

Autocorrelation_stats

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Load and Preprocess Datasets

We load two datasets: one with a preparation technique (repeated frond selection) and one without.

```
# This dataset contains replicates for which a preparation technique was performed (repeated first born
original_dataset_2 <- read.csv("https://raw.githubusercontent.com/Cuddington-Lab/thermal-experiments/main/original_dataset_2.csv")
original_dataset_2$prep <- rep("yes",times=length(original_dataset_2$Experiment_Number))

# This dataset contains replicates of experiments performed without a preparation technique
original_dataset_1 <- read.csv("https://raw.githubusercontent.com/Cuddington-Lab/thermal-experiments/main/original_dataset_1.csv")
original_dataset_1$prep <- rep("no",times=length(original_dataset_1$Experiment_Number))
```

Combine Datasets

We combine both datasets and filter out rows based on specific conditions for standard deviation (Obs_sd) and autocorrelation (Obs_ac) to clean the data.

```
# Blending both datasets, as there are no significant differences between preparation methods (probably
datin <- rbind(original_dataset_1,original_dataset_2)

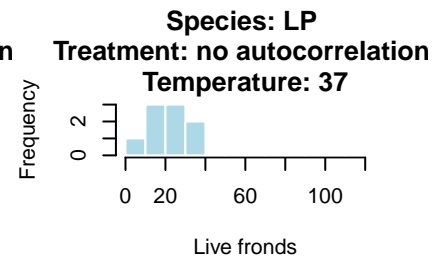
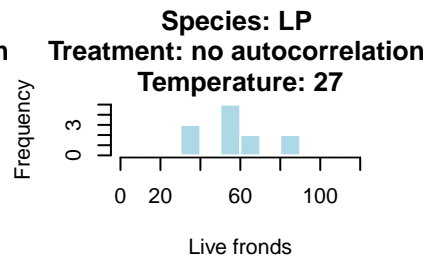
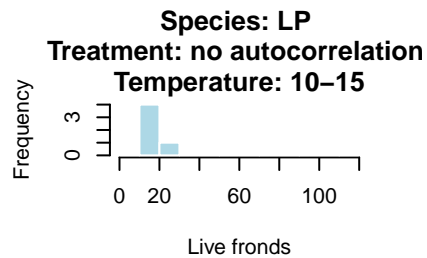
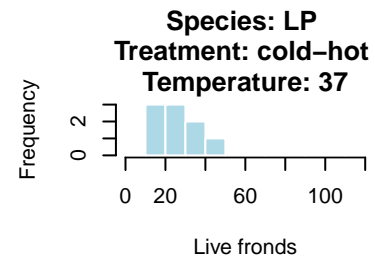
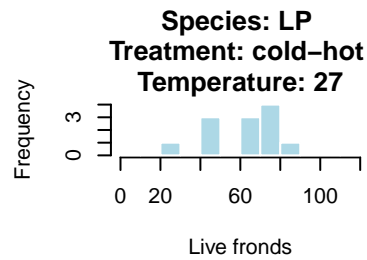
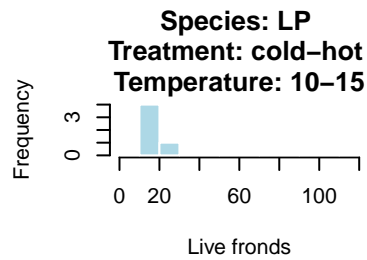
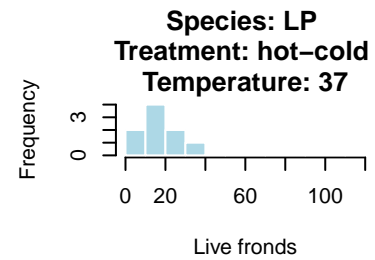
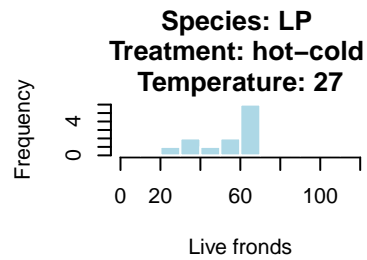
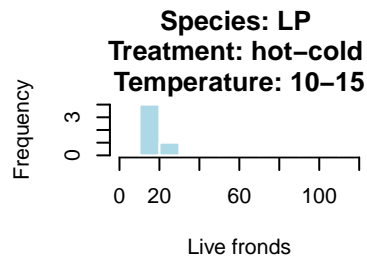
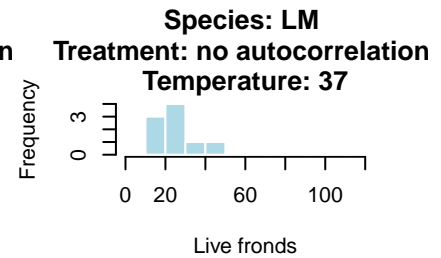
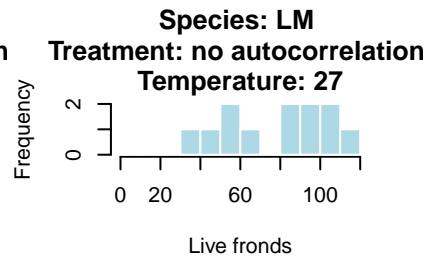
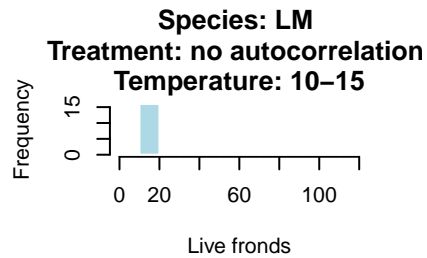
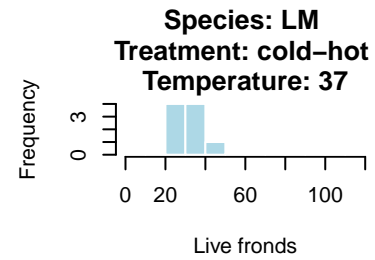
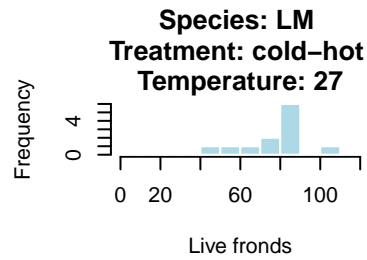
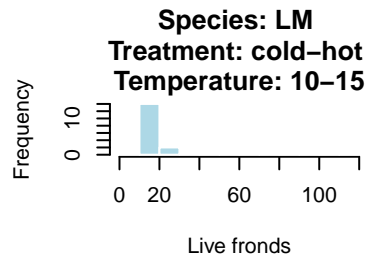
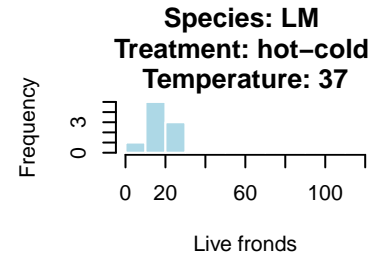
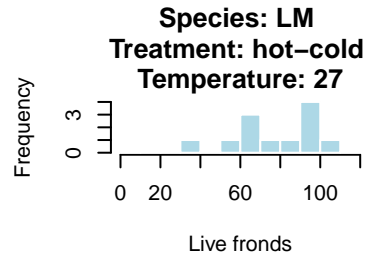
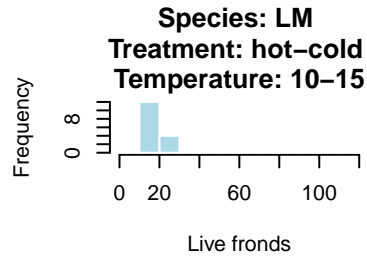
datin <- datin[!(datin$Treatment == 0 & (datin$Obs_sd <= 2.1 | datin$Obs_sd >= 2.9))
              &!(datin$Treatment == 0.95 & (datin$Obs_sd <= 2.1 | datin$Obs_sd >= 2.9)),]

datin <- datin[!(datin$Treatment == 0 & (datin$Obs_ac <= -0.2 | datin$Obs_ac >= 0.2))
              &!(datin$Treatment == 0.95 & (datin$Obs_ac <= 0.92 | datin$Obs_ac >= 0.98)),]

datin <- subset(datin, !Errors == "y"|is.na(Errors))
datin <- subset(datin, !Treatment == "constant")
```

View dataset and response variable

	Species	Exp_run	Treatment	total_living_fronds
395	LM	2733	cold-hot	90
396	LP	2733	cold-hot	74
397	LM	2733	hot-cold	91
398	LP	2733	hot-cold	63
399	LM	2733	no autocorrelation	101
400	LP	2733	no autocorrelation	88



View number of replicates

LM

```
##
##          no autocorrelation cold-hot hot-cold
## 10-15          16          16          16
## 27            12          12          12
## 37             9           9           9
```

LP

```
##
##          no autocorrelation cold-hot hot-cold
## 10-15          5           5           5
## 27            12          12          12
## 37             9           9           9
```

Mixed-Effects Model Fitting

We fit candidate simple or mixed-effects models to the data, including random effects for Experiment run (Exp_run).

```
## [1] "Comparing simple x mixed model:"
## p_value: 0
## [1] "Comparing simple x mixed model:"
## p_value: 0
```

Model Comparison and Results

We compare the performance of the models and extract estimates, confidence intervals, and p values.

```
## [1] "Model comparison for species: LM"
##
##
##          Name          AIC
## -----
## no random effects  no random effects  892.90
## experiment number  experiment number  772.12
## [1] "Model comparison for species: LP"
##
##
##          Name          AIC
## -----
## no random effects  no random effects  793.81
## experiment number  experiment number  680.89
```

Model significance testing

```
## Wald test type 3 for significance of predictor: LM
## Analysis of Deviance Table (Type III Wald chisquare tests)
##
## Response: total_living_fronds
##          Chisq Df          Pr(>Chisq)
## (Intercept) 1317.9353 1 < 0.00000000000000022 ***
## Treatment    0.6144 2          0.7355
## Mean_temperature 240.9907 2 < 0.00000000000000022 ***
```

```
## Treatment:Mean_temperature 35.9543 4 0.0000002957 ***
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## [1] "Residual degrees of freedom - species : LM : 101"
## Wald test type 3 for significance of predictor: LP
## Analysis of Deviance Table (Type III Wald chisquare tests)
##
## Response: total_living_fronds
##              Chisq Df      Pr(>Chisq)
## (Intercept)    319.8839 1 <0.0000000000000002 ***
## Treatment         0.8332 2      0.6593
## Mean_temperature    85.9939 2 <0.0000000000000002 ***
## Treatment:Mean_temperature 4.4267 4      0.3513
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## [1] "Residual degrees of freedom - species : LP : 68"
```

R2 for common duckweeds

```
## Marginal R2: NA
## Conditional R2: NA
```

Visualization of Results for common duckweeds

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: total_living_fronds ~ Treatment * Mean_temperature + (1 | Exp_run)
## Data: dataset_species
## Control: glmerControl(optimizer = "nloptwrap")
##
##      AIC      BIC    logLik deviance df.resid
##  772.1    799.2   -376.1    752.1     101
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.3375 -0.3678 -0.0017  0.3794  3.6435
##
## Random effects:
## Groups Name          Variance Std.Dev.
## Exp_run (Intercept) 0.03766  0.1941
## Number of obs: 111, groups: Exp_run, 37
##
## Fixed effects:
##              Estimate Std. Error z value
## (Intercept)      2.82097    0.07771  36.303
## Treatmentcold-hot    0.05397    0.08459   0.638
## Treatmenthot-cold    0.06070    0.08446   0.719
## Mean_temperature27    1.51541    0.10126  14.965
## Mean_temperature37    0.46435    0.11965   3.881
## Treatmentcold-hot:Mean_temperature27 -0.05601    0.09635  -0.581
## Treatmenthot-cold:Mean_temperature27 -0.05632    0.09619  -0.585
## Treatmentcold-hot:Mean_temperature37  0.07823    0.12134   0.645
## Treatmenthot-cold:Mean_temperature37 -0.55293    0.13329  -4.148
```

```

##                                     Pr(>|z|)
## (Intercept)                        < 0.0000000000000002 ***
## Treatmentcold-hot                  0.523492
## Treatmenthot-cold                  0.472348
## Mean_temperature27                 < 0.0000000000000002 ***
## Mean_temperature37                 0.000104 ***
## Treatmentcold-hot:Mean_temperature27 0.560991
## Treatmenthot-cold:Mean_temperature27 0.558218
## Treatmentcold-hot:Mean_temperature37 0.519091
## Treatmenthot-cold:Mean_temperature37 0.0000335 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##              (Intr) Trtmntc- Trtmnth- Mn_t27 Mn_t37 Trtmntc-:M_27
## Trtmntcld-h    -0.559
## Trtmntht-cl    -0.560  0.514
## Mn_tmprtr27    -0.767  0.429   0.430
## Mn_tmprtr37    -0.649  0.363   0.364   0.498
## Trtmntc-:M_27  0.491 -0.878  -0.452  -0.486 -0.319
## Trtmnth-:M_27  0.492 -0.452  -0.878  -0.486 -0.319  0.511
## Trtmntc-:M_37  0.390 -0.697  -0.359  -0.299 -0.531  0.612
## Trtmnth-:M_37  0.355 -0.326  -0.634  -0.272 -0.483  0.286
##              Trtmnth-:M_27 Trtmntc-:M_37
## Trtmntcld-h
## Trtmntht-cl
## Mn_tmprtr27
## Mn_tmprtr37
## Trtmntc-:M_27
## Trtmnth-:M_27
## Trtmntc-:M_37  0.315
## Trtmnth-:M_37  0.556      0.477
## optimizer (nloptwrap) convergence code: 0 (OK)
## Model failed to converge with max|grad| = 0.00674263 (tol = 0.002, component 1)

```

Model validation for common duckweeds

```

## [1] "Model dispersion ratio : 0.780382048699719"
## [1] "Shapiro test for normality of random factors 0.051"

```

Post-hoc test for common duckweeds

```

## [1] "Pairwise interactions"
## Mean_temperature = 10-15:
## Treatment      rate      SE  df asymp.LCL asymp.UCL
## no autocorrelation 16.79316 1.304921 Inf  14.42080 19.55580
## cold-hot          17.72437 1.355084 Inf  15.25786 20.58959
## hot-cold          17.84400 1.361503 Inf  15.36545 20.72236
##
## Mean_temperature = 27:
## Treatment      rate      SE  df asymp.LCL asymp.UCL
## no autocorrelation 76.43063 4.964703 Inf  67.29395 86.80784
## cold-hot          76.27457 4.955841 Inf  67.15434 86.63343

```

```

## hot-cold          76.76596 4.983742 Inf  67.59391  87.18258
##
## Mean_temperature = 37:
## Treatment          rate          SE  df asymp.LCL asymp.UCL
## no autocorrelation 26.71753 2.431967 Inf  22.35195  31.93574
## cold-hot          30.49379 2.690734 Inf  25.65089  36.25103
## hot-cold          16.33133 1.701186 Inf  13.31540  20.03035
##
## Confidence level used: 0.95
## Intervals are back-transformed from the log scale

## Mean_temperature = 10-15:
## contrast          ratio          SE  df null z.ratio p.value
## no autocorrelation / (cold-hot) 0.947 0.0801 Inf    1  -0.638  0.7992
## no autocorrelation / (hot-cold) 0.941 0.0795 Inf    1  -0.719  0.7524
## (cold-hot) / (hot-cold)         0.993 0.0827 Inf    1  -0.081  0.9964
##
## Mean_temperature = 27:
## contrast          ratio          SE  df null z.ratio p.value
## no autocorrelation / (cold-hot) 1.002 0.0462 Inf    1   0.044  0.9989
## no autocorrelation / (hot-cold) 0.996 0.0458 Inf    1  -0.095  0.9950
## (cold-hot) / (hot-cold)         0.994 0.0458 Inf    1  -0.139  0.9893
##
## Mean_temperature = 37:
## contrast          ratio          SE  df null z.ratio p.value
## no autocorrelation / (cold-hot) 0.876 0.0762 Inf    1  -1.520  0.2816
## no autocorrelation / (hot-cold) 1.636 0.1687 Inf    1   4.774 <.0001
## (cold-hot) / (hot-cold)         1.867 0.1880 Inf    1   6.203 <.0001
##
## P value adjustment: tukey method for comparing a family of 3 estimates
## Tests are performed on the log scale

```

