
##
## Test for Residual Heterogeneity:
## QE(df = 355) = 6522.6407, p-val < .0001
##
## Test of Moderators (coefficients 2:4):
## QM(df = 3) = 2.8138, p-val = 0.4212
##
## Model Results:
##
##            estimate      se     zval    pval    ci.lb   ci.ub
## intrcpt      0.4893  0.3499   1.3983  0.1620  -0.1965  1.1751
## exp_age      0.0793  0.0730   1.0857  0.2776  -0.0638  0.2224
## size        -0.2398  0.2014  -1.1908  0.2337  -0.6345  0.1549
## org_level   -0.2252  0.2773  -0.8122  0.4167  -0.7688  0.3183
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Non-linear averaging model with all modifiers

```
## Warning: Rows with NAs omitted from model fitting.

##
## Multivariate Meta-Analysis Model (k = 359; method: REML)
##
## Variance Components:
##
##             estim    sqrt  nlvls  fixed                              factor
## sigma^2.1  0.0464  0.2154     27     no                            study_id
## sigma^2.2  0.3284  0.5731     44     no               study_id/experiment_id
## sigma^2.3  0.4578  0.6766     98     no  study_id/experiment_id/response_id
##
## Test for Residual Heterogeneity:
## QE(df = 352) = 6377.2072, p-val < .0001
##
## Test of Moderators (coefficients 2:7):
## QM(df = 6) = 97.4285, p-val < .0001
##
## Model Results:
##
```

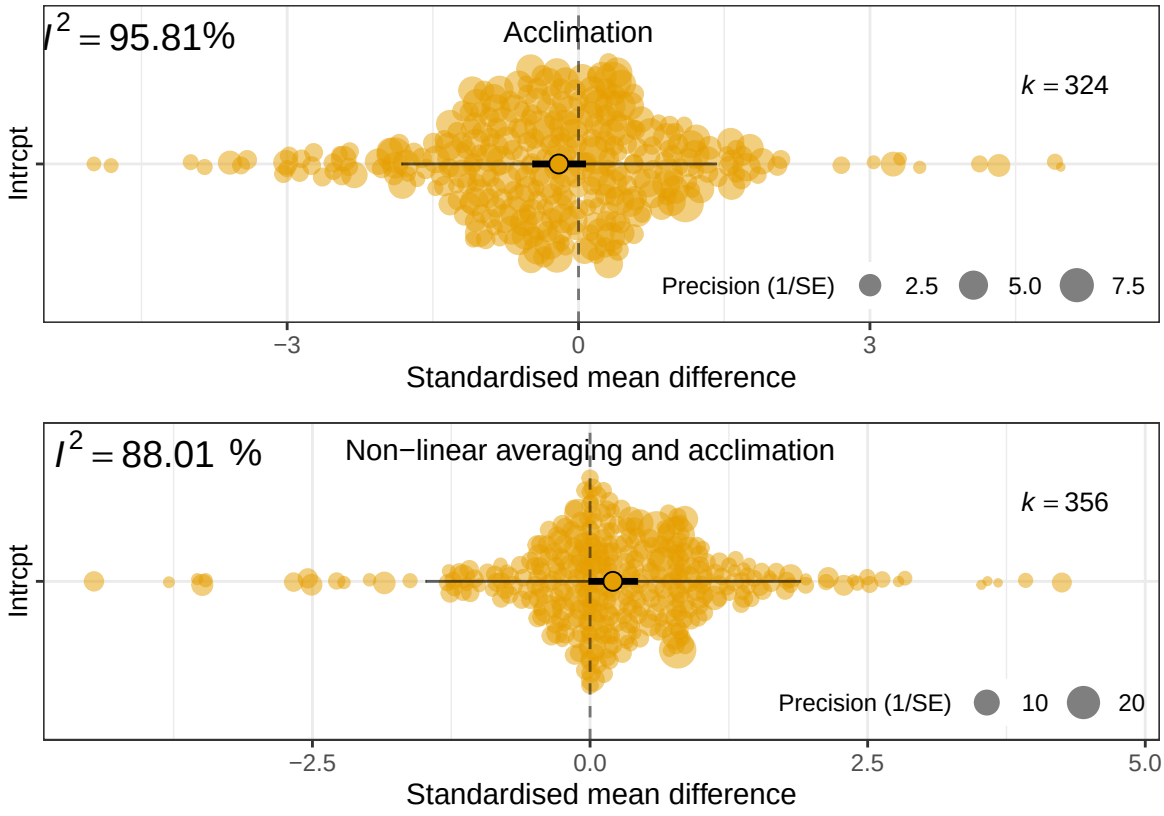
```
##                                estimate      se     zval    pval    ci.lb
## intrcpt                          1.3702  0.4645   2.9495  0.0032   0.4597
## flux_range                      -0.0209  0.0223  -0.9399  0.3473  -0.0646
## mean_temp_constant              -0.0466  0.0129  -3.6196  0.0003  -0.0719
## exp_age                          0.0706  0.0737   0.9580  0.3381  -0.0738
## size                            -0.1461  0.2205  -0.6626  0.5076  -0.5783
## org_level                       -0.2797  0.2824  -0.9905  0.3220  -0.8331
## flux_range:mean_temp_constant    0.0012  0.0010   1.2001  0.2301  -0.0008
##                                   ci.ub
## intrcpt                          2.2806   **
## flux_range                       0.0227
## mean_temp_constant              -0.0214  ***
## exp_age                          0.2150
## size                             0.2861
## org_level                        0.2738
## flux_range:mean_temp_constant    0.0031
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
#Model selection
AIC(temp_acclimation_model, trait_acclimation_model, acclimation_model, temp_full_var_model, trait_full
```

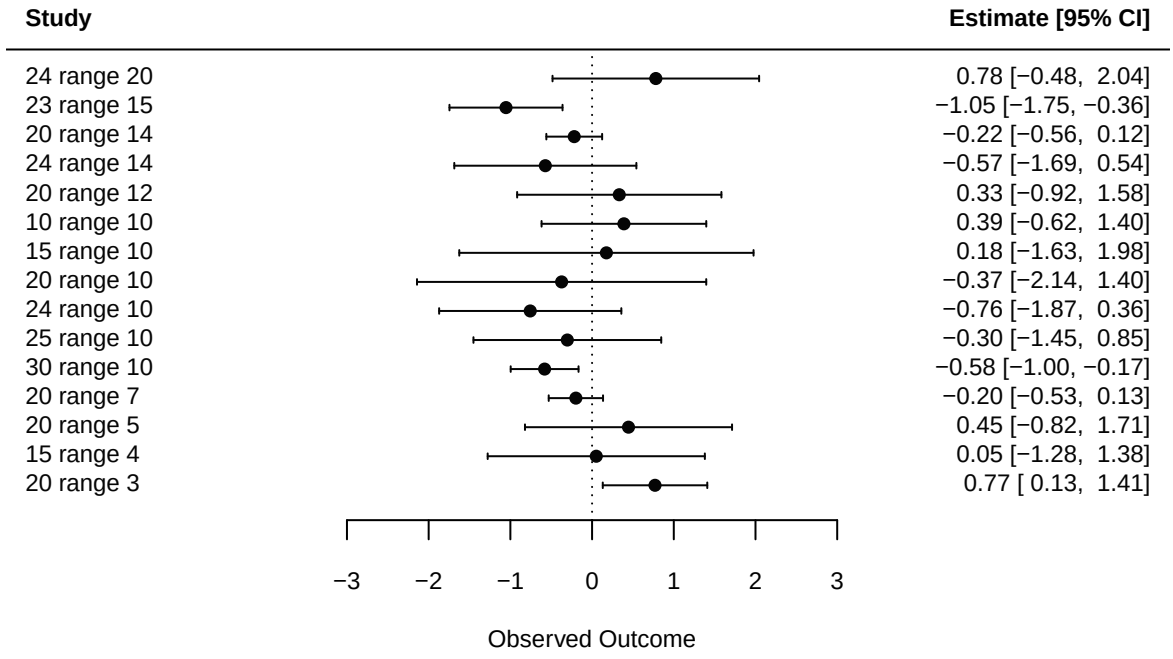
```
## Warning: Models not all fitted to the same data.
```

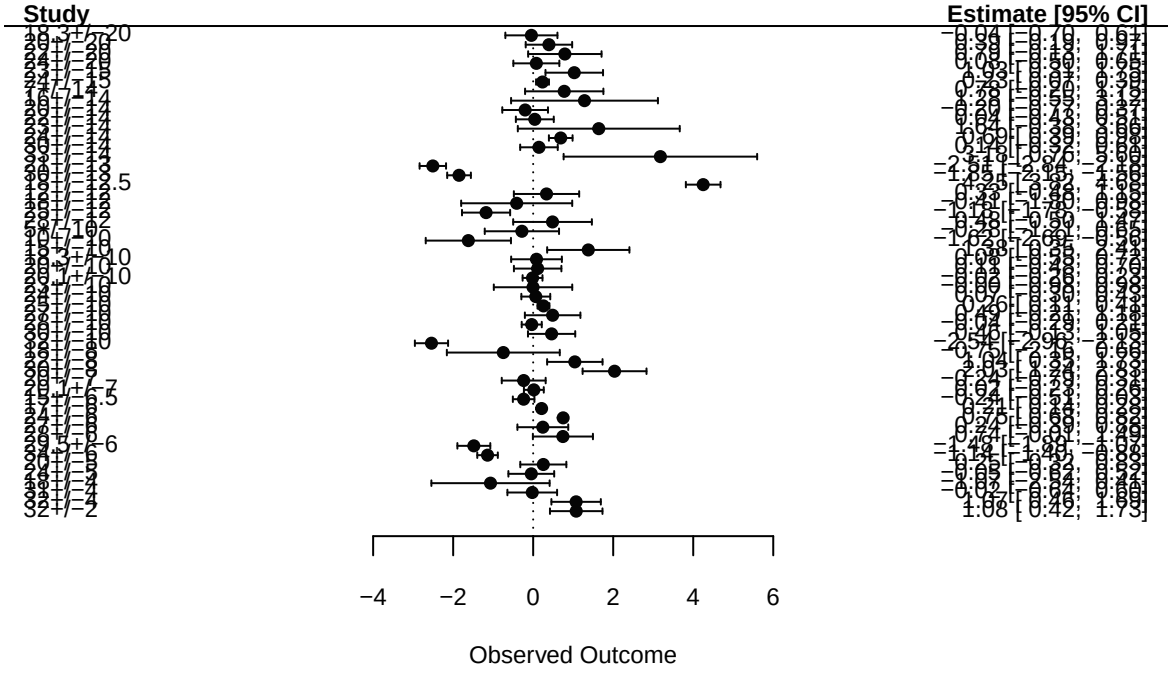
```
##                          df      AIC
## temp_acclimation_model    7 2513.012
## trait_acclimation_model   7 2622.262
## acclimation_model        10 2504.172
## temp_full_var_model       7 4235.311
## trait_full_var_model      7 4187.426
## full_var_model           10 4100.259
```

Figures

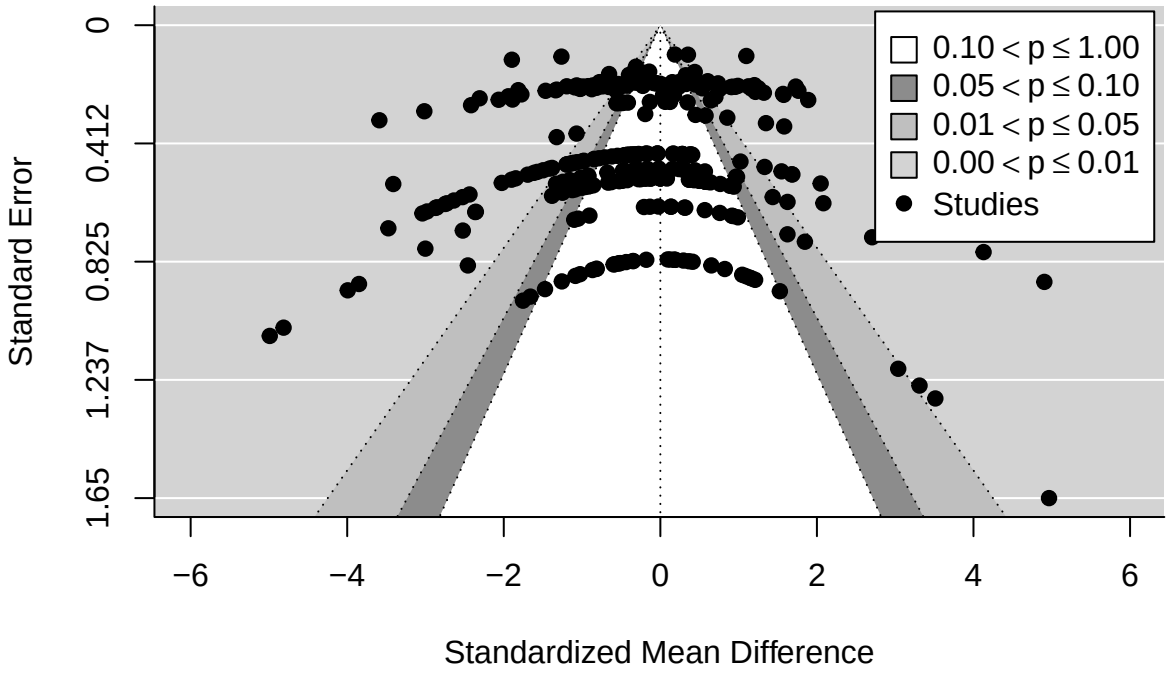


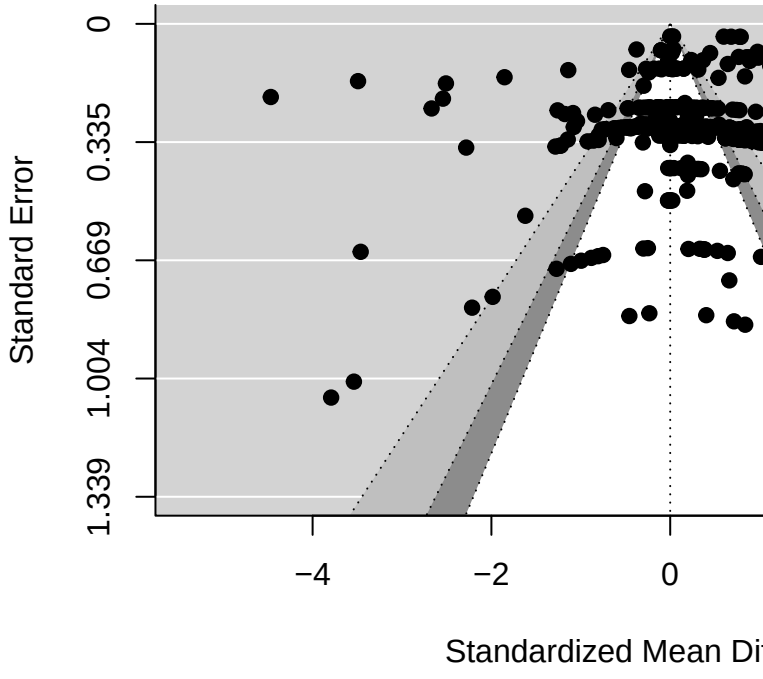

```
## `summarise()` has grouped output by 'mean_temp_reared'. You can override using the `.groups` argumen

## `summarise()` has grouped output by 'mean_temp_constant'. You can override using the `.groups` argume
```


Study
Estimate [95% CI]
24 range 20
0.78 [−0.48, 2.04]
23 range 15
−1.05 [−1.75, −0.36]
20 range 14
−0.22 [−0.56, 0.12]
24 range 14
−0.57 [−1.69, 0.54]
20 range 12
0.33 [−0.92, 1.58]
10 range 10
0.39 [−0.62, 1.40]
15 range 10
0.18 [−1.63, 1.98]
20 range 10
−0.37 [−2.14, 1.40]
24 range 10
−0.76 [−1.87, 0.36]
25 range 10
−0.30 [−1.45, 0.85]
30 range 10
−0.58 [−1.00, −0.17]
20 range 7
−0.20 [−0.53, 0.13]
20 range 5
0.45 [−0.82, 1.71]
15 range 4
0.05 [−1.28, 1.38]
20 range 3
0.77 [0.13, 1.41]
−3
−2
−1
0
1
2
3
Observed Outcome


Study
Estimate [95% CI]
−4
−2
0
2
4
6
Observed Outcome

Funnel plot of acclimation data



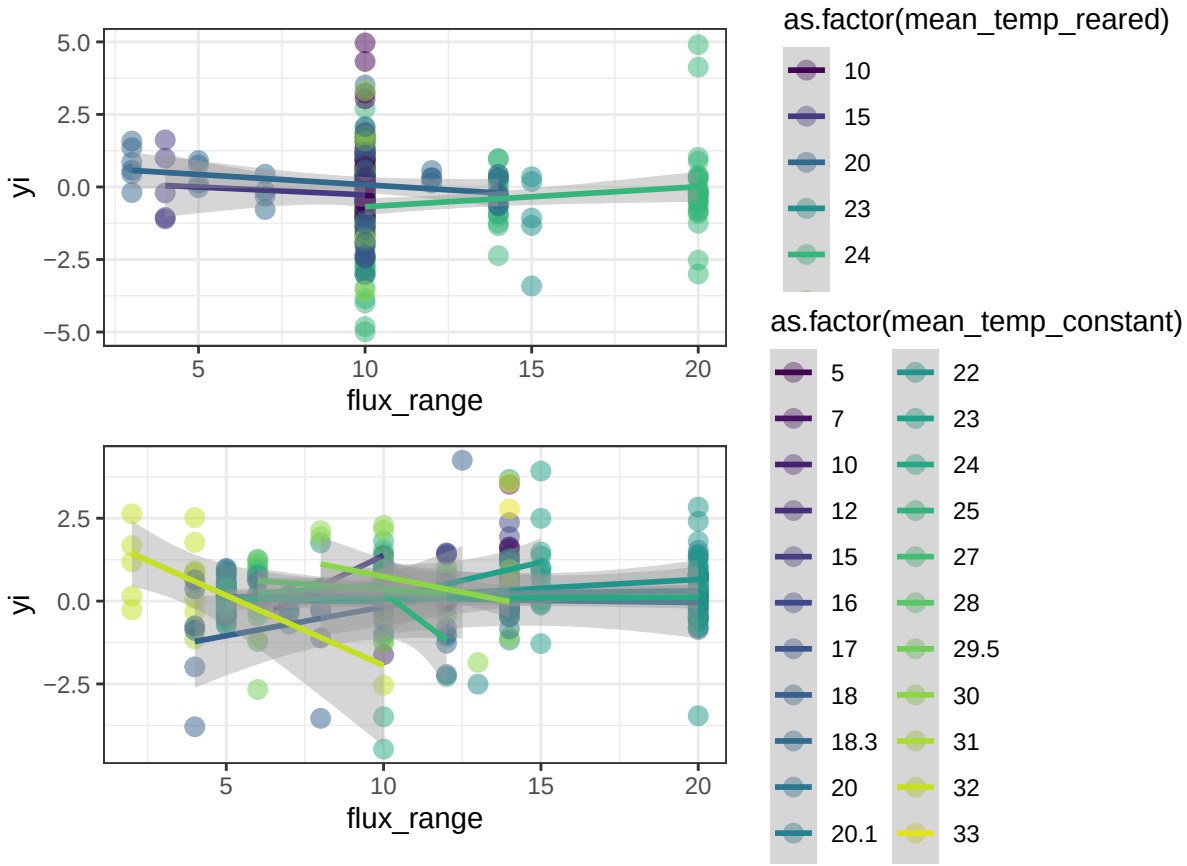


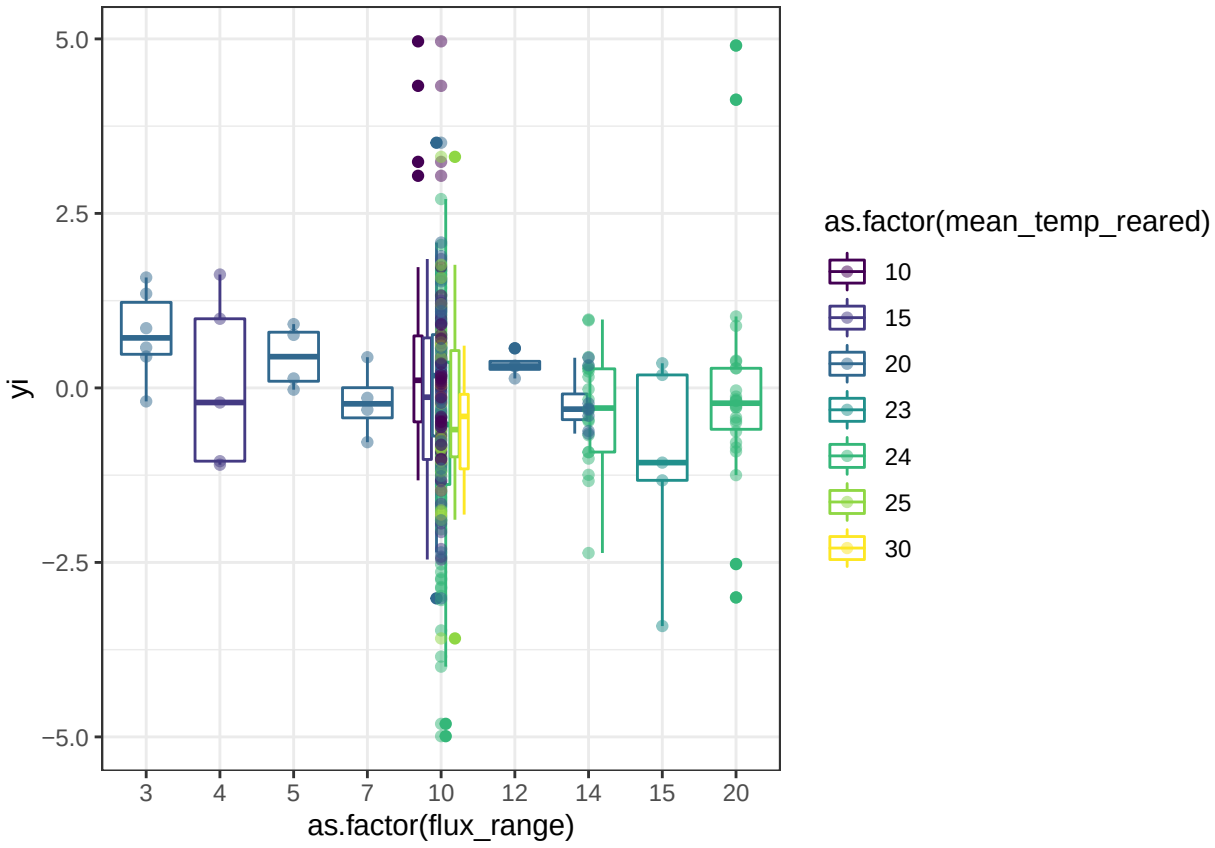
Funnel plot of non-linear averaging + acclimation data

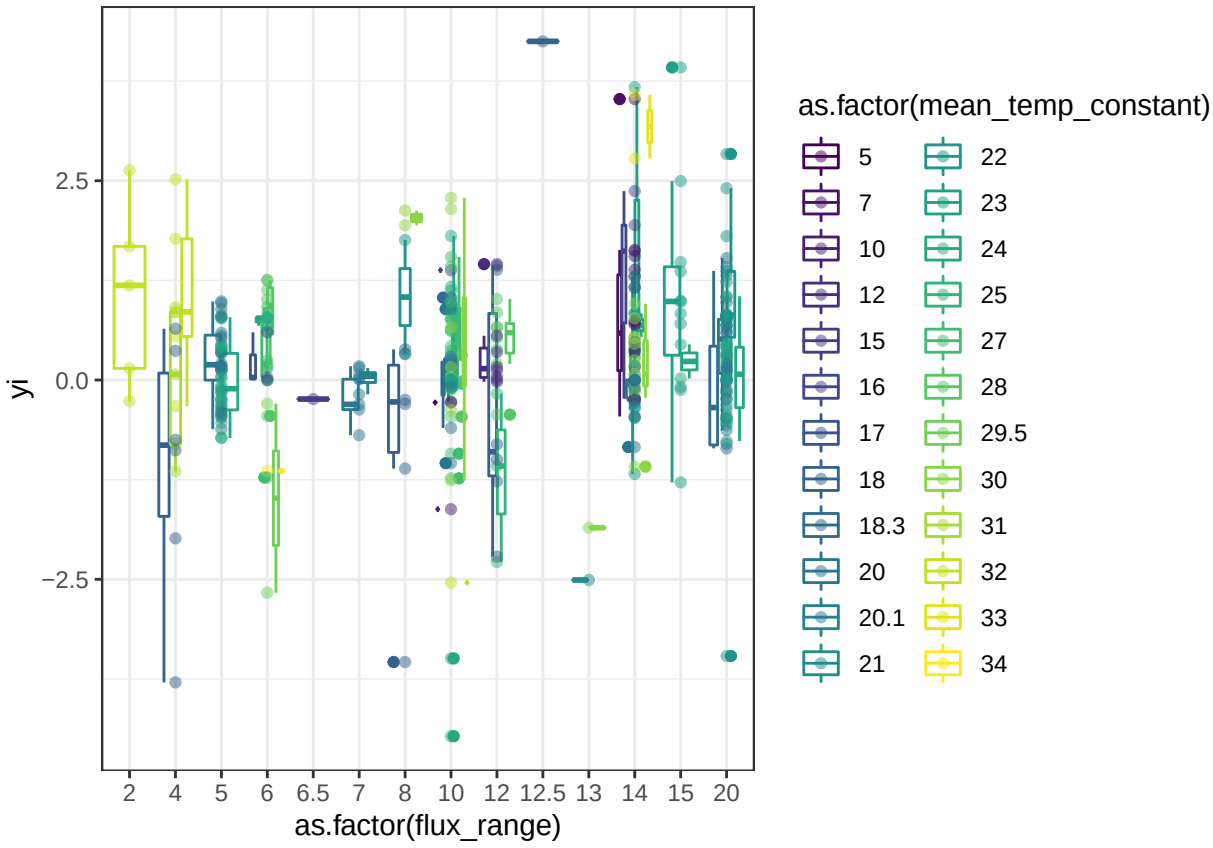
```
## `geom_smooth()` using formula 'y ~ x'
## `geom_smooth()` using formula 'y ~ x'
```

```
## Warning in qt((1 - level)/2, df): NaNs produced
```

```
## Warning in max(ids, na.rm = TRUE): no non-missing arguments to max; returning
## -Inf
```




5.0
2.5
0.0
−2.5
−5.0
yi
3
4
5
7
10
12
14
15
20
as.factor(flux_range)
as.factor(mean_temp_reared)
10
15
20
23
24
25
30



Supplementary code and models

Acclimation data split out by CT data and other thermal performance metrics

CT aggregated model

```
## Warning: Redundant predictors dropped from the model.
```

Remaining acclimation metrics model

```
## Warning: Rows with NAs omitted from model fitting.
```

```
## Warning: Redundant predictors dropped from the model.
```