warmXtrophic Project: Flowering Duration Phenology Analyses

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Load in packages & data

```
# clear all existing data
rm(list = ls())

# Load packages
library(tidyverse)
library(ggplot2)
library(lme4)
library(lmerTest)
library(emmeans)
library(vegan)
library(car)
library(rstatix)
library(scales)
library(fitdistrplus)
library(moments)  # for calculating skewness of data
library(ggpubr)
library(jtools)  # summ() function
library(predictmeans)
library(olsrr)
library(car)
library(fitdistrplus)
library(ggpubr)
library(interactions)
library(sjPlot)
library(effects)
library(glmmTMB)
library(GGally)  # ggpairs() function
library(bbmle)  # AICtab() function

# Set working directory
Sys.getenv("L1DIR")
```

```
## [1] "/Volumes/GoogleDrive/Shared drives/SpaCE_Lab_warmXtrophic/data/L1"
```

```
L0_dir <- Sys.getenv("L0DIR")
L1_dir <- Sys.getenv("L1DIR")
L2_dir <- Sys.getenv("L2DIR")
```

```r
# Set ggplot2 plotting This code for ggplot2 sets the theme to mostly black and
# white (Arial font, and large font, base size=24)
theme_set(theme_bw(14))
theme_update(axis.text.x = element_text(size = 12, angle = 90), axis.text.y = element_text(size = 12))

# Read in data
flwr_species <- read.csv(file.path(L2_dir, "phenology/final_flwr_species_L2.csv"))  # species level dat
flwr_plot <- read.csv(file.path(L2_dir, "phenology/final_flwr_plot_L2.csv"))  # plot level data
flwr_plot_origin <- read.csv(file.path(L2_dir, "phenology/final_flwr_plot_origin_L2.csv"))  # plot leve
flwr_plot_growthhabit <- read.csv(file.path(L2_dir, "phenology/final_flwr_plot_growthhabit_L2.csv"))  #

# get rid of 'X' column that shows up
flwr_species$X <- NULL
flwr_plot$X <- NULL
flwr_plot_origin$X <- NULL
flwr_plot_growthhabit$X <- NULL

# Order warmed and ambient so that warmed shows up first in plotting (and is
# default is red = warmed; blue = ambient). First make it a factor
flwr_species$state <- as.factor(flwr_species$state)
levels(flwr_species$state)
```

```
## [1] "ambient" "warmed"
```

```r
# [1] 'ambient' 'warmed'
flwr_species$state <- factor(flwr_species$state, levels(flwr_species$state)[c(2,
    1)])
levels(flwr_species$state)
```

```
## [1] "warmed"  "ambient"
```

```r
# [1] 'warmed' 'ambient'

# again for plot level data
flwr_plot$state <- as.factor(flwr_plot$state)
levels(flwr_plot$state)
```

```
## [1] "ambient" "warmed"
```

```r
# [1] 'ambient' 'warmed'
flwr_plot$state <- factor(flwr_plot$state, levels(flwr_plot$state)[c(2, 1)])
levels(flwr_plot$state)
```

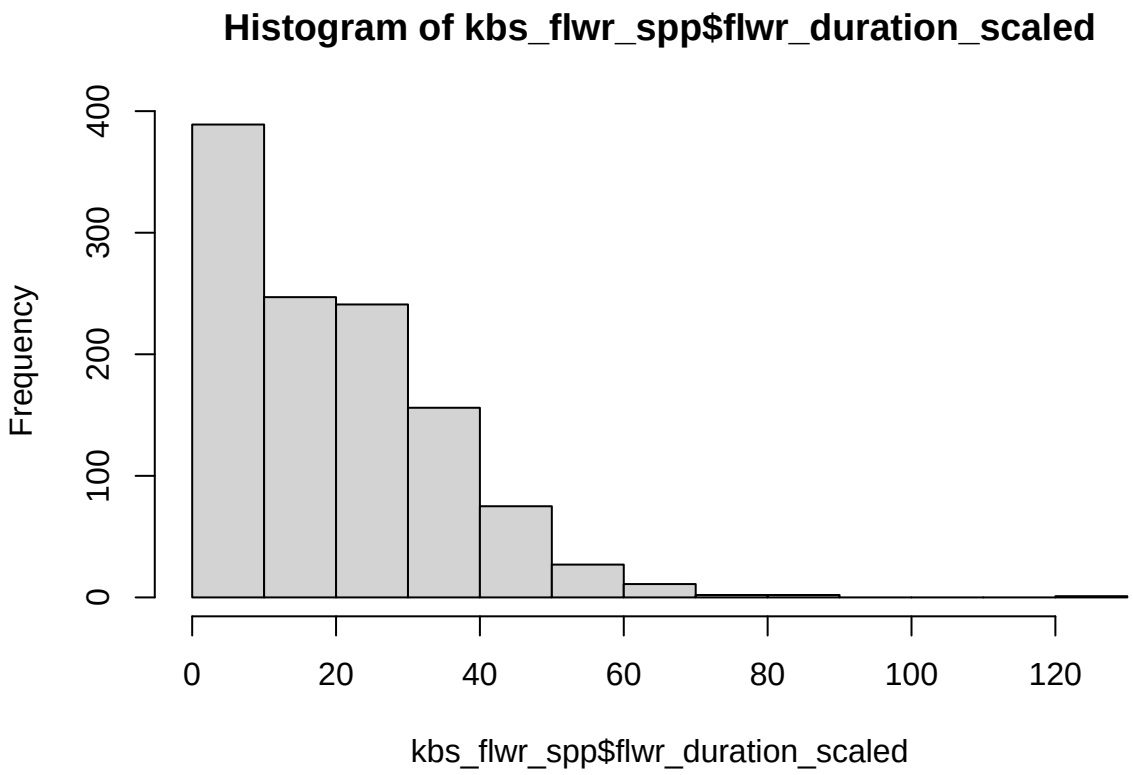
```
## [1] "warmed"  "ambient"
```

```r
# [1] 'warmed' 'ambient'

flwr_species$flwr_duration <- as.numeric(as.character(flwr_species$flwr_duration))
flwr_plot$flwr_duration <- as.numeric(as.character(flwr_plot$flwr_duration))
flwr_plot_origin$flwr_duration <- as.numeric(as.character(flwr_plot_origin$flwr_duration))
```

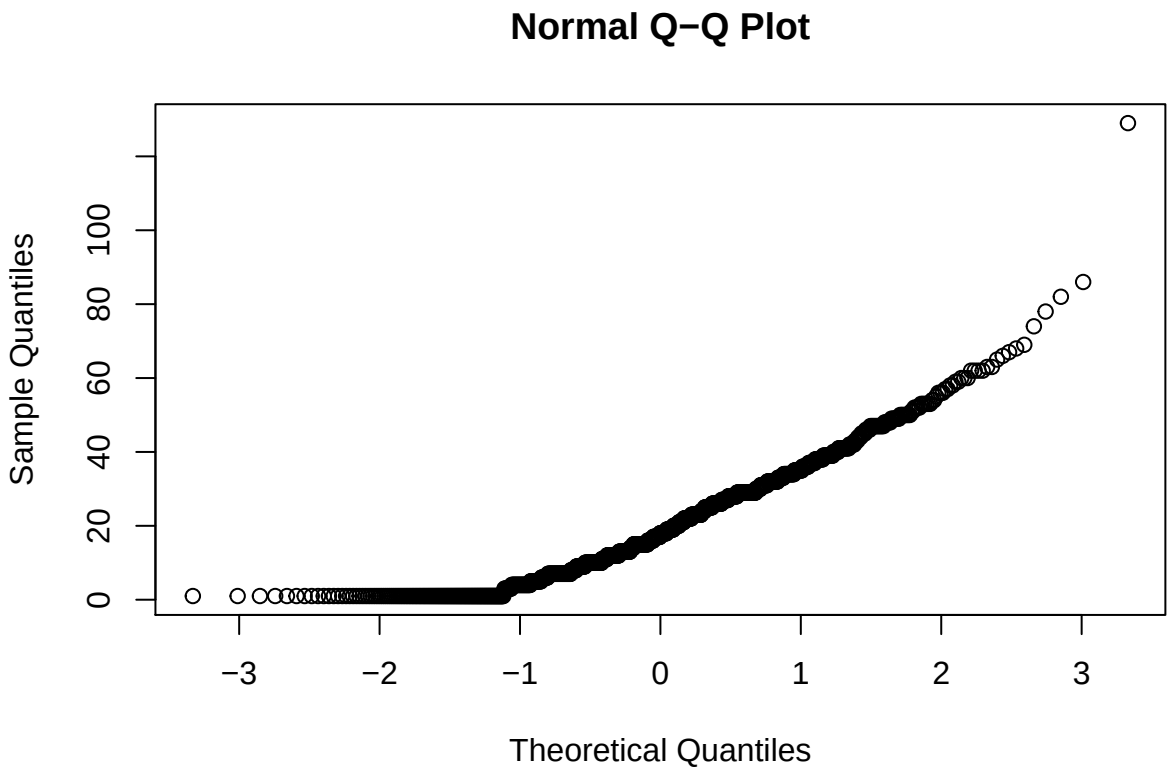
```r
flwr_plot_growthhabit$flwr_duration <- as.numeric(as.character(flwr_plot_growthhabit$flwr_duration))

# Kara's edits: adding 1 to each occurrence in the flwr_duration column so
# everything is scaled up the same & removes 0's
flwr_plot$flwr_duration_scaled <- flwr_plot$flwr_duration + 1
flwr_species$flwr_duration_scaled <- flwr_species$flwr_duration + 1
flwr_plot_origin$flwr_duration_scaled <- flwr_plot_origin$flwr_duration + 1
flwr_plot_growthhabit$flwr_duration_scaled <- flwr_plot_growthhabit$flwr_duration +
    1

umbs_flwr_plot <- subset(flwr_plot, site == "umbs")  # pull out umbs only data at plot level
umbs_flwr_spp <- subset(flwr_species, site == "umbs")  # pull out umbs only data at species level
kbs_flwr_plot <- subset(flwr_plot, site == "kbs")  # pull out kbs only data at plot level
kbs_flwr_spp <- subset(flwr_species, site == "kbs")  # pull out kbs only data at species level
kbs_flwr_plot_origin <- subset(flwr_plot_origin, site == "kbs")
kbs_flwr_plot_growthhabit <- subset(flwr_plot_growthhabit, site == "kbs")
umbs_flwr_plot_origin <- subset(flwr_plot_origin, site == "umbs")
umbs_flwr_plot_growthhabit <- subset(flwr_plot_growthhabit, site == "umbs")
```

KBS SPECIES LEVEL - Looking at DURATION of flowering

```r
### KBS ### Kara editing: I didn't change these below to the flwr_duration_scaled
### column, but they'd probably look about the same
hist(kbs_flwr_spp$flwr_duration_scaled)
```



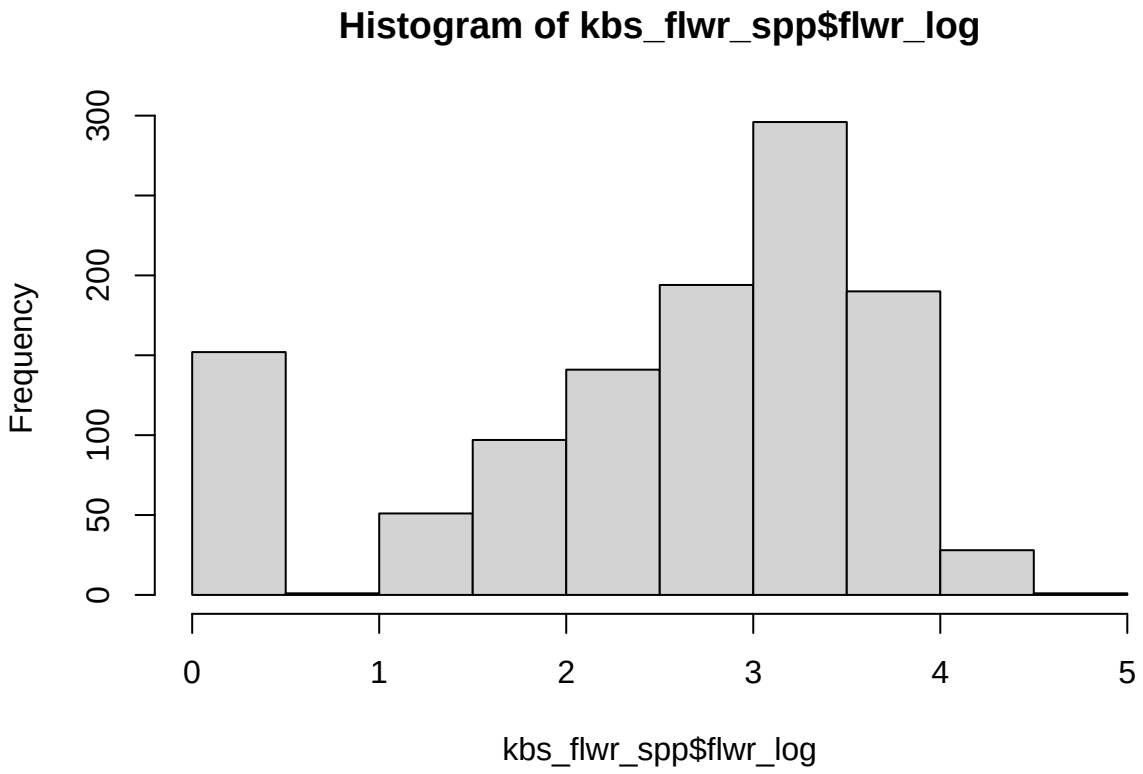
```r
qqnorm(kbs_flwr_spp$flwr_duration_scaled)
```



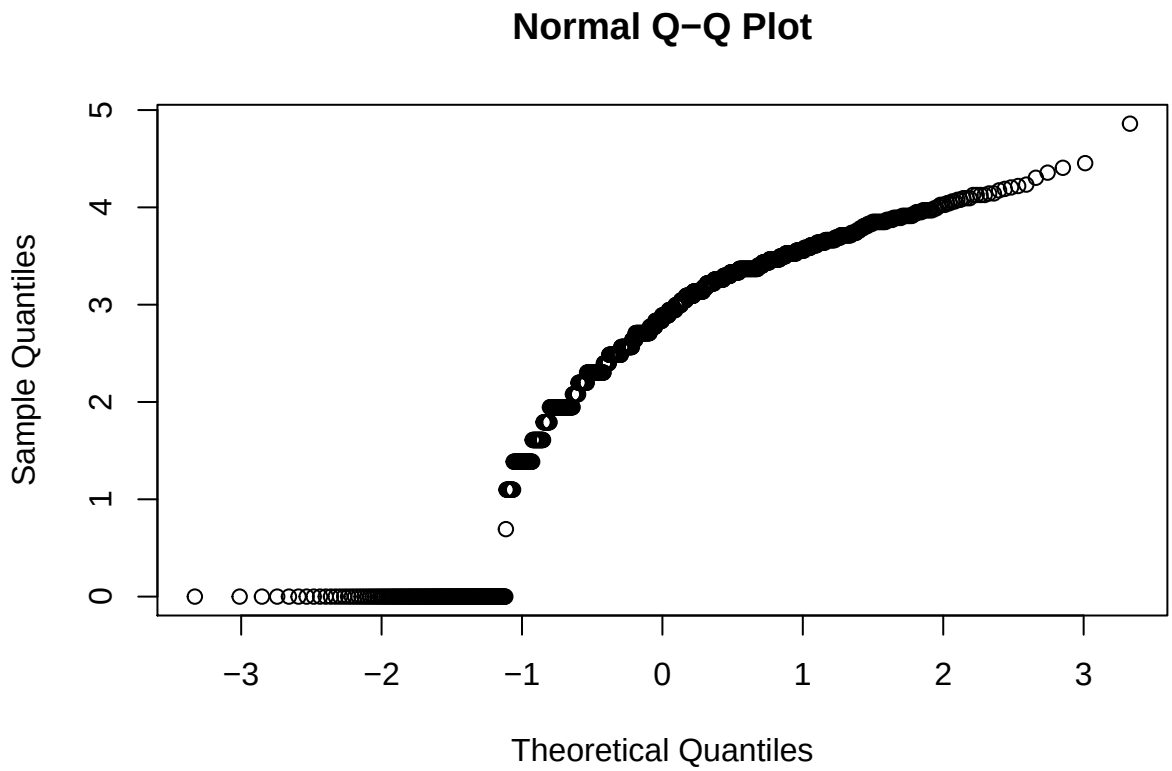

```r
shapiro.test(kbs_flwr_spp$flwr_duration)  # pvalue is < 0.05 so we reject the null hypothesis that the
```

```
##
##  Shapiro-Wilk normality test
##
## data:  kbs_flwr_spp$flwr_duration
## W = 0.92583, p-value < 2.2e-16
```

```r
# Kara editing: maybe log transforming or log transforming the data could help
# here since its right skewed
kbs_flwr_spp$flwr_log <- log(kbs_flwr_spp$flwr_duration_scaled)
hist(kbs_flwr_spp$flwr_log)
```



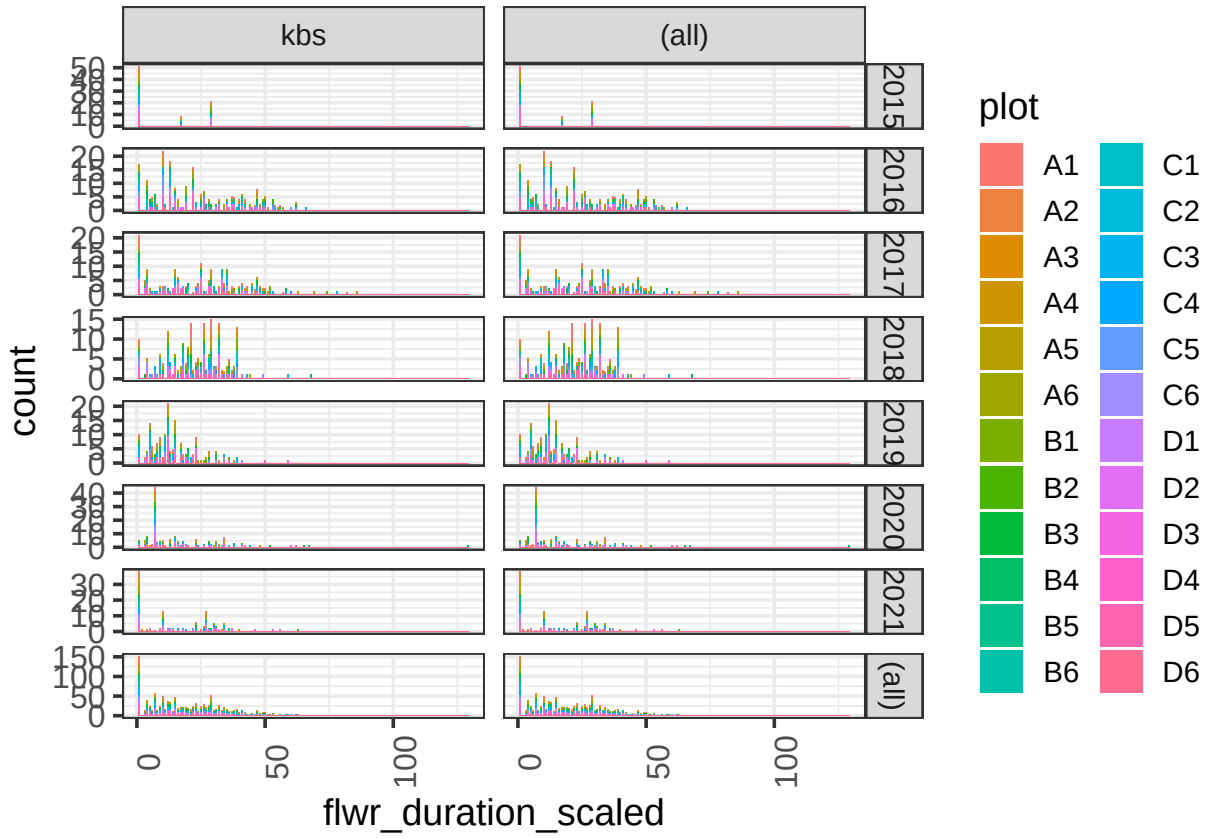

```
qqnorm(kbs_flwr_spp$flwr_log)
```



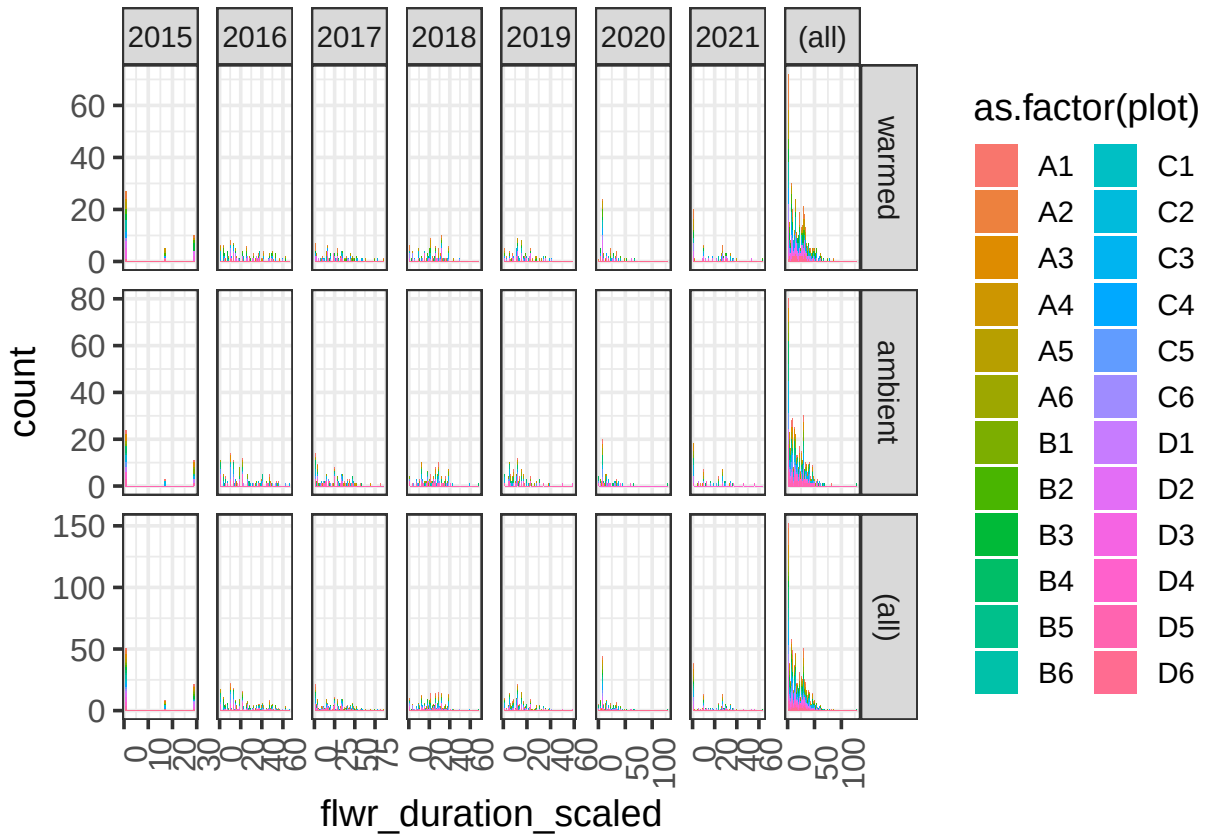
```
shapiro.test(kbs_flwr_spp$flwr_log)  #eh, not great
```

```
##
##  Shapiro-Wilk normality test
##
## data:  kbs_flwr_spp$flwr_log
## W = 0.86646, p-value < 2.2e-16
```

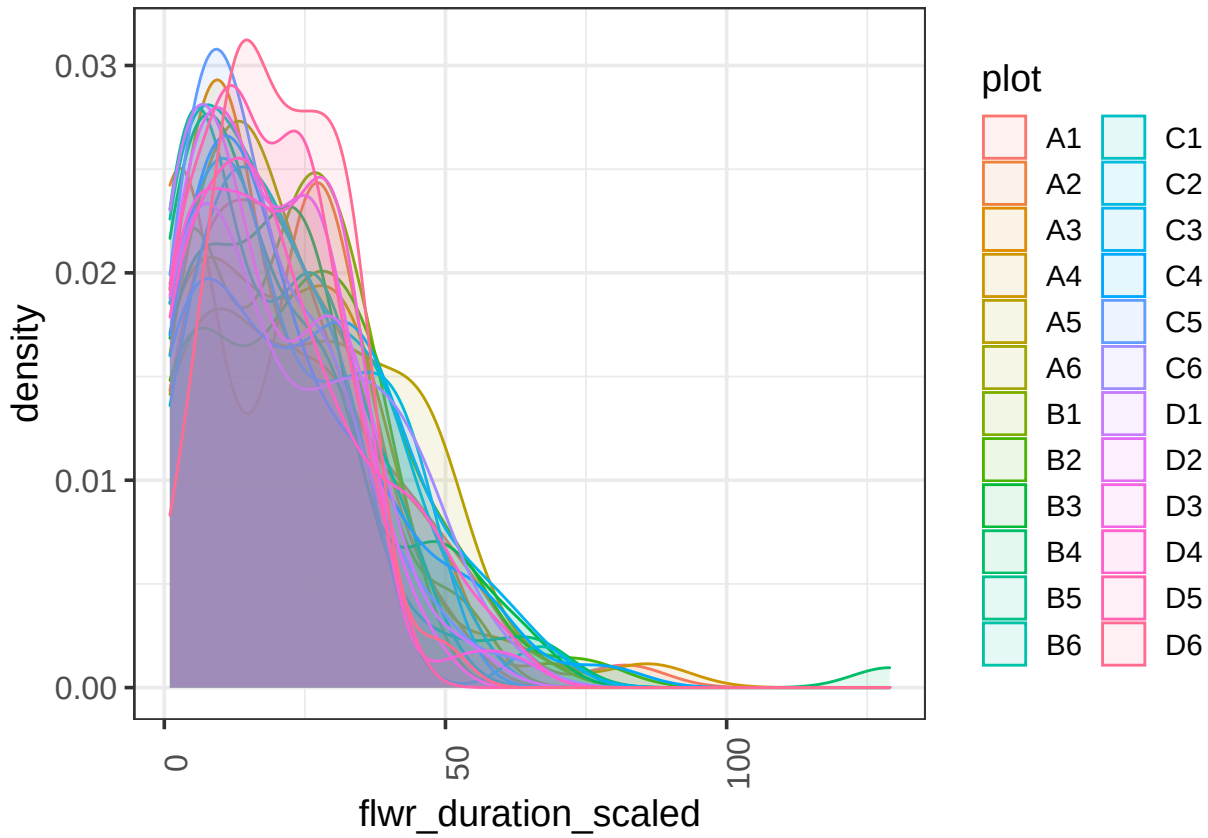
```
# Visualizing median Julian date for umbs at the PLOT LEVEL
ggplot(kbs_flwr_spp, aes(flwr_duration_scaled, fill = plot)) + geom_histogram(binwidth = 0.5) +
    facet_grid(year ~ site, margins = TRUE, scales = "free")
```



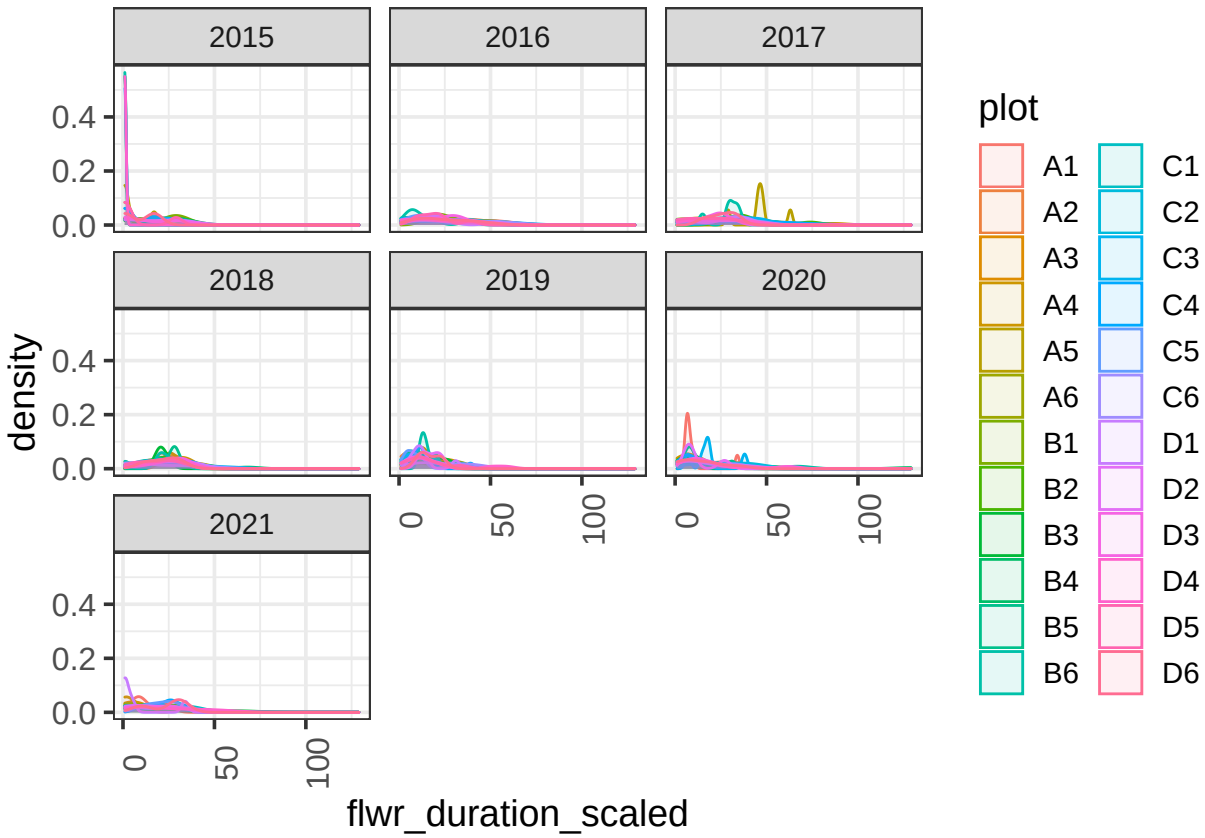

```
ggplot(kbs_flwr_spp, aes(flwr_duration_scaled, fill = as.factor(plot))) + geom_histogram(binwidth = 0.5)
    facet_grid(state ~ year, margins = TRUE, scales = "free")
```



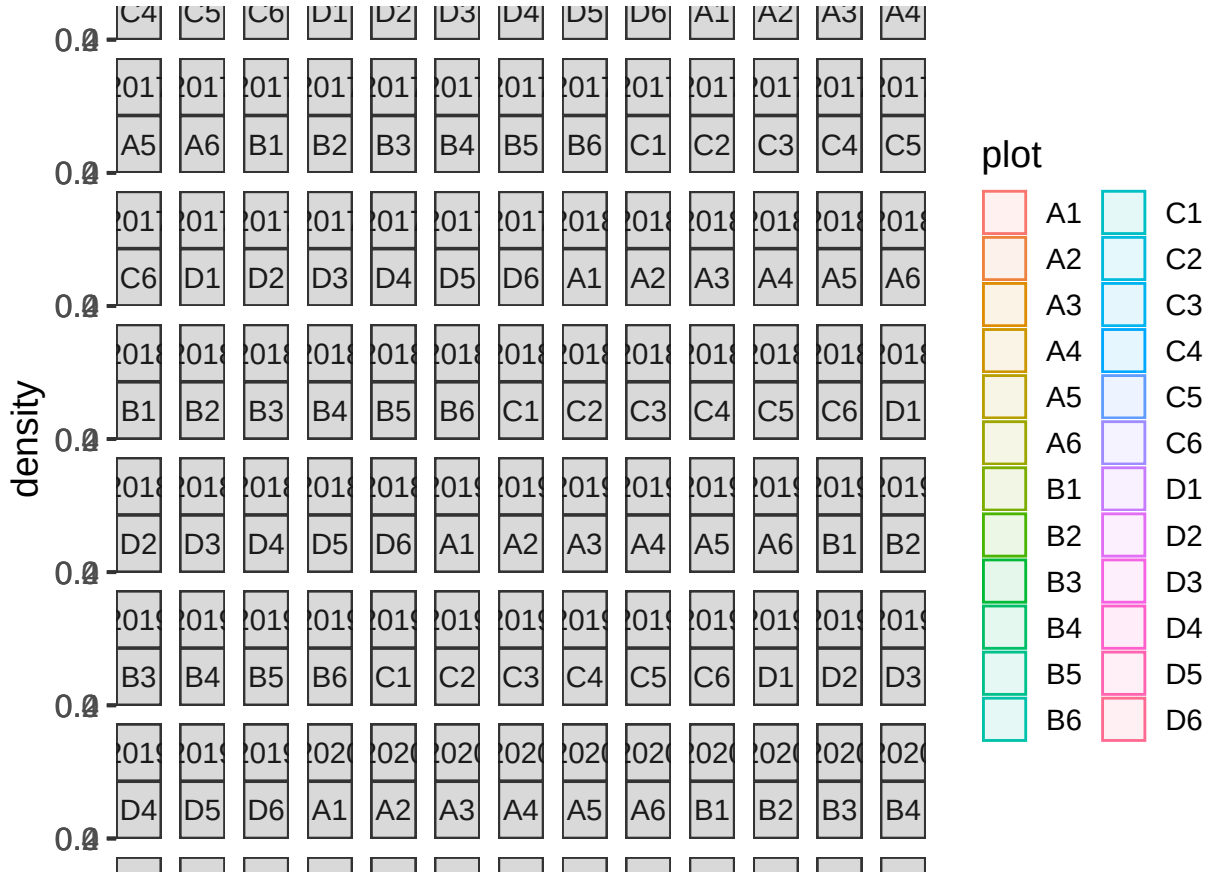

```
ggplot(kbs_flwr_spp, aes(flwr_duration_scaled, fill = plot, color = plot)) + geom_density(alpha = 0.1)
```



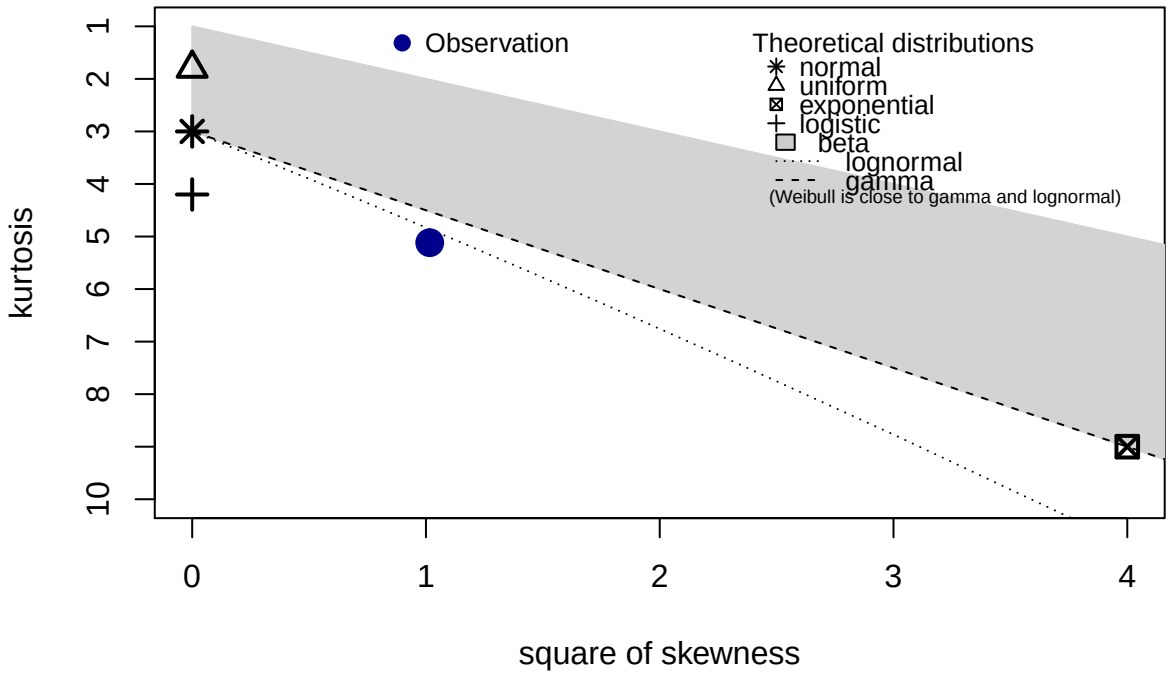

```
ggplot(kbs_flwr_spp, aes(flwr_duration_scaled, fill = plot, color = plot)) + geom_density(alpha = 0.1) +
    facet_wrap(~year)
```




```
ggplot(kbs_flwr_spp, aes(flwr_duration_scaled, fill = plot, color = plot)) + geom_density(alpha = 0.1) +
    facet_wrap(~year + plot)
```

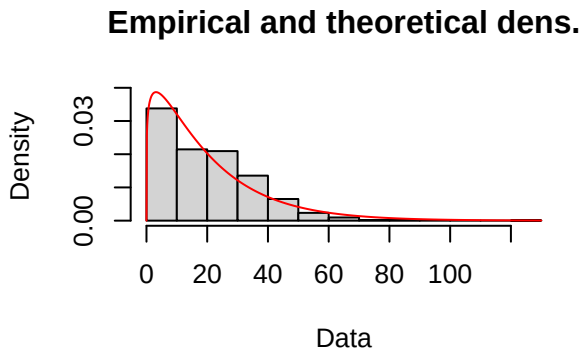


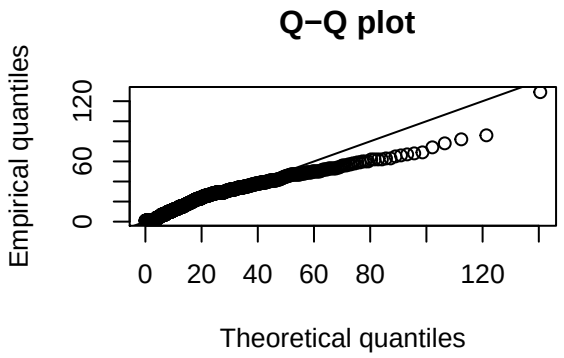

```
# Exploring distributions for these right-skewed data:
descdist(kbs_flwr_spp$flwr_duration_scaled, discrete = FALSE)
```

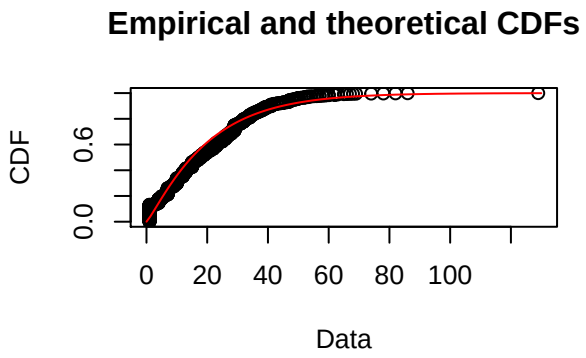


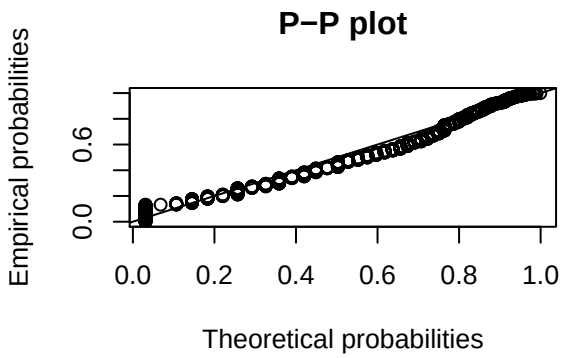

```
## summary statistics
## ------
## min:  1   max:  129
## median:  18
## mean:  20.20938
## estimated sd:  15.62808
## estimated skewness:  1.008056
## estimated kurtosis:  5.117459
```

```
# Gamma distribution
fit.gamma <- fitdist(kbs_flwr_spp$flwr_duration_scaled, "gamma")
plot(fit.gamma)
```

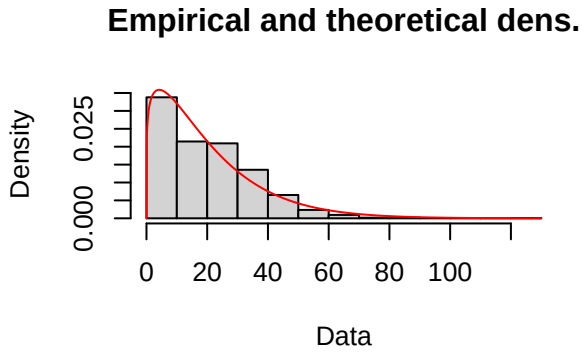


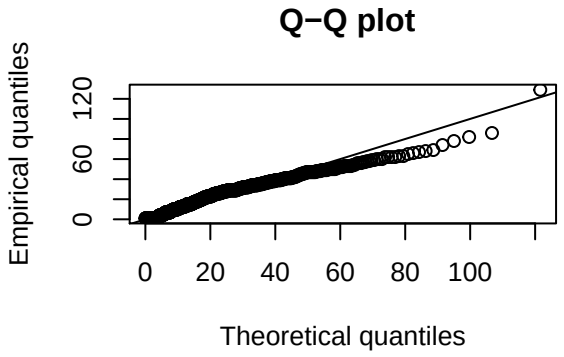


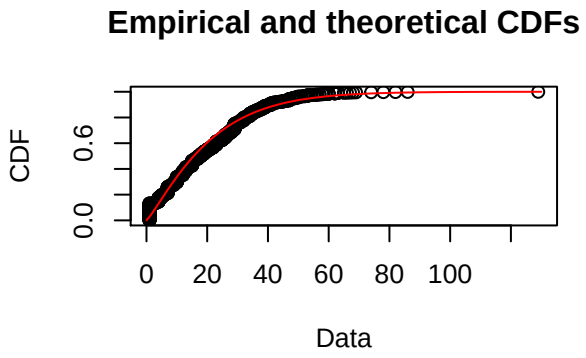


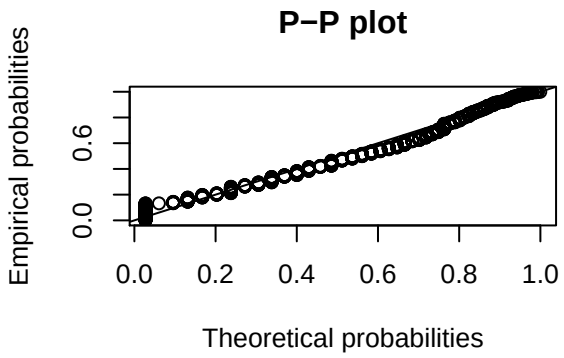



```
# Weibull distribution
fit.weibull <- fitdist(kbs_flwr_spp$flwr_duration_scaled, "weibull")
plot(fit.weibull)
```

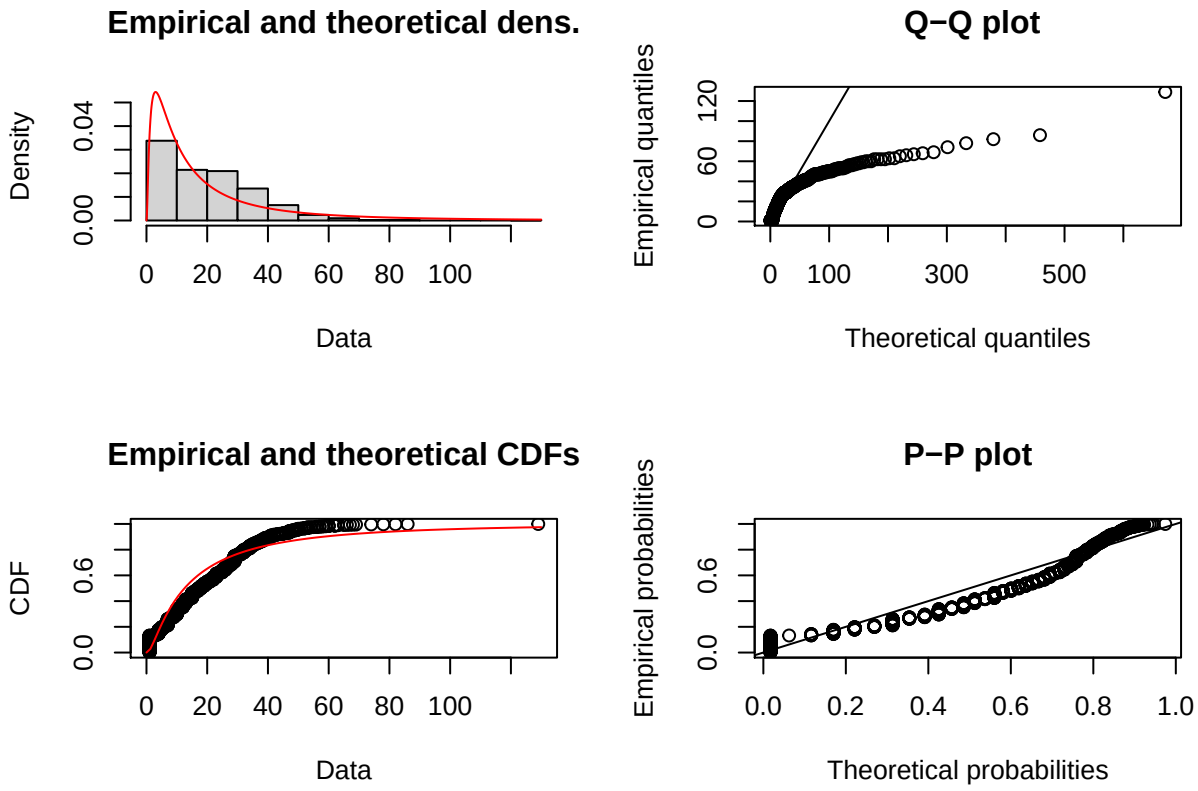




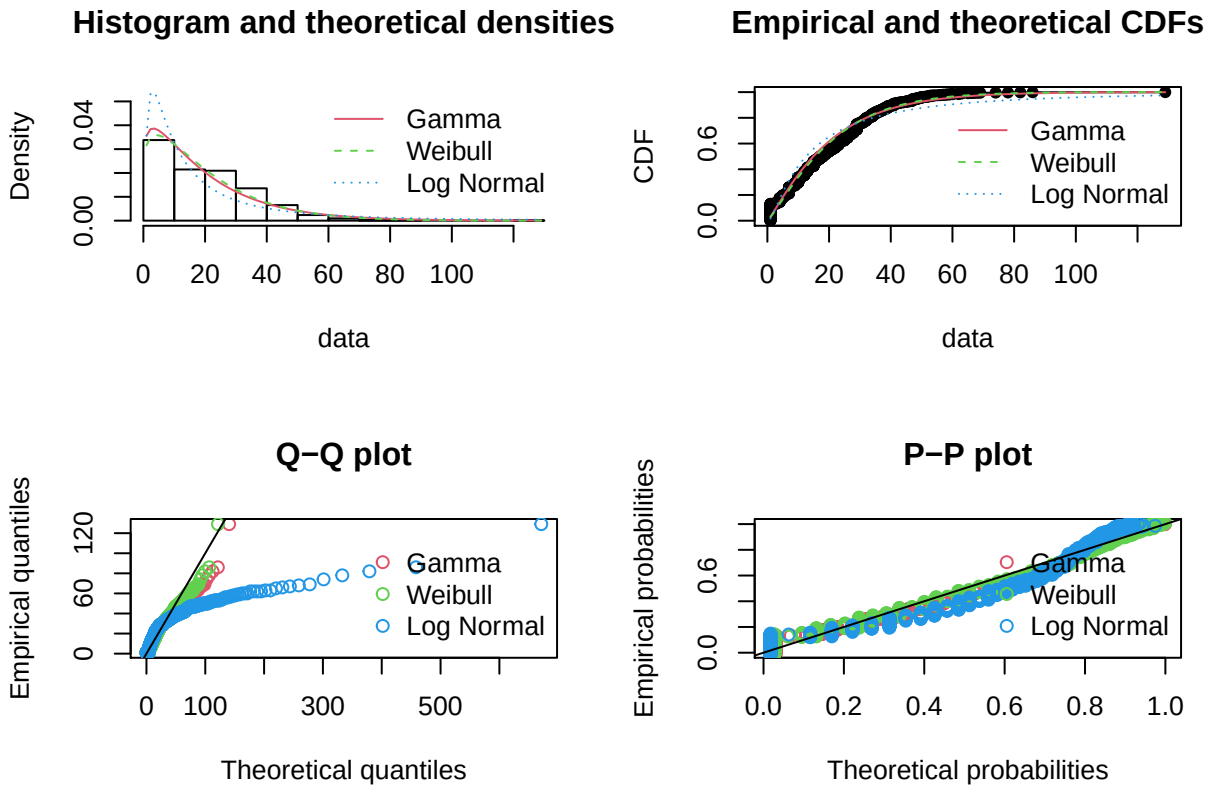




```
# Lognormal distribution
fit.ln <- fitdist(kbs_flwr_spp$flwr_duration_scaled, "lnorm")
plot(fit.ln)
```




```
par(mfrow = c(2, 2))
plot.legend <- c("Gamma", "Weibull", "Log Normal")
denscomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
cdfcomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
qqcomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
ppcomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
```



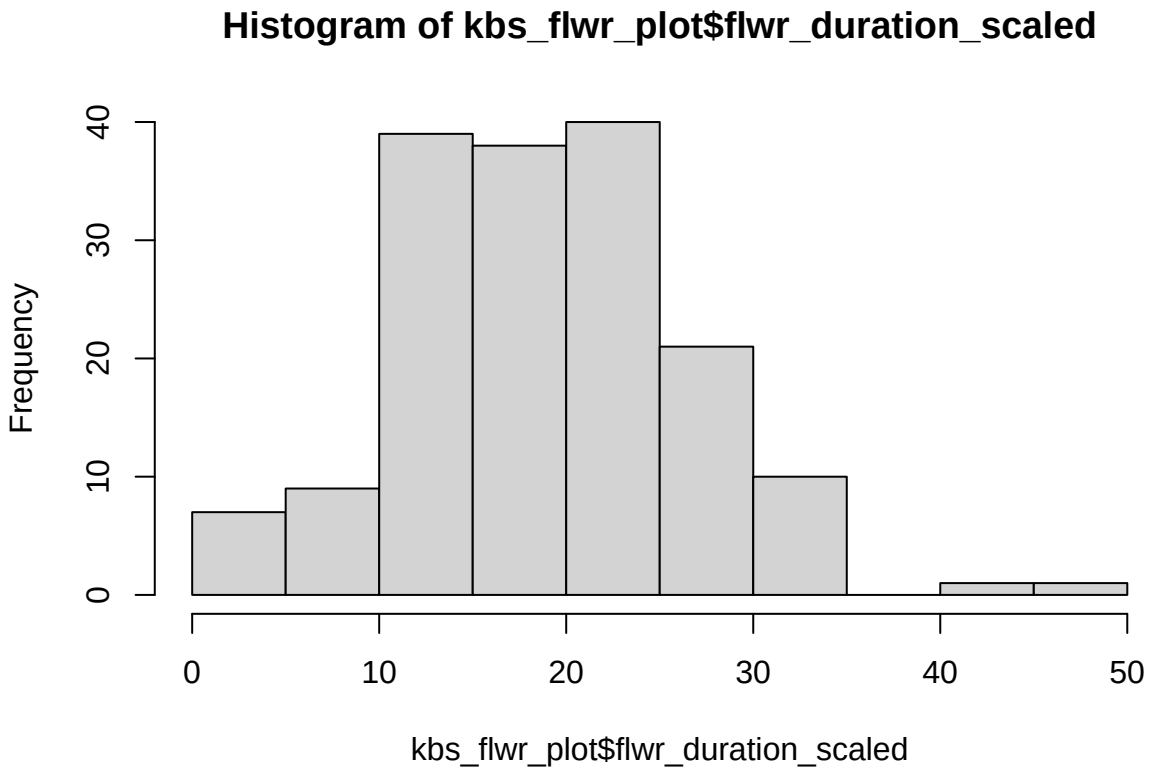

```
# Goodness of fit comparisons across fits (can't include the log normal bc it
# becomes diff response values)
gofstat(list(fit.gamma, fit.weibull, fit.ln), fitnames = c("Gamma", "Weibull", "Log Normal"))
```

```
## Goodness-of-fit statistics
##                                 Gamma    Weibull Log Normal
## Kolmogorov-Smirnov statistic  0.1012177  0.1047727  0.1360167
## Cramer-von Mises statistic    2.5633225  1.9099784  7.3586400
## Anderson-Darling statistic   19.9451679 17.9655150 52.0510035
##
## Goodness-of-fit criteria
##                                 Gamma  Weibull Log Normal
## Akaike's Information Criterion 9206.583 9185.581   9500.254
## Bayesian Information Criterion 9216.680 9195.678   9510.350
```

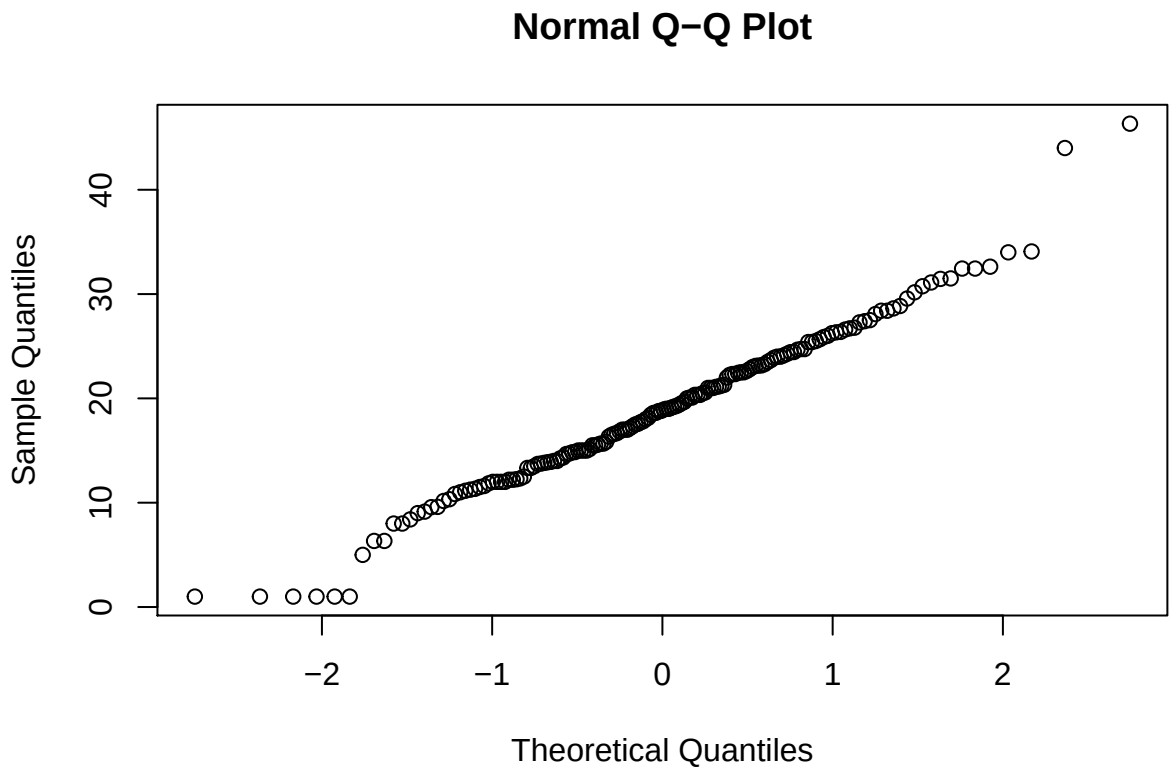
```
# weibull best fit
```

KBS PLOT LEVEL - Looking at DURATION of flowering

```
### KBS ###
hist(kbs_flwr_plot$flwr_duration_scaled)
```



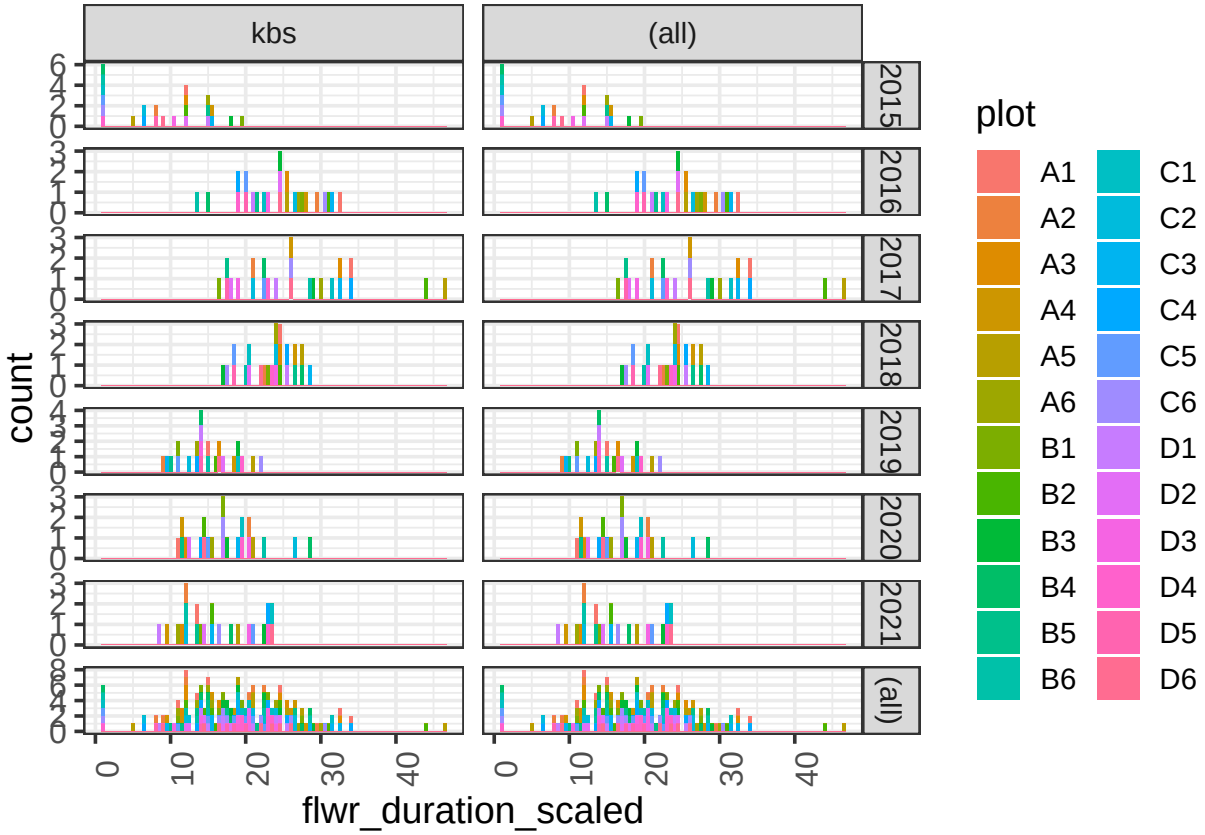

```
qqnorm(kbs_flwr_plot$flwr_duration_scaled)
```



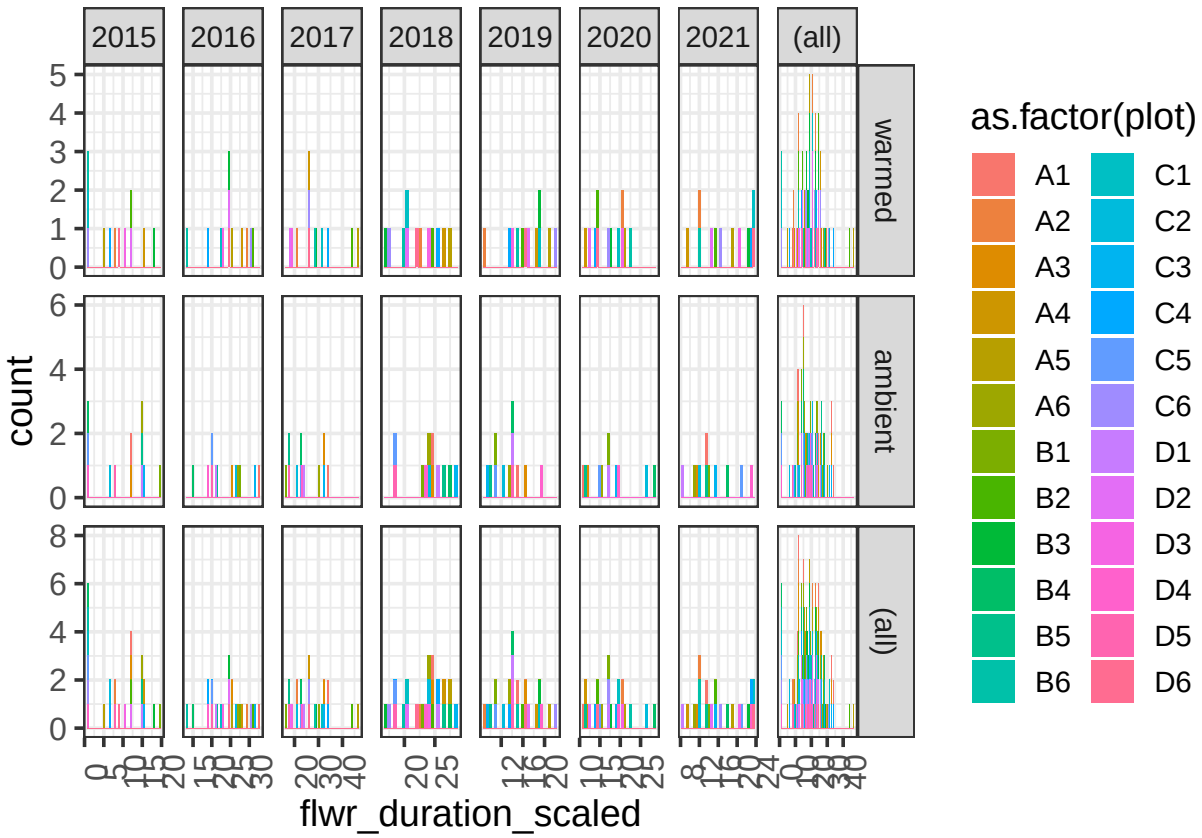
```
shapiro.test(kbs_flwr_plot$flwr_duration_scaled)  # pvalue is > 0.05 so we do not reject the null hypot
```

```
##
##  Shapiro-Wilk normality test
##
## data:  kbs_flwr_plot$flwr_duration_scaled
## W = 0.98388, p-value = 0.05128
```

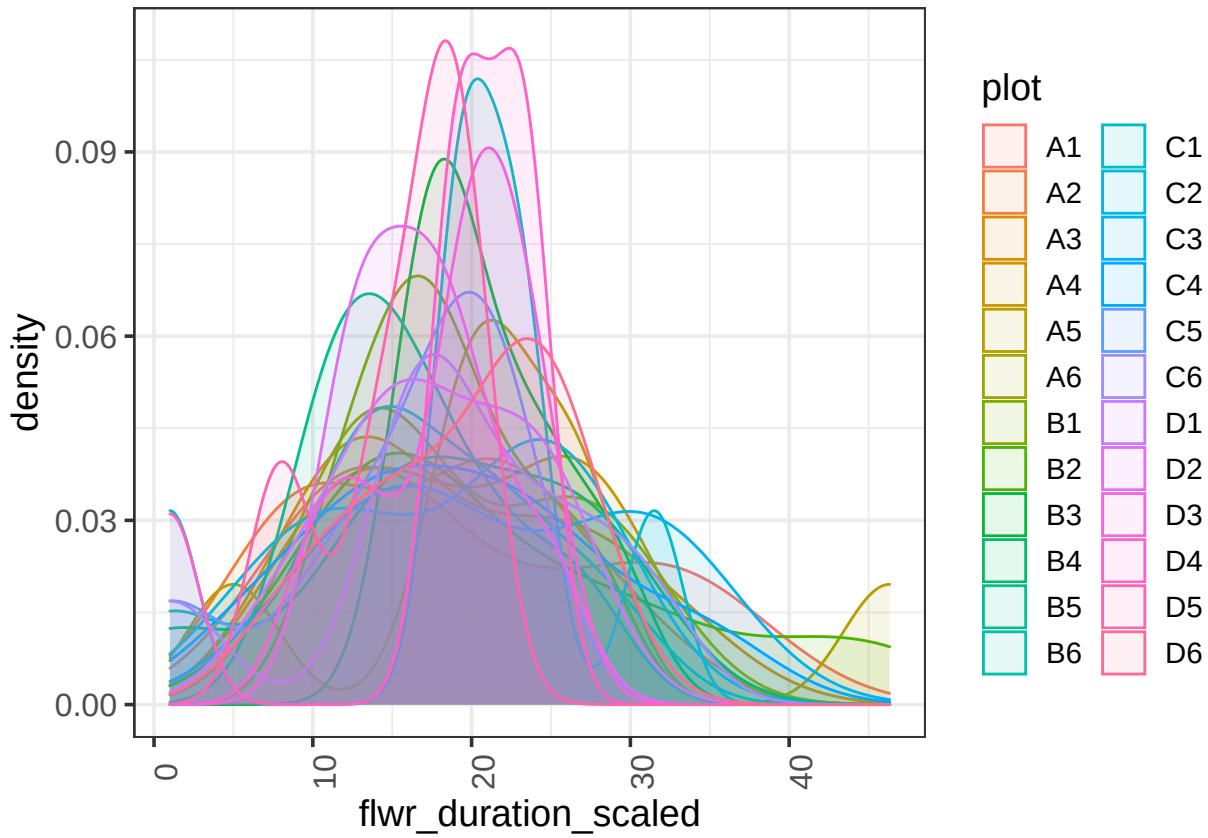
```
# Visualizing median Julian date for umbs at the PLOT LEVEL
ggplot(kbs_flwr_plot, aes(flwr_duration_scaled, fill = plot)) + geom_histogram(binwidth = 0.5) +
    facet_grid(year ~ site, margins = TRUE, scales = "free")
```



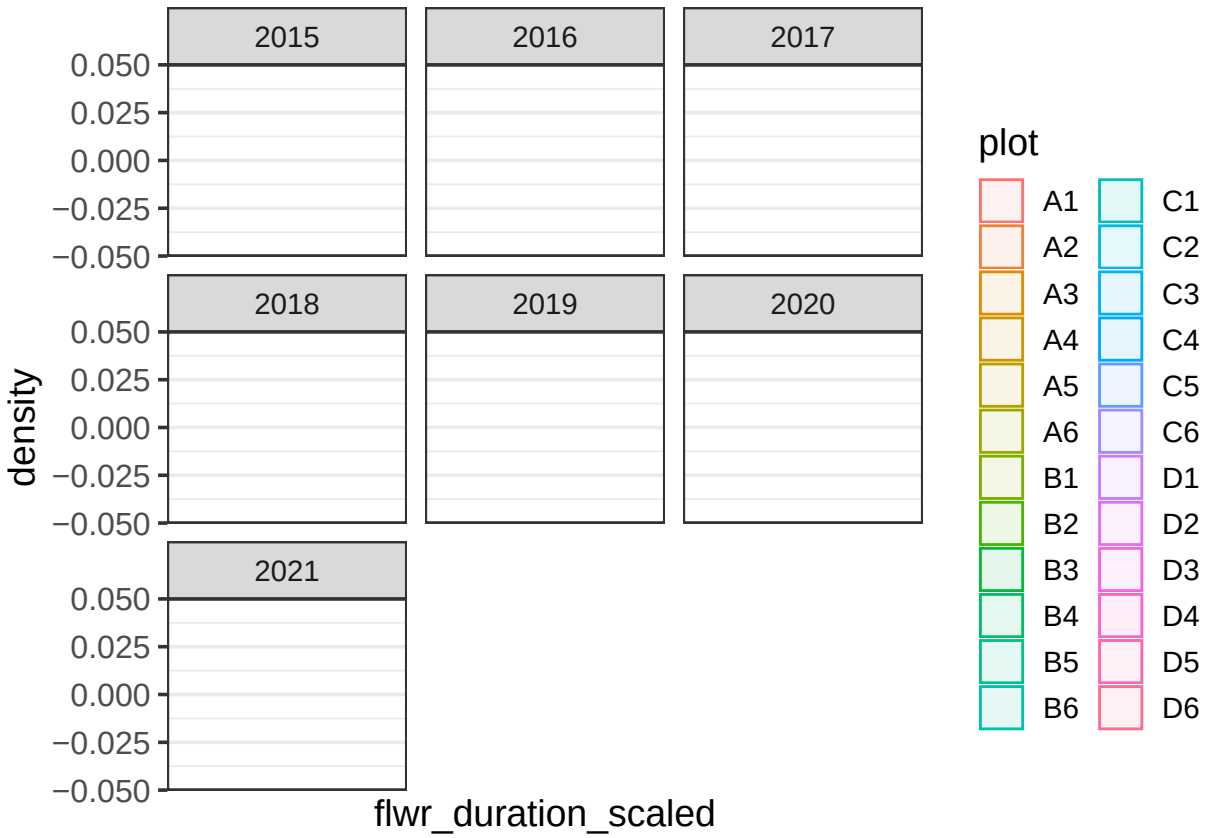

```
ggplot(kbs_flwr_plot, aes(flwr_duration_scaled, fill = as.factor(plot))) + geom_histogram(binwidth = 0.5
    facet_grid(state ~ year, margins = TRUE, scales = "free")
```



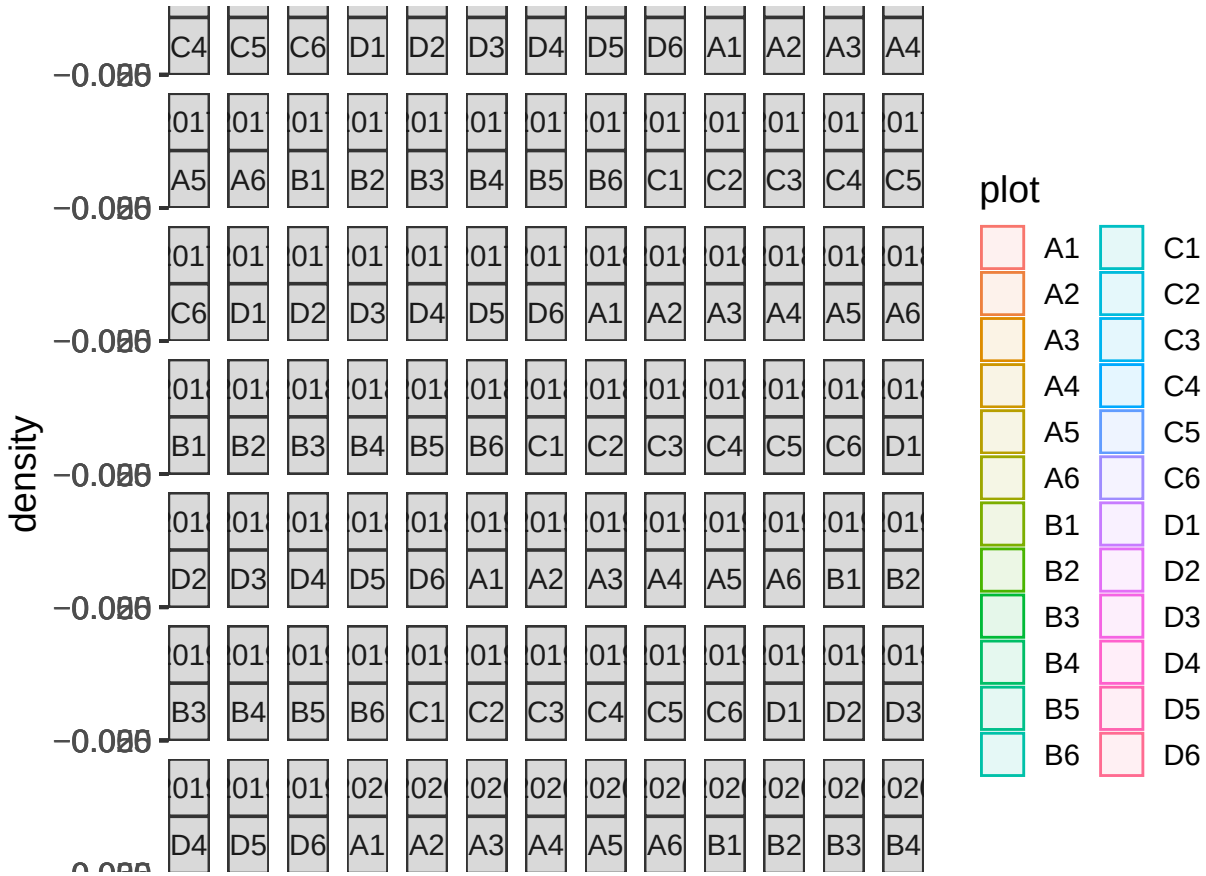

```
ggplot(kbs_flwr_plot, aes(flwr_duration_scaled, fill = plot, color = plot)) + geom_density(alpha = 0.1)
```



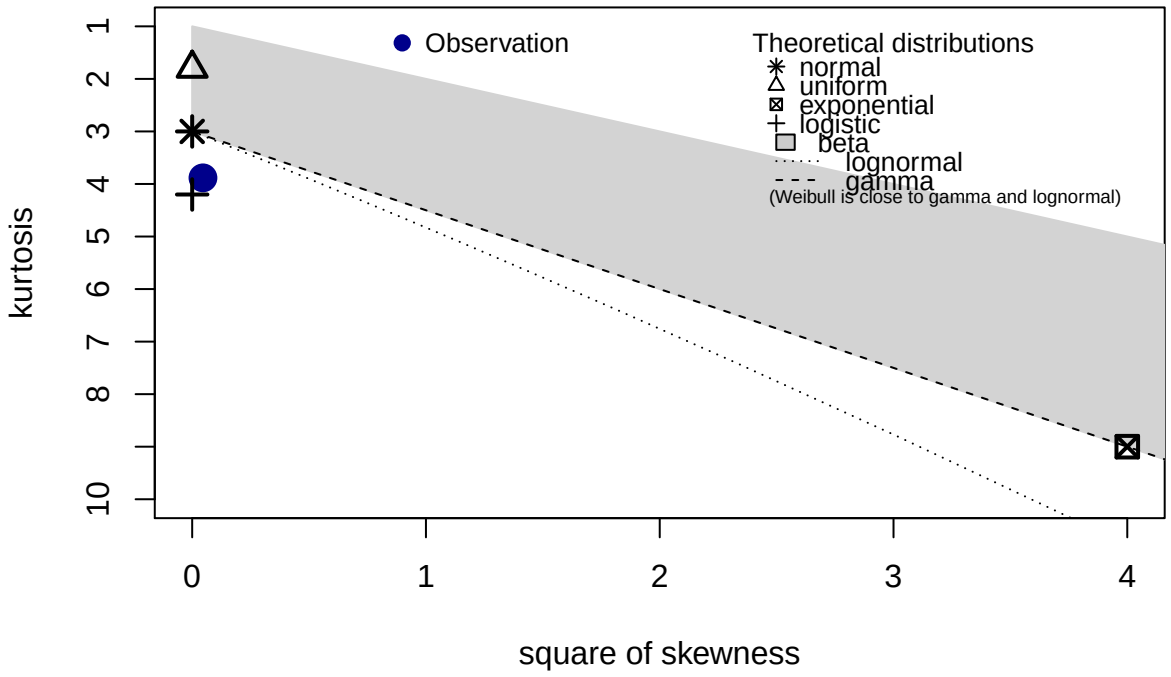

```
ggplot(kbs_flwr_plot, aes(flwr_duration_scaled, fill = plot, color = plot)) + geom_density(alpha = 0.1)
    facet_wrap(~year)
```




```
ggplot(kbs_flwr_plot, aes(flwr_duration_scaled, fill = plot, color = plot)) + geom_density(alpha = 0.1)
    facet_wrap(~year + plot)
```

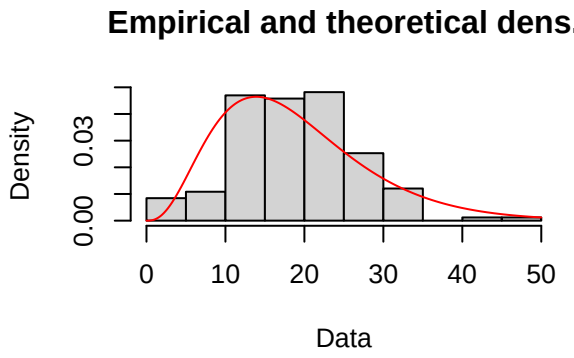


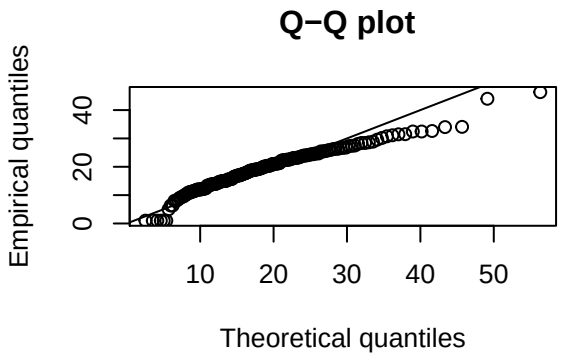

```
# Exploring distributions for these data:
descdist(kbs_flwr_plot$flwr_duration_scaled, discrete = FALSE)
```

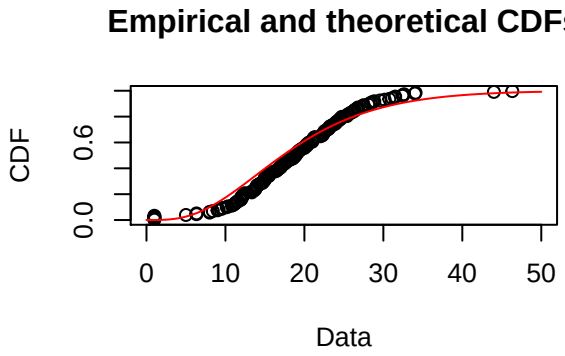


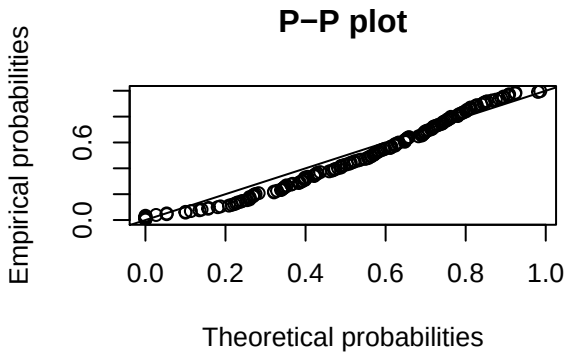

```
## summary statistics
## ------
## min:  1   max:  46.33333
## median:  18.86429
## mean:  18.89765
## estimated sd:  7.73299
## estimated skewness:  0.2148509
## estimated kurtosis:  3.883797
```

```
# Gamma distribution
fit.gamma <- fitdist(kbs_flwr_plot$flwr_duration_scaled, "gamma")
plot(fit.gamma)
```

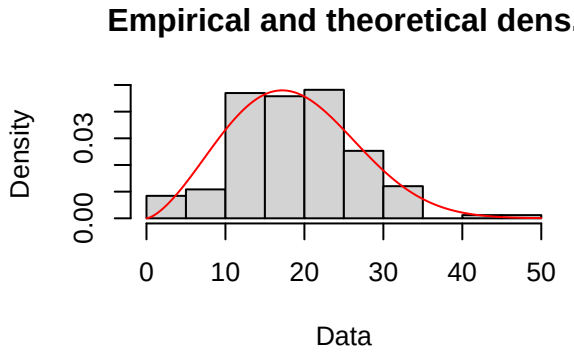


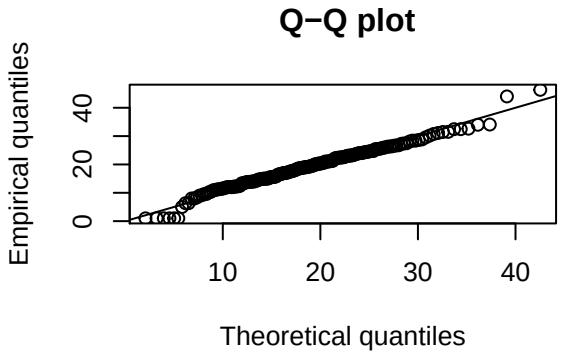


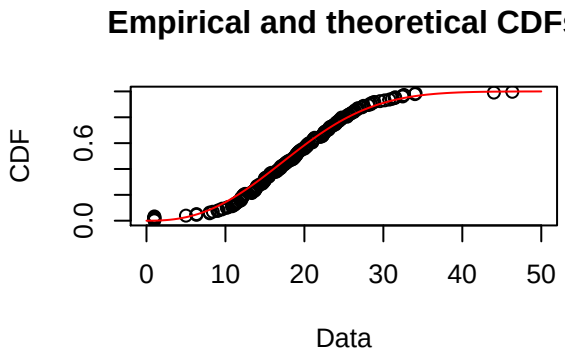


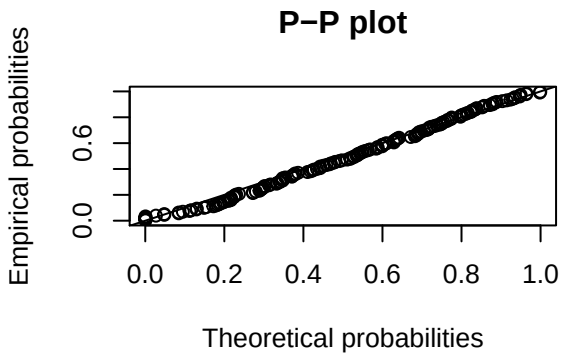



```
# Weibull distribution
fit.weibull <- fitdist(kbs_flwr_plot$flwr_duration_scaled, "weibull")
plot(fit.weibull)
```

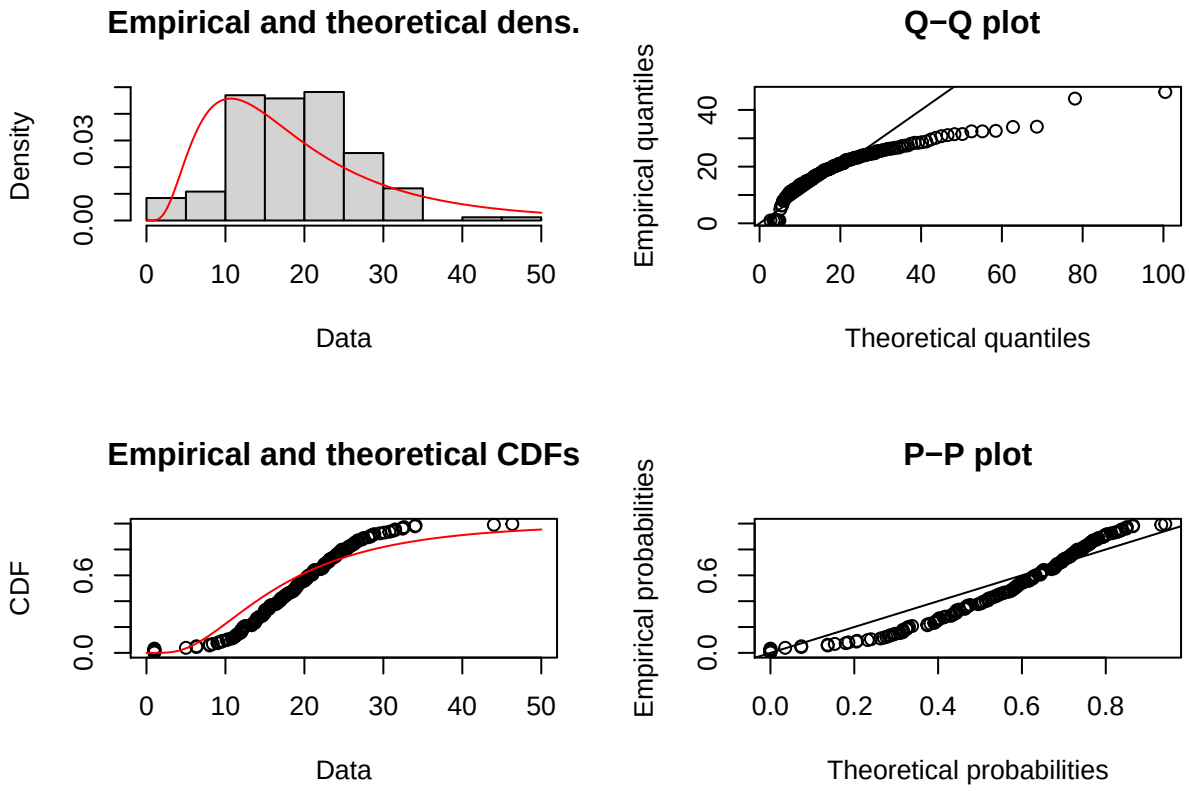




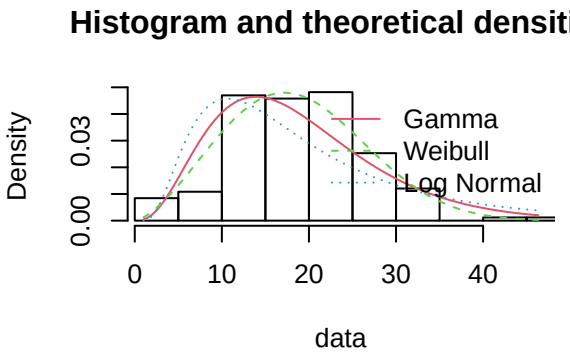


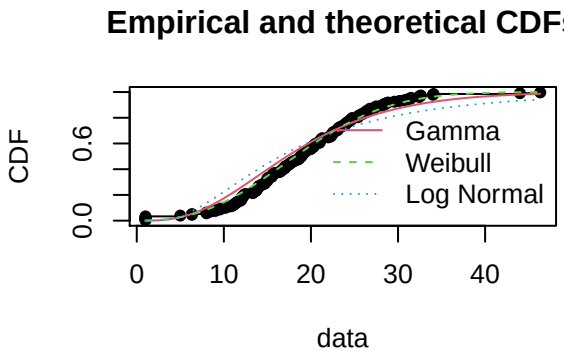


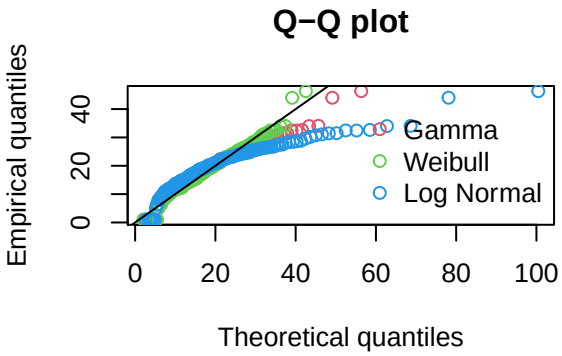
```r
# Lognormal distribution
fit.ln <- fitdist(kbs_flwr_plot$flwr_duration_scaled, "lnorm")
plot(fit.ln)
```

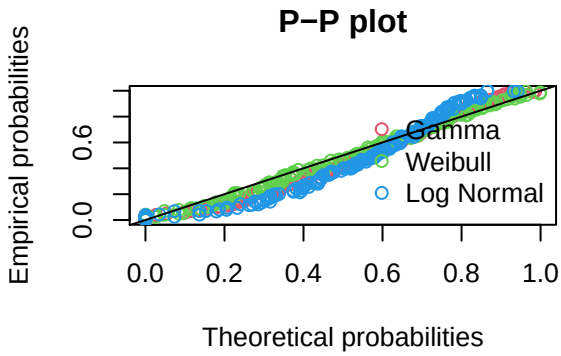



```r
par(mfrow = c(2, 2))
plot.legend <- c("Gamma", "Weibull", "Log Normal")
denscomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
cdfcomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
qqcomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
ppcomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
```









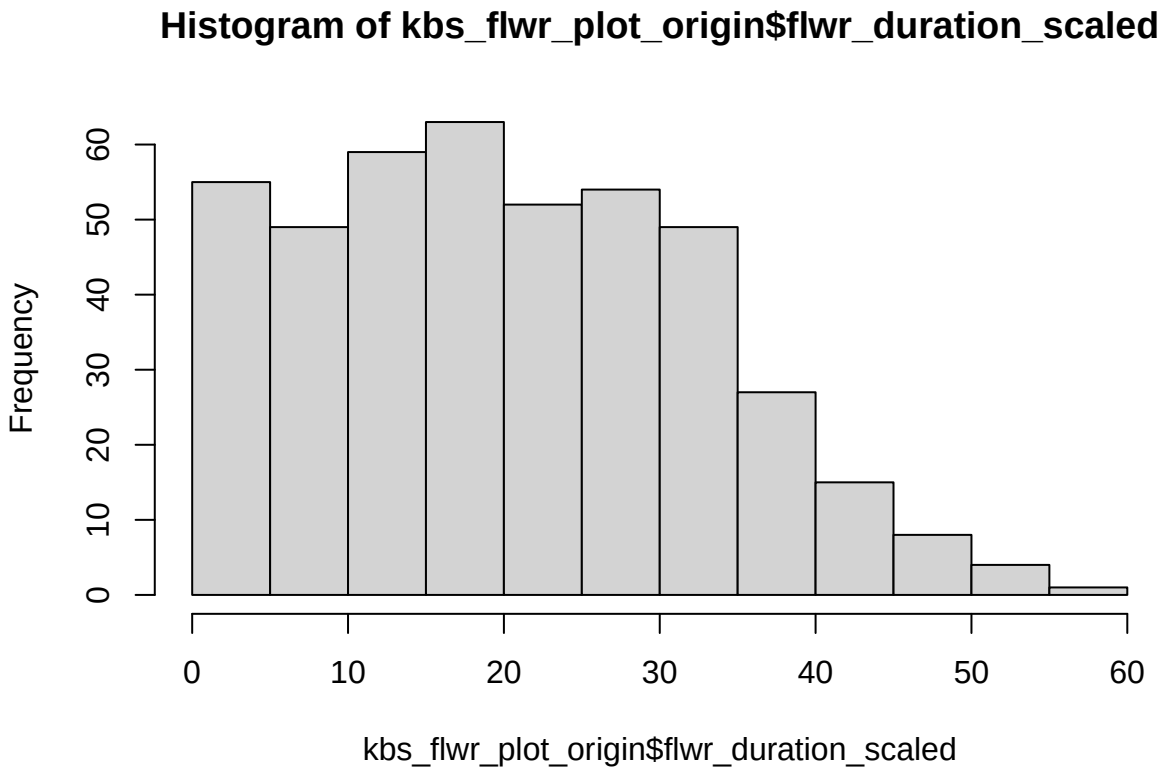

```
# Goodness of fit comparisons across fits (can't include the log normal bc it
# becomes diff response values)
gofstat(list(fit.gamma, fit.weibull, fit.ln), fitnames = c("Gamma", "Weibull", "Log Normal"))
```

```
## Goodness-of-fit statistics
##                                 Gamma    Weibull Log Normal
## Kolmogorov-Smirnov statistic 0.1103947 0.06380716  0.1636293
## Cramer-von Mises statistic   0.6493450 0.14666364  1.5887202
## Anderson-Darling statistic   4.6911012 1.56654597 10.4217087
##
## Goodness-of-fit criteria
##                                   Gamma  Weibull Log Normal
## Akaike's Information Criterion 1198.797 1166.530   1266.349
## Bayesian Information Criterion 1205.021 1172.754   1272.573
```

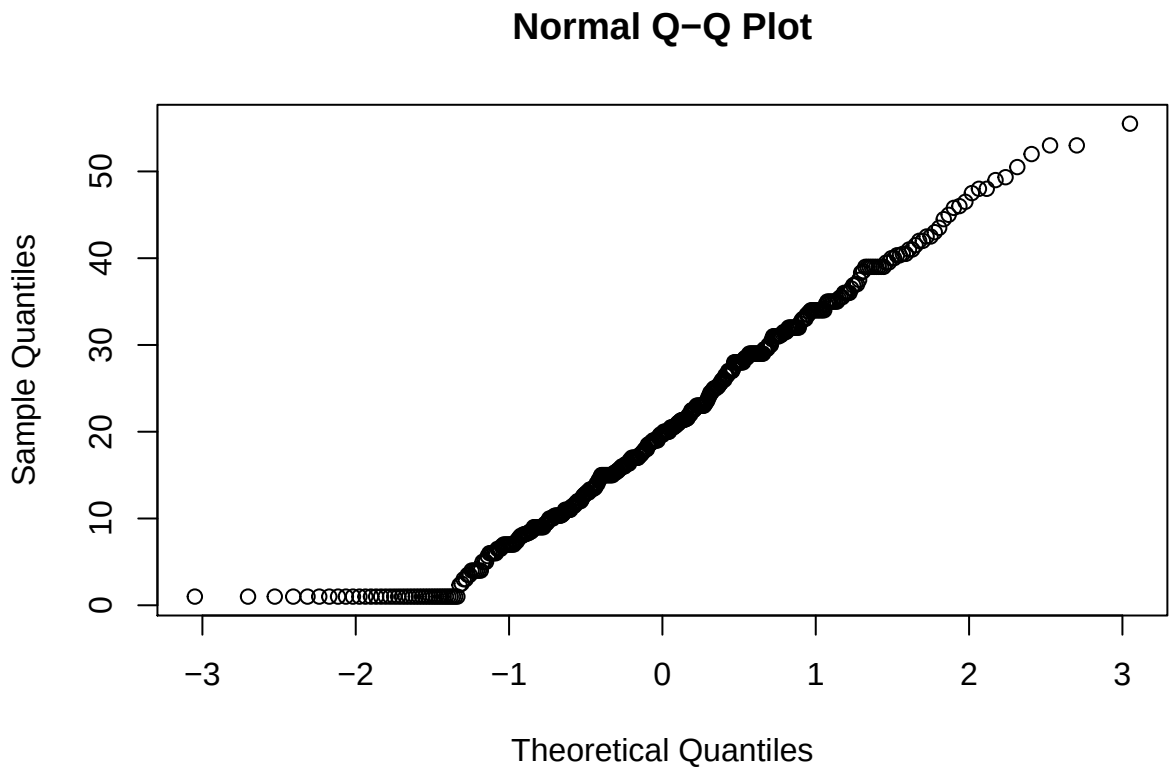
```
# weibull
```

KBS PLOT LEVEL ORIGIN - Looking at DURATION of flowering

```
### KBS ###
hist(kbs_flwr_plot_origin$flwr_duration_scaled)
```



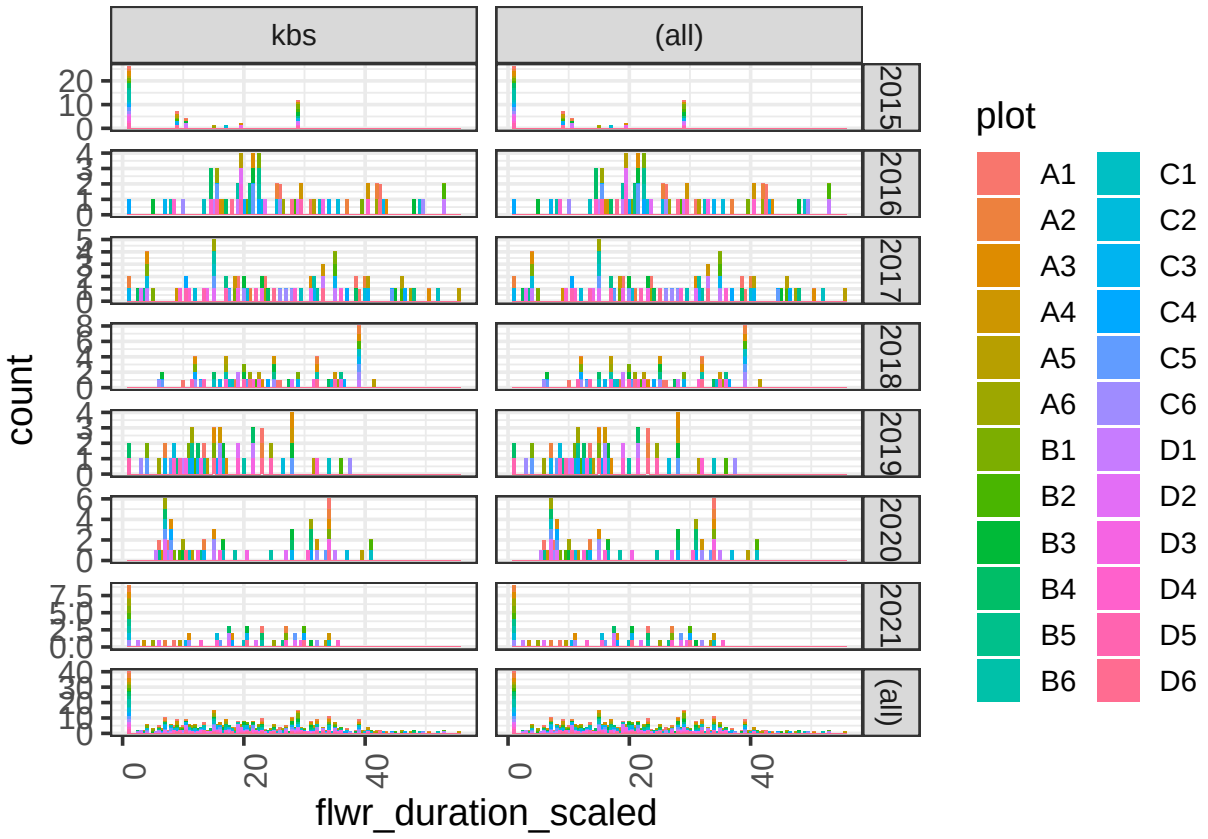

```
qqnorm(kbs_flwr_plot_origin$flwr_duration_scaled)
```



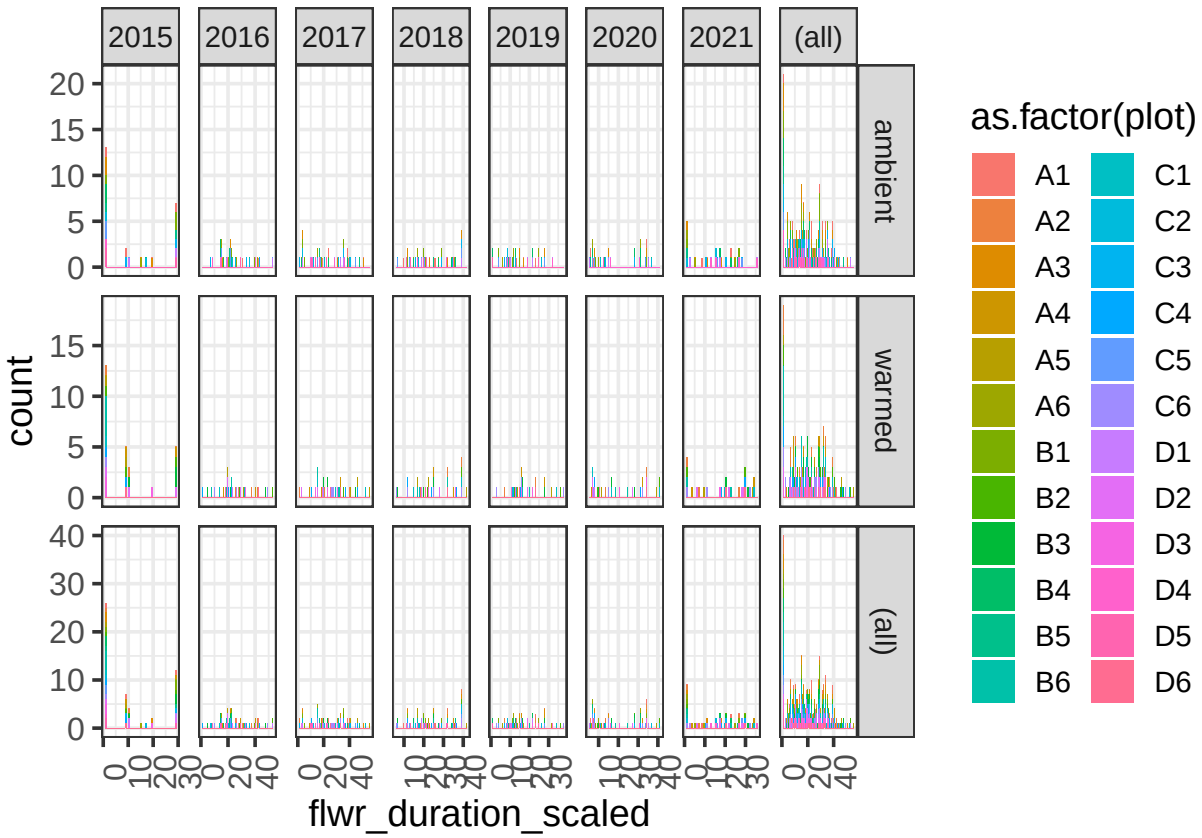
```
shapiro.test(kbs_flwr_plot_origin$flwr_duration_scaled)  # pvalue is < 0.05 so we reject the null hypot
```

```
##
##  Shapiro-Wilk normality test
##
## data:  kbs_flwr_plot_origin$flwr_duration_scaled
## W = 0.97267, p-value = 2.782e-07
```

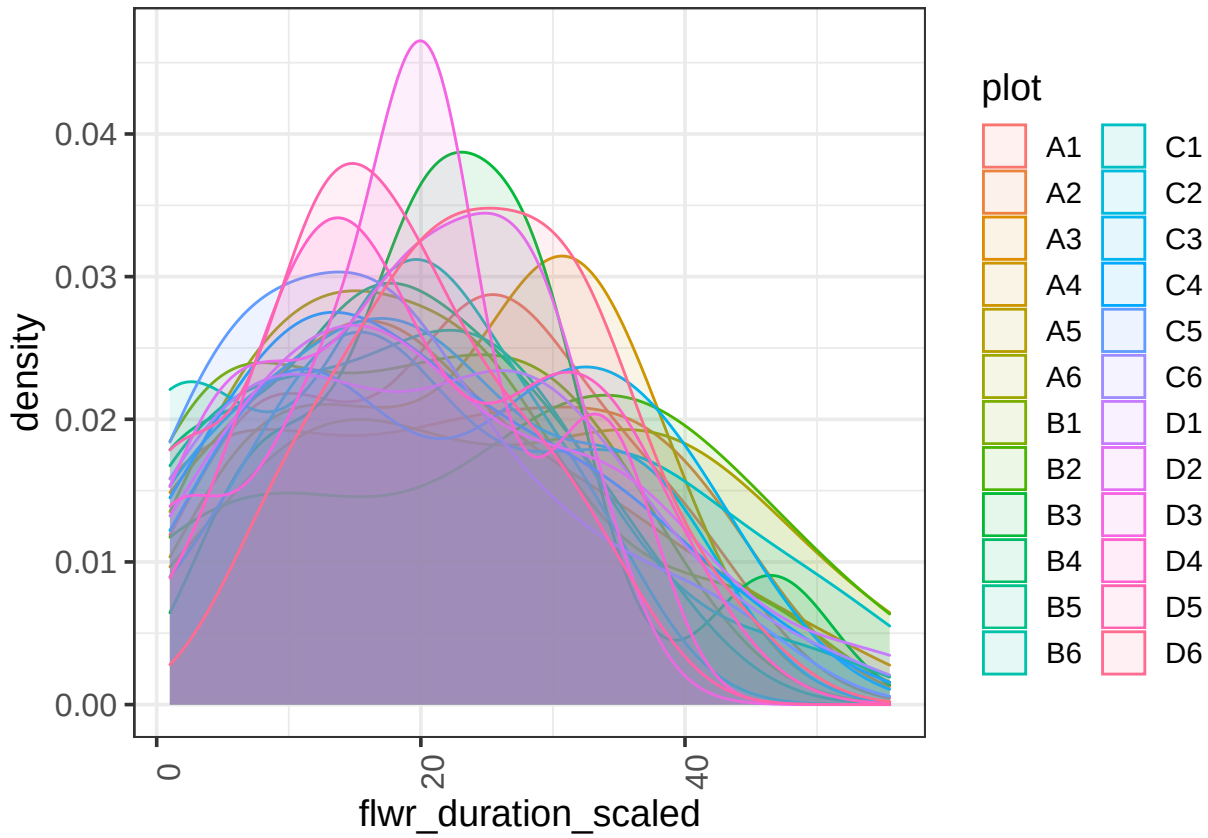
```
# Visualizing median Julian date for umbs at the PLOT LEVEL
ggplot(kbs_flwr_plot_origin, aes(flwr_duration_scaled, fill = plot)) + geom_histogram(binwidth = 0.5) +
    facet_grid(year ~ site, margins = TRUE, scales = "free")
```



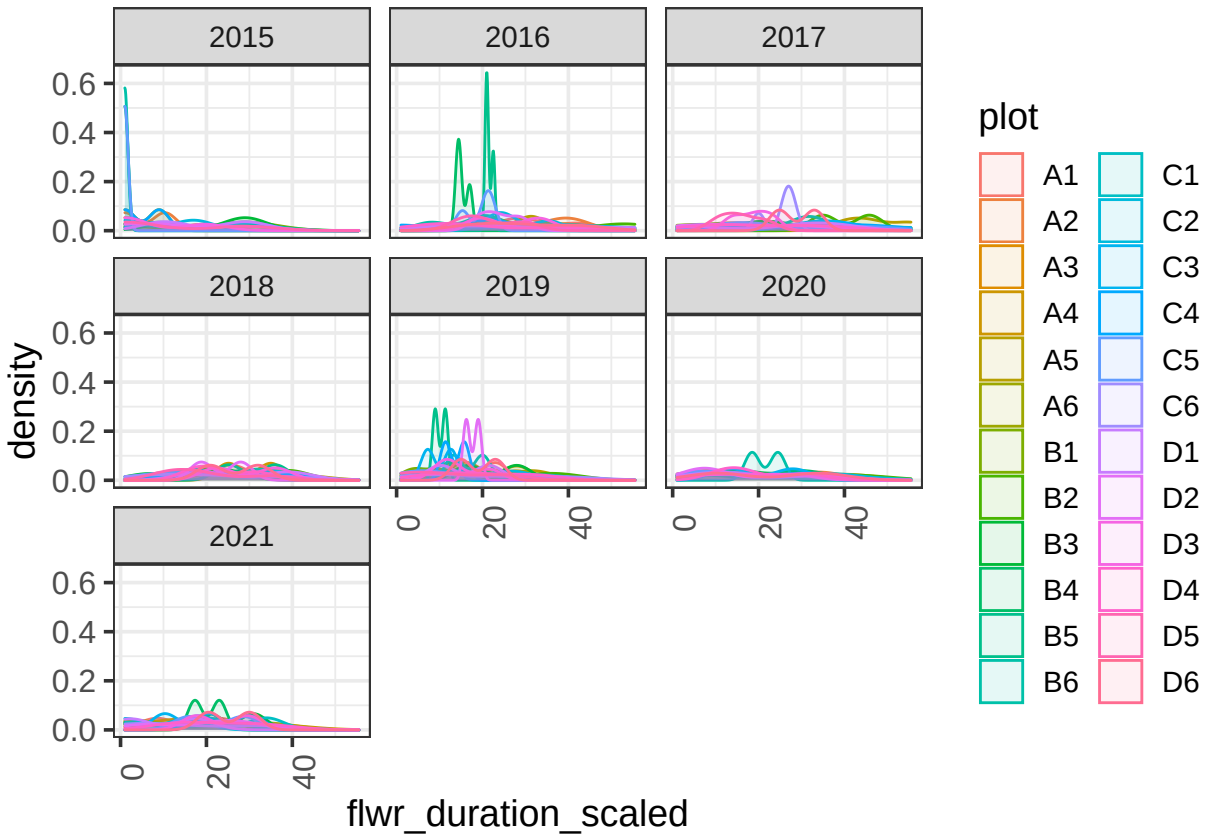

```
ggplot(kbs_flwr_plot_origin, aes(flwr_duration_scaled, fill = as.factor(plot))) +
    geom_histogram(binwidth = 0.5) + facet_grid(state ~ year, margins = TRUE, scales = "free")
```



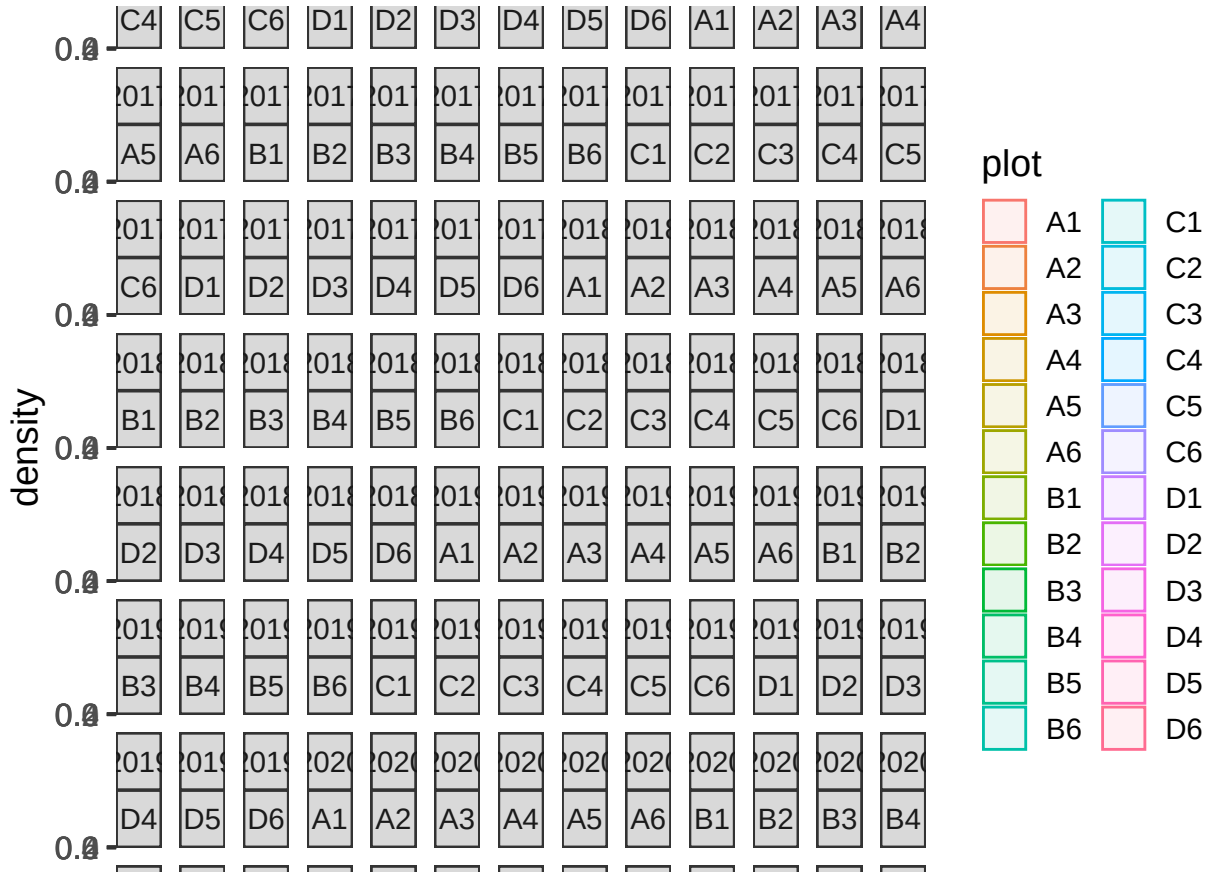

```
ggplot(kbs_flwr_plot_origin, aes(flwr_duration_scaled, fill = plot, color = plot)) +
    geom_density(alpha = 0.1)
```



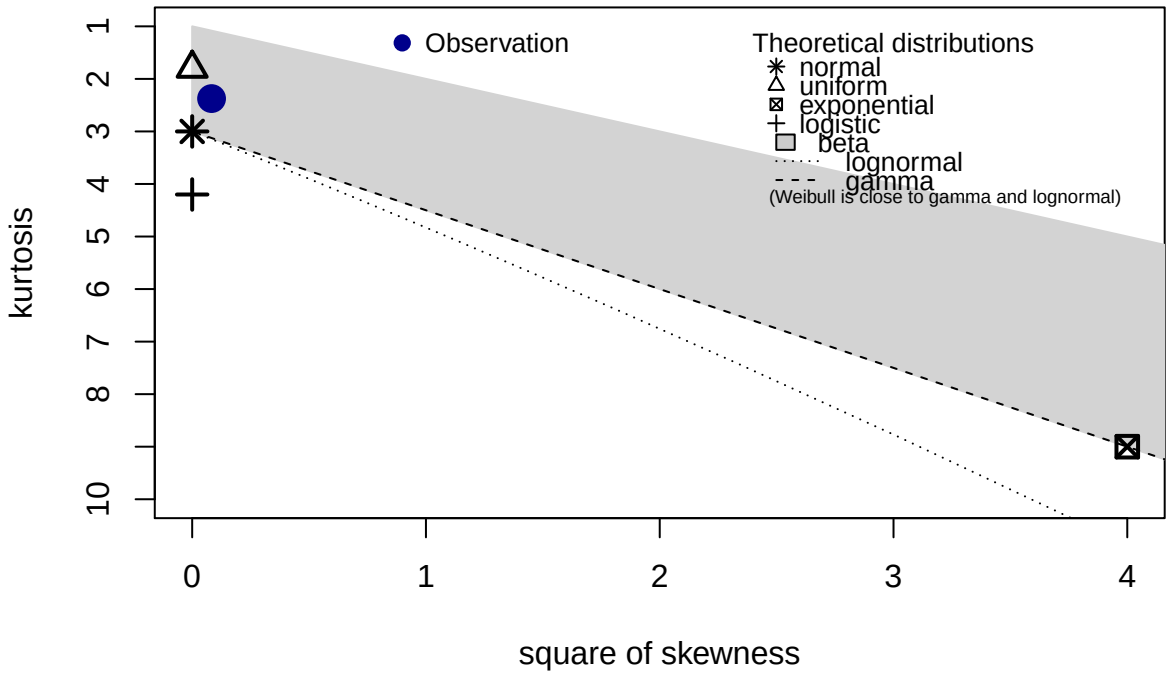

```
ggplot(kbs_flwr_plot_origin, aes(flwr_duration_scaled, fill = plot, color = plot)) +
    geom_density(alpha = 0.1) + facet_wrap(~year)
```




```
ggplot(kbs_flwr_plot_origin, aes(flwr_duration_scaled, fill = plot, color = plot)) +
    geom_density(alpha = 0.1) + facet_wrap(~year + plot)
```

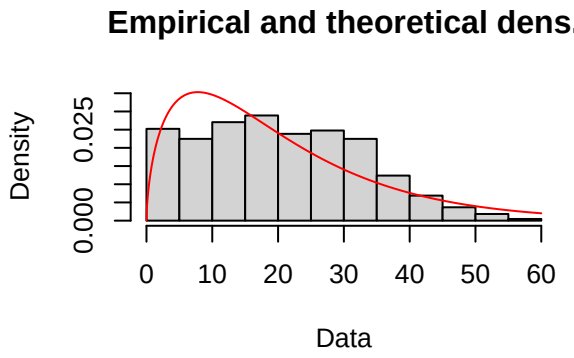


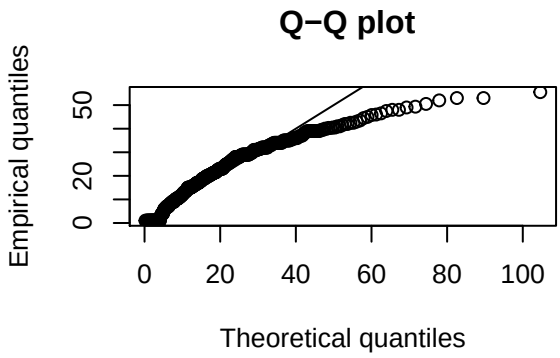

```
# Exploring distributions for these data:
descdist(kbs_flwr_plot_origin$flwr_duration_scaled, discrete = FALSE)
```

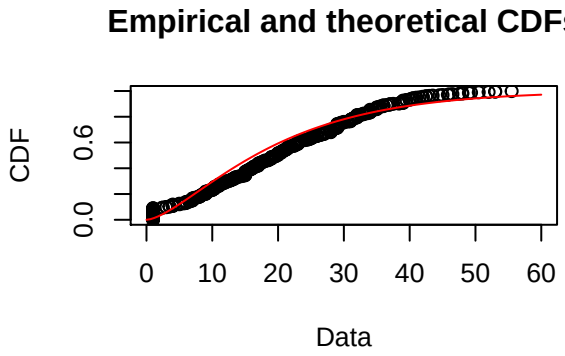


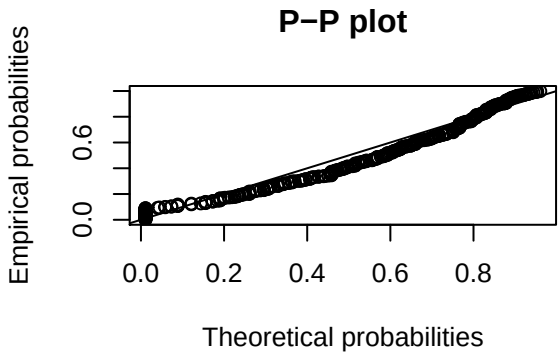

```
## summary statistics
## ------
## min:  1   max:  55.5
## median:  19.66667
## mean:  20.4813
## estimated sd:  12.57484
## estimated skewness:  0.2880935
## estimated kurtosis:  2.374742
```

```
# Gamma distribution
fit.gamma <- fitdist(kbs_flwr_plot_origin$flwr_duration_scaled, "gamma")
plot(fit.gamma)
```

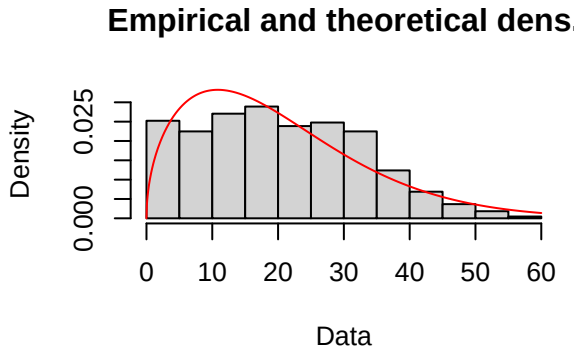


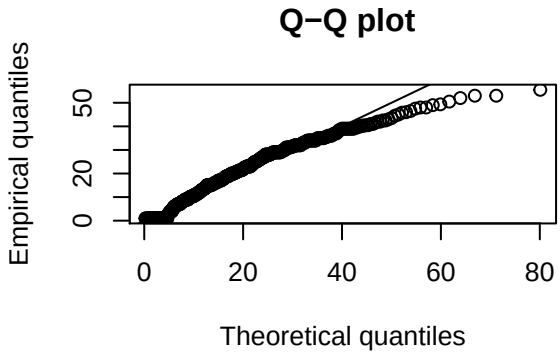


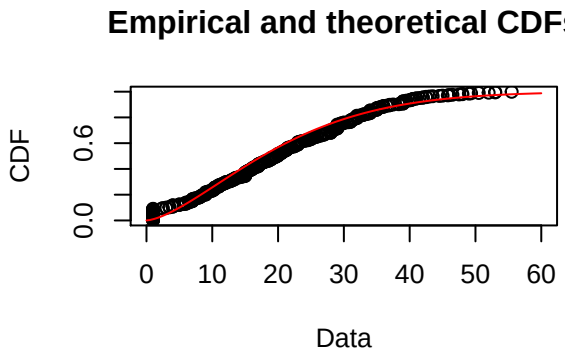


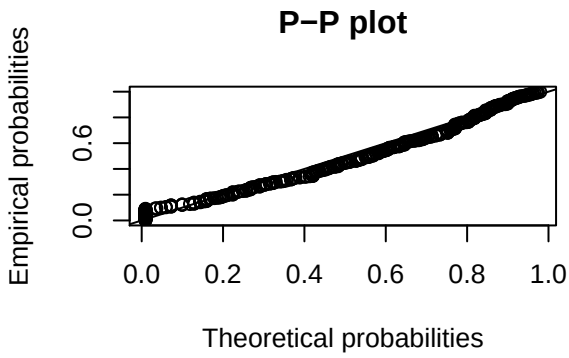



```
# Weibull distribution
fit.weibull <- fitdist(kbs_flwr_plot_origin$flwr_duration_scaled, "weibull")
plot(fit.weibull)
```

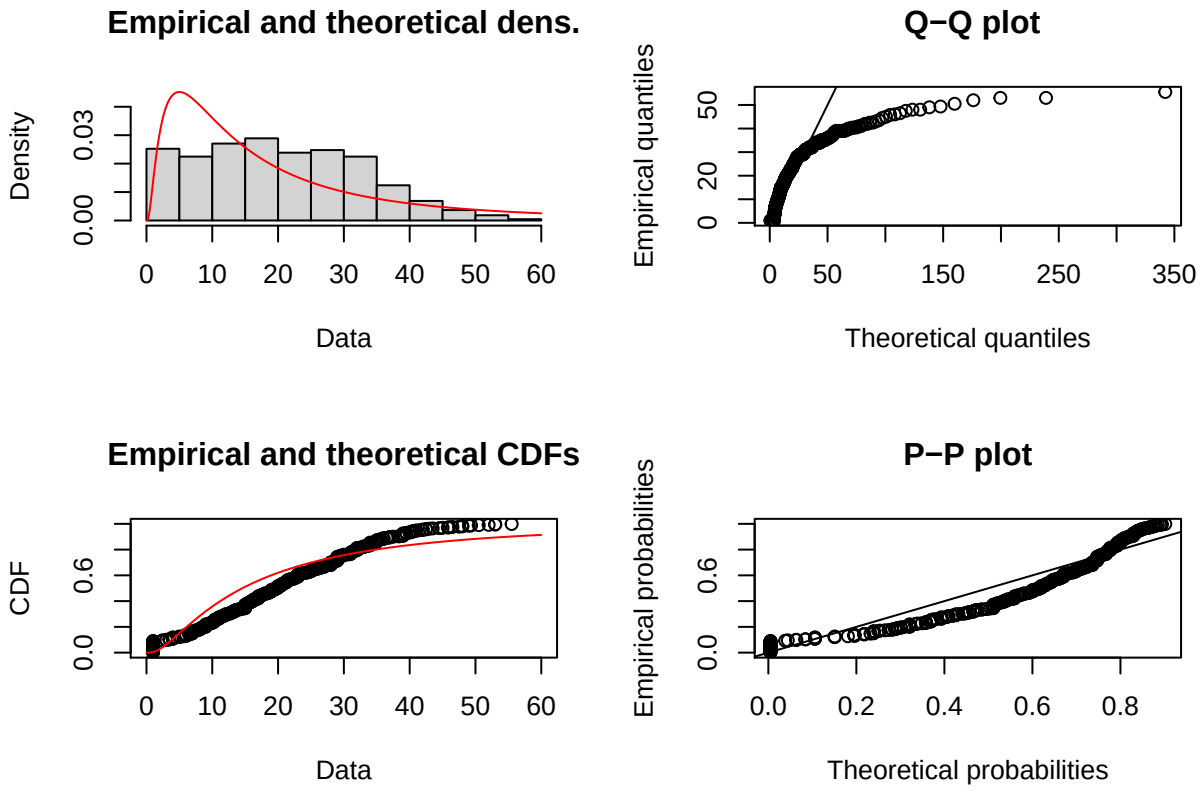




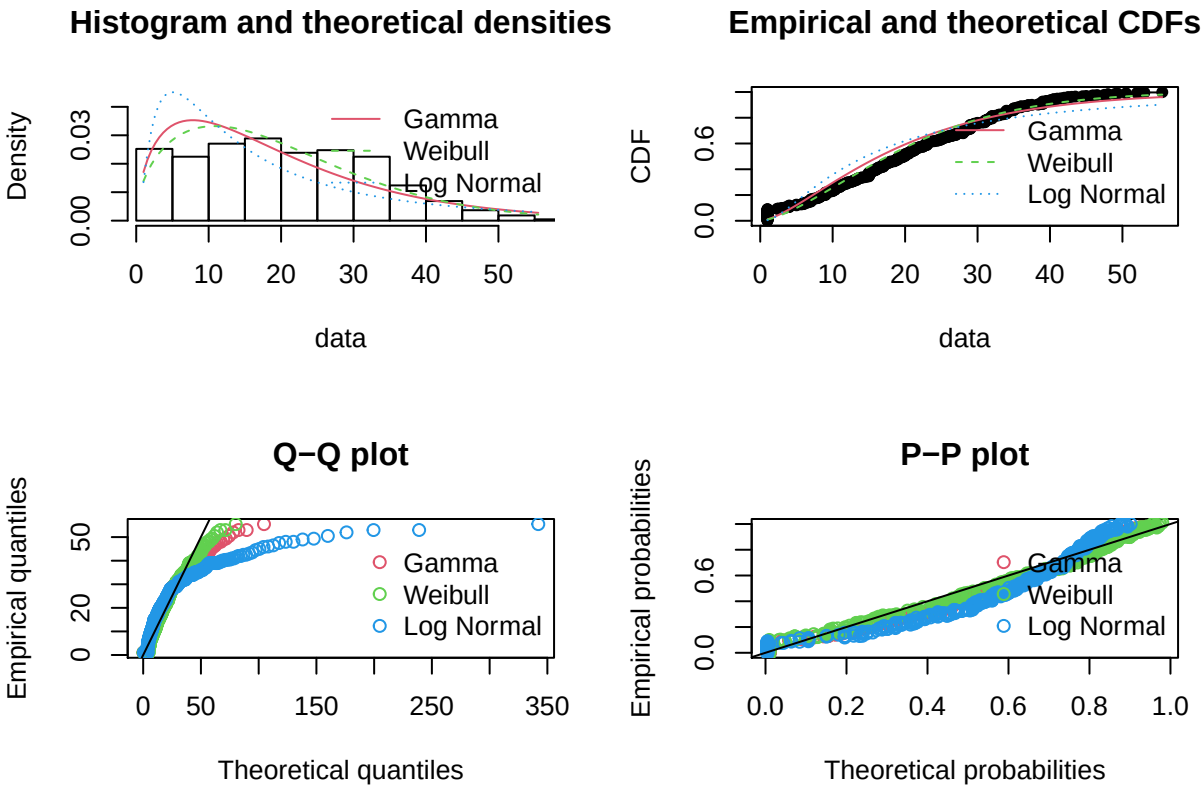




```
# Lognormal distribution
fit.ln <- fitdist(kbs_flwr_plot_origin$flwr_duration_scaled, "lnorm")
plot(fit.ln)
```




```
par(mfrow = c(2, 2))
plot.legend <- c("Gamma", "Weibull", "Log Normal")
denscomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
cdfcomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
qqcomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
ppcomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
```



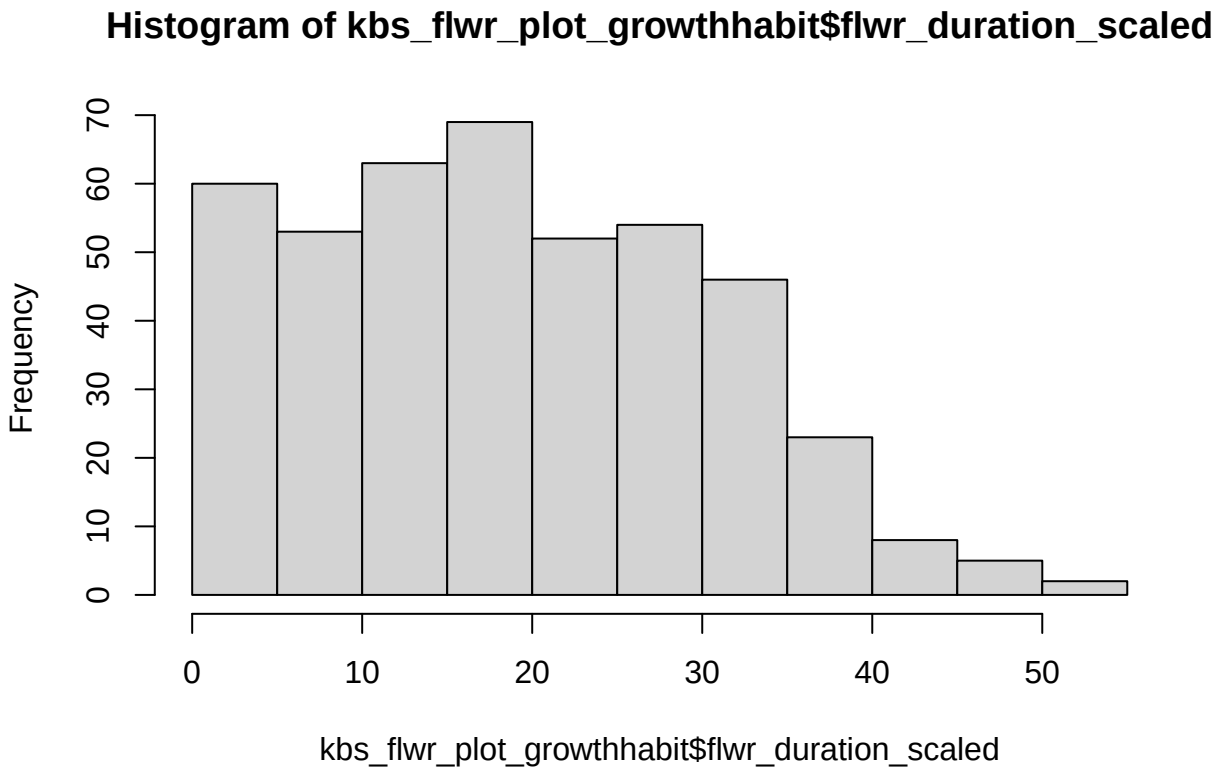

```
# Goodness of fit comparisons across fits (can't include the log normal bc it
# becomes diff response values)
gofstat(list(fit.gamma, fit.weibull, fit.ln), fitnames = c("Gamma", "Weibull", "Log Normal"))
```

```
## Goodness-of-fit statistics
##                                 Gamma    Weibull Log Normal
## Kolmogorov-Smirnov statistic  0.1139634 0.08246571  0.1671529
## Cramer-von Mises statistic    1.5552914 0.76255050  3.7540550
## Anderson-Darling statistic   11.1245128 7.55672816 25.2157916
##
## Goodness-of-fit criteria
##                                 Gamma  Weibull Log Normal
## Akaike's Information Criterion 3456.411 3422.532   3607.446
## Bayesian Information Criterion 3464.566 3430.687   3615.602
```

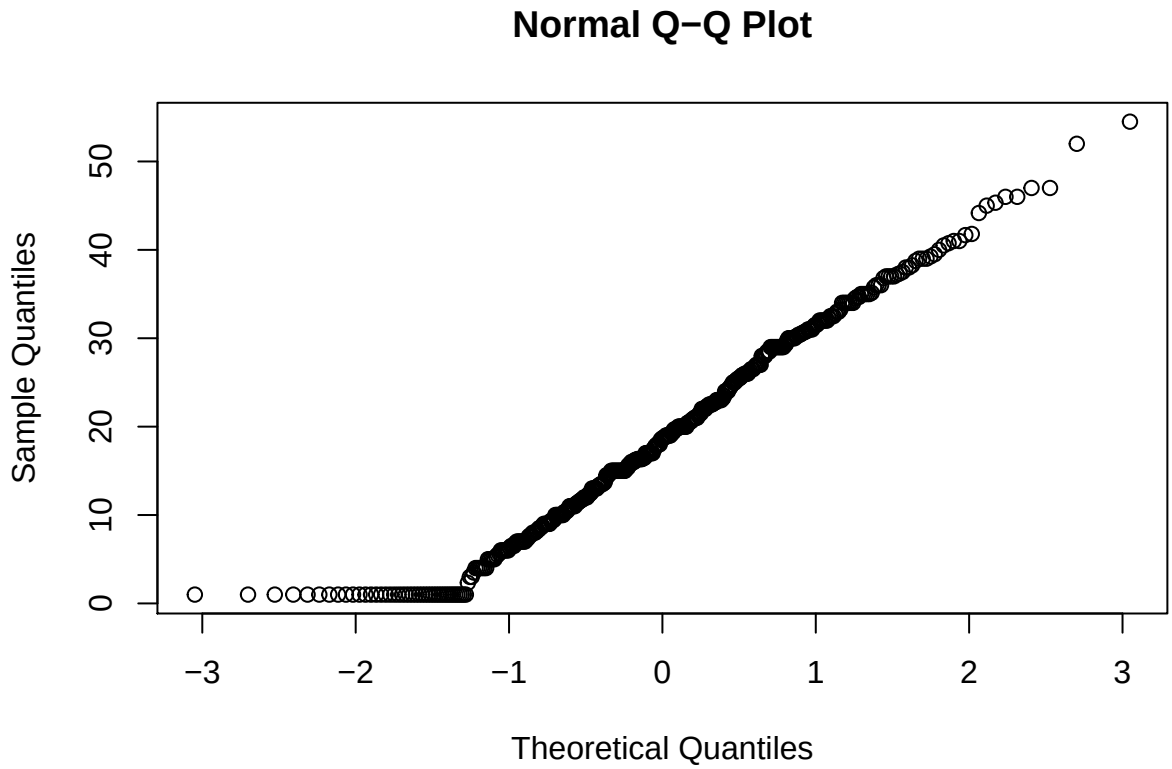
```
# weibull
```

KBS PLOT LEVEL GROWTH HABIT - Looking at DURATION of flowering

```
### KBS ###
hist(kbs_flwr_plot_growthhabit$flwr_duration_scaled)
```



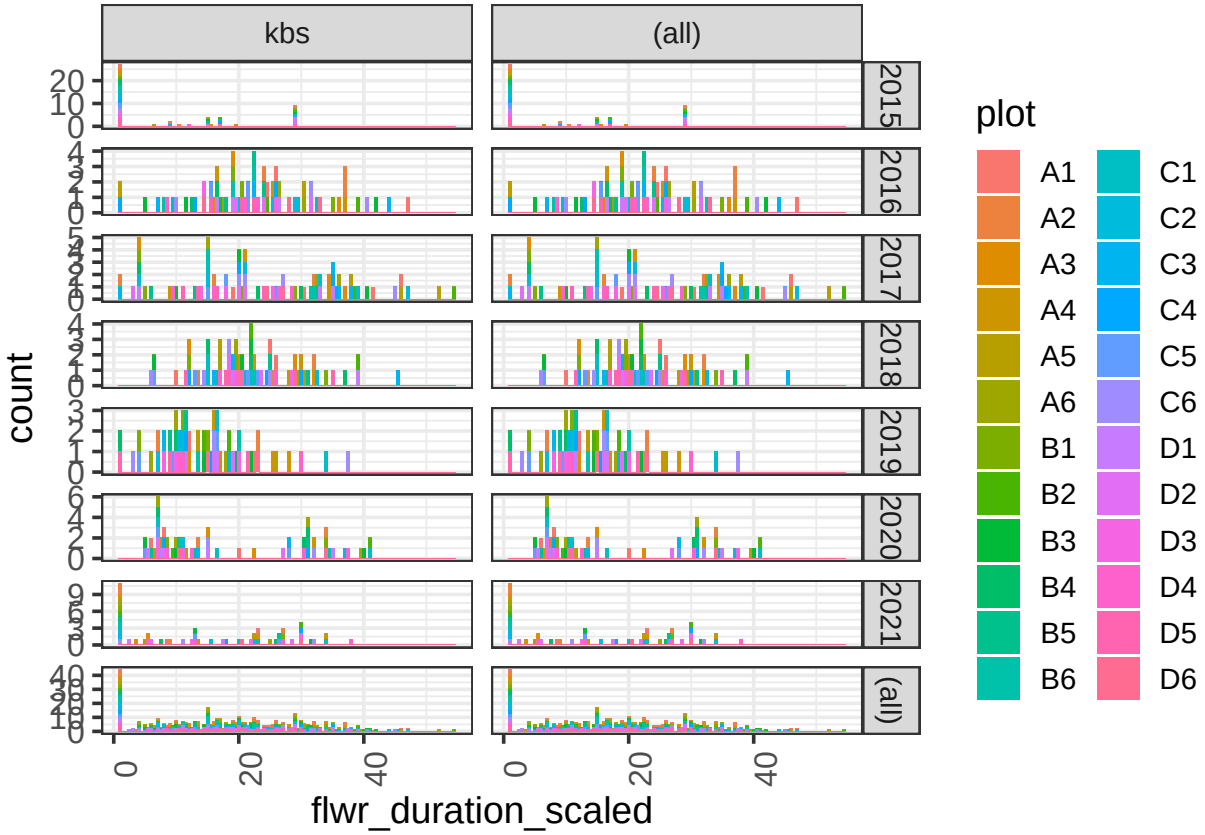

```
qqnorm(kbs_flwr_plot_growthhabit$flwr_duration_scaled)
```



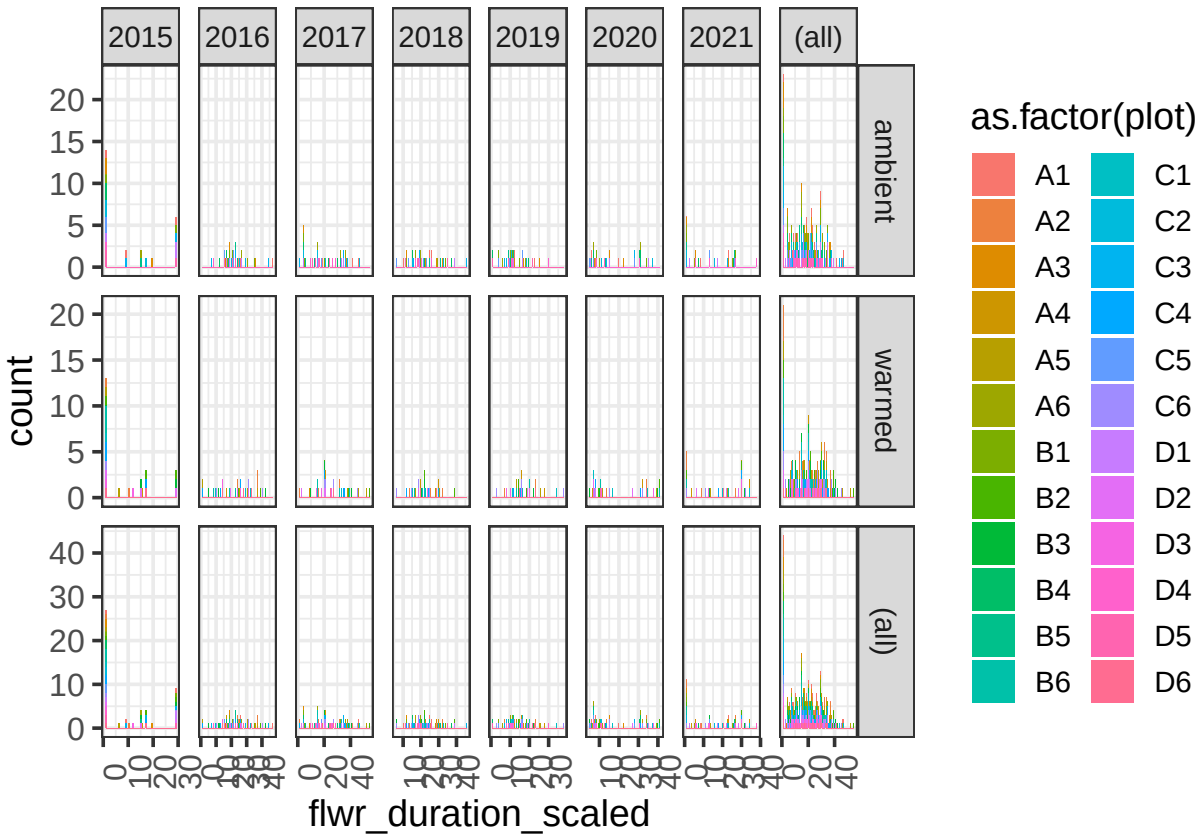
```
shapiro.test(kbs_flwr_plot_growthhabit$flwr_duration_scaled)  # pvalue is < 0.05 so we reject the null
```

```
##
##  Shapiro-Wilk normality test
##
## data:  kbs_flwr_plot_growthhabit$flwr_duration_scaled
## W = 0.97333, p-value = 3.876e-07
```

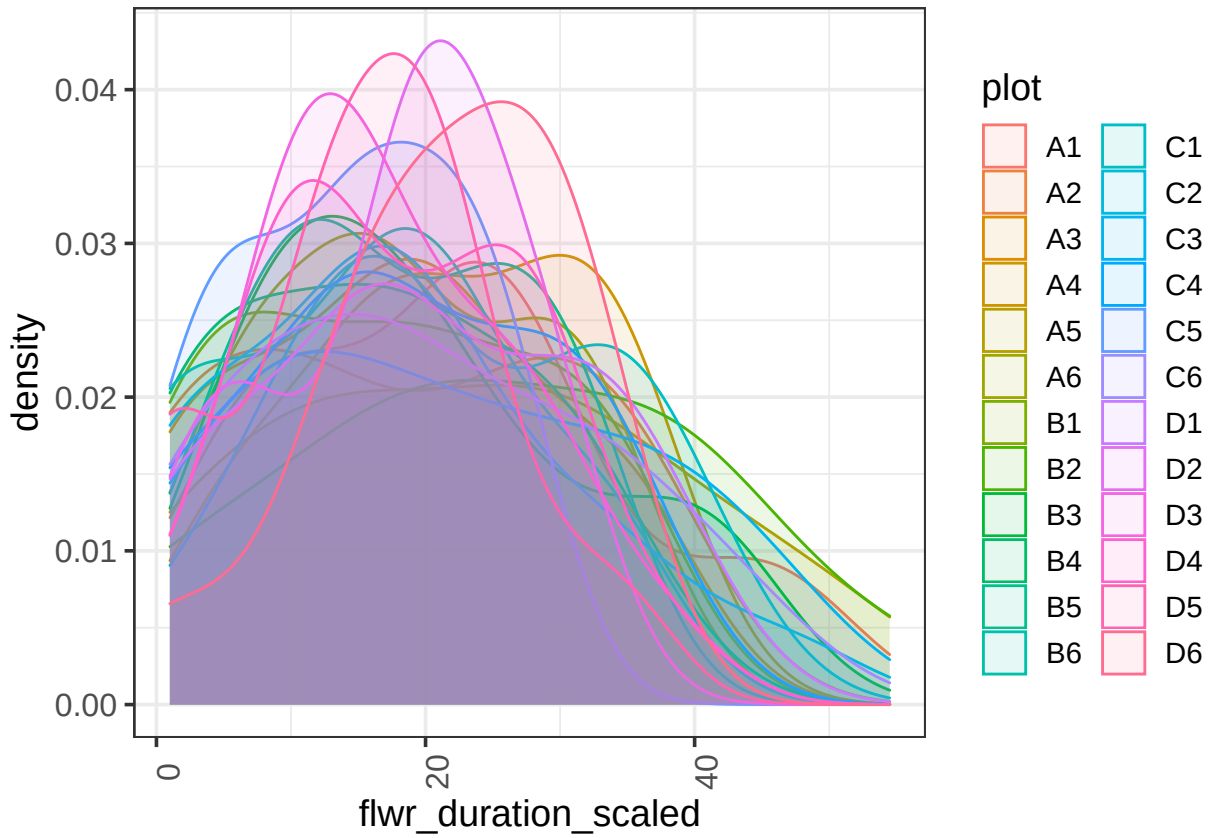
```
# Visualizing median Julian date for umbs at the PLOT LEVEL
ggplot(kbs_flwr_plot_growthhabit, aes(flwr_duration_scaled, fill = plot)) + geom_histogram(binwidth = 0
    facet_grid(year ~ site, margins = TRUE, scales = "free")
```



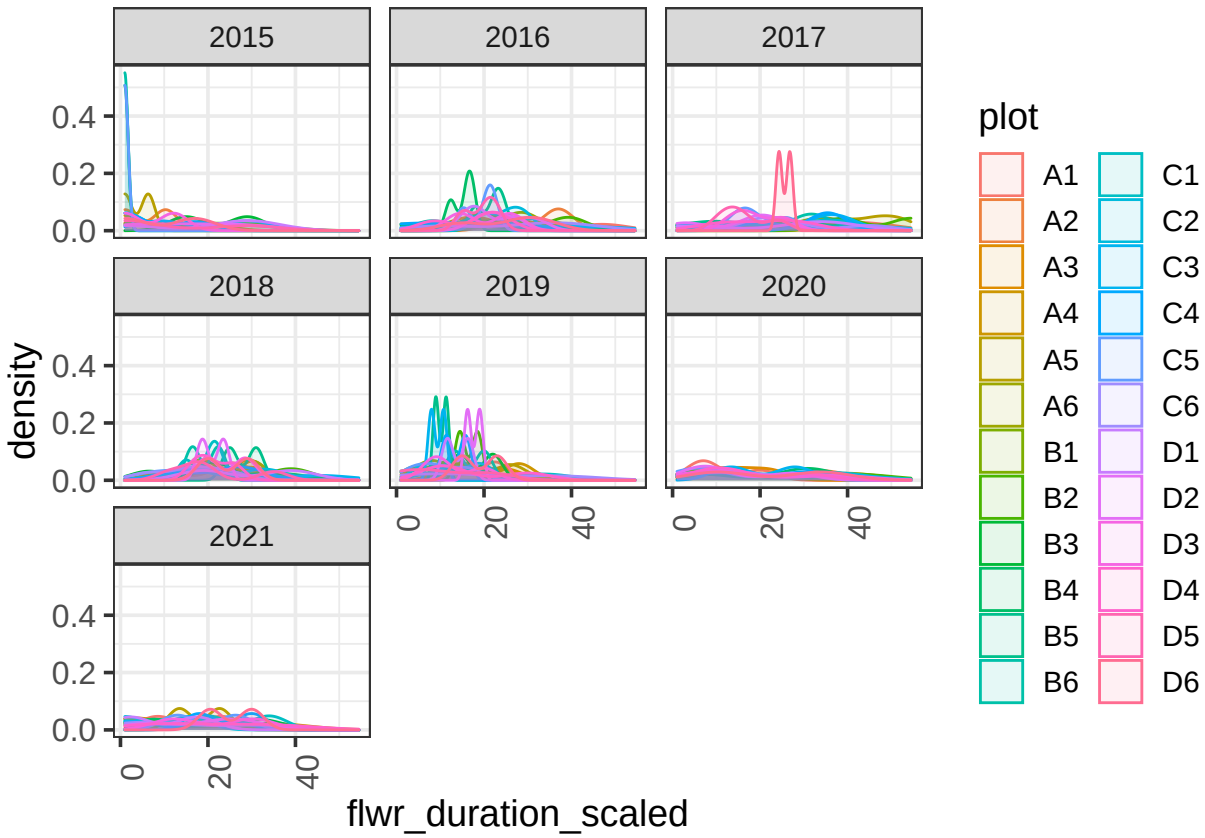

```
ggplot(kbs_flwr_plot_growthhabit, aes(flwr_duration_scaled, fill = as.factor(plot))) +
    geom_histogram(binwidth = 0.5) + facet_grid(state ~ year, margins = TRUE, scales = "free")
```



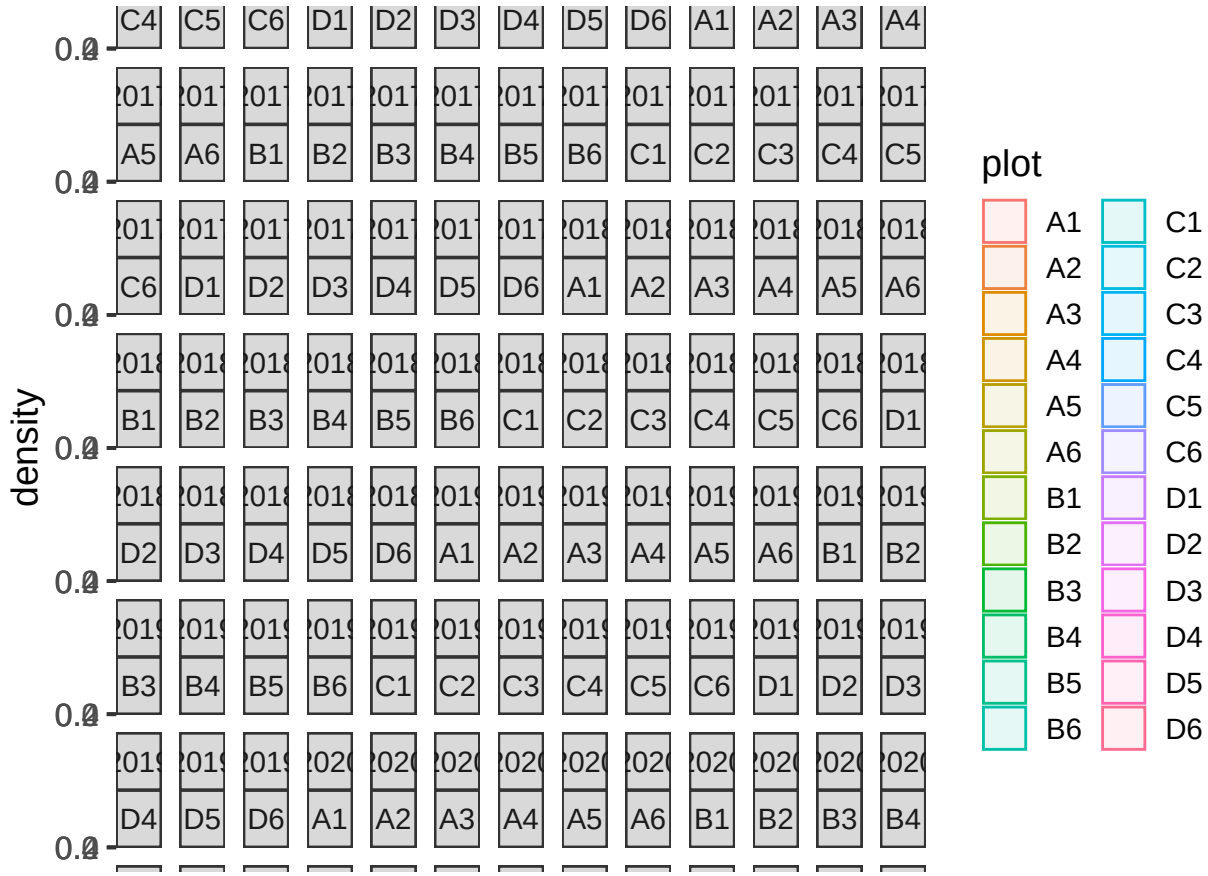

```
ggplot(kbs_flwr_plot_growthhabit, aes(flwr_duration_scaled, fill = plot, color = plot)) +
    geom_density(alpha = 0.1)
```



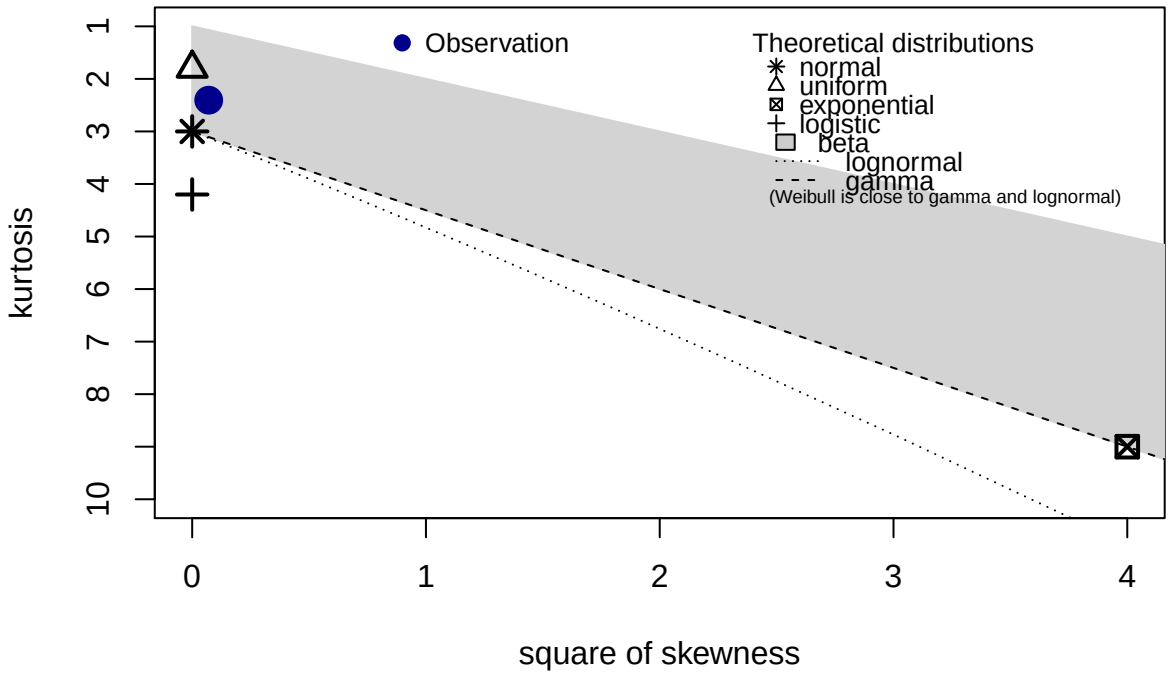

```
ggplot(kbs_flwr_plot_growthhabit, aes(flwr_duration_scaled, fill = plot, color = plot)) +
    geom_density(alpha = 0.1) + facet_wrap(~year)
```




```
ggplot(kbs_flwr_plot_growthhabit, aes(flwr_duration_scaled, fill = plot, color = plot)) +
    geom_density(alpha = 0.1) + facet_wrap(~year + plot)
```




```
# Exploring distributions for these data:
descdist(kbs_flwr_plot_growthhabit$flwr_duration_scaled, discrete = FALSE)
```

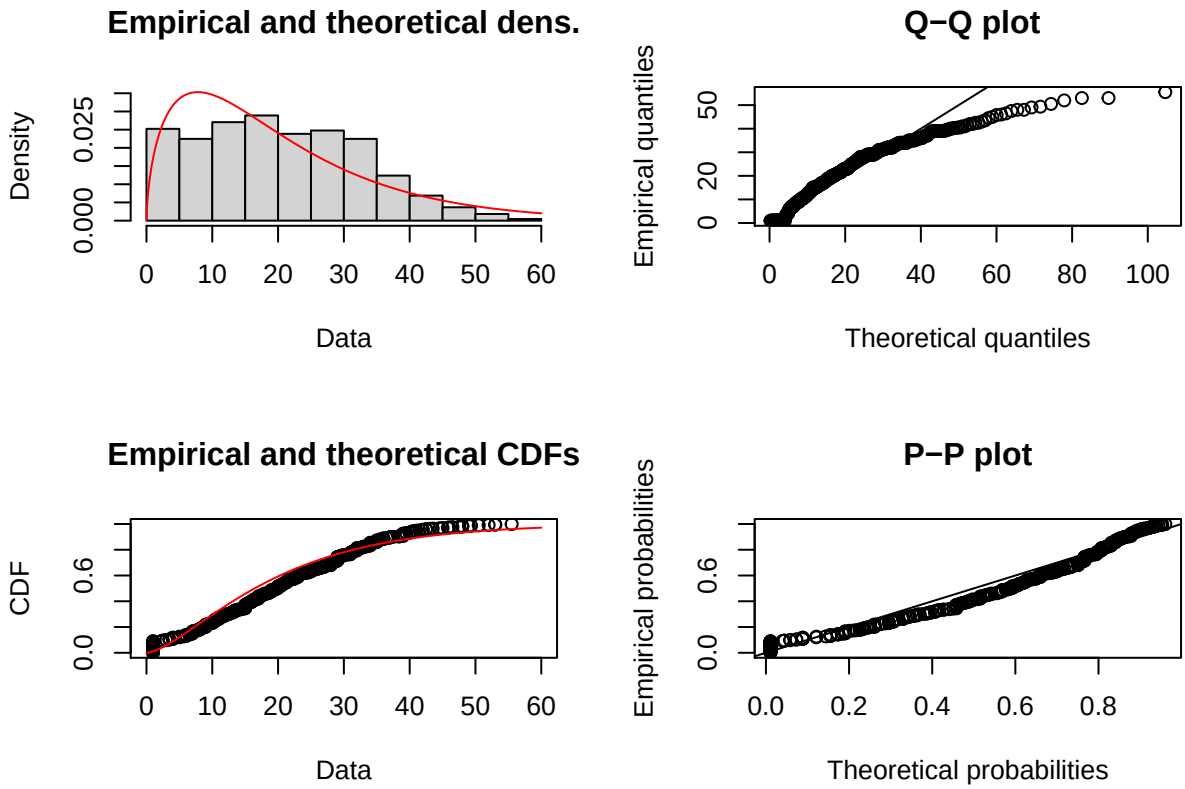



```
## summary statistics
## ------
## min:  1   max:  54.5
## median:  18.66667
## mean:  19.03002
## estimated sd:  11.65004
## estimated skewness:  0.2659687
## estimated kurtosis:  2.404991
```

```
# Gamma distribution
fit.gamma <- fitdist(kbs_flwr_plot_growthhabit$flwr_duration, "gamma")
```

```
## <simpleError in optim(par = vstart, fn = fnobj, fix.arg = fix.arg, obs = data,     gr = gradient, dd

## Error in fitdist(kbs_flwr_plot_growthhabit$flwr_duration, "gamma"): the function mle failed to estima
##                 with the error code 100
```

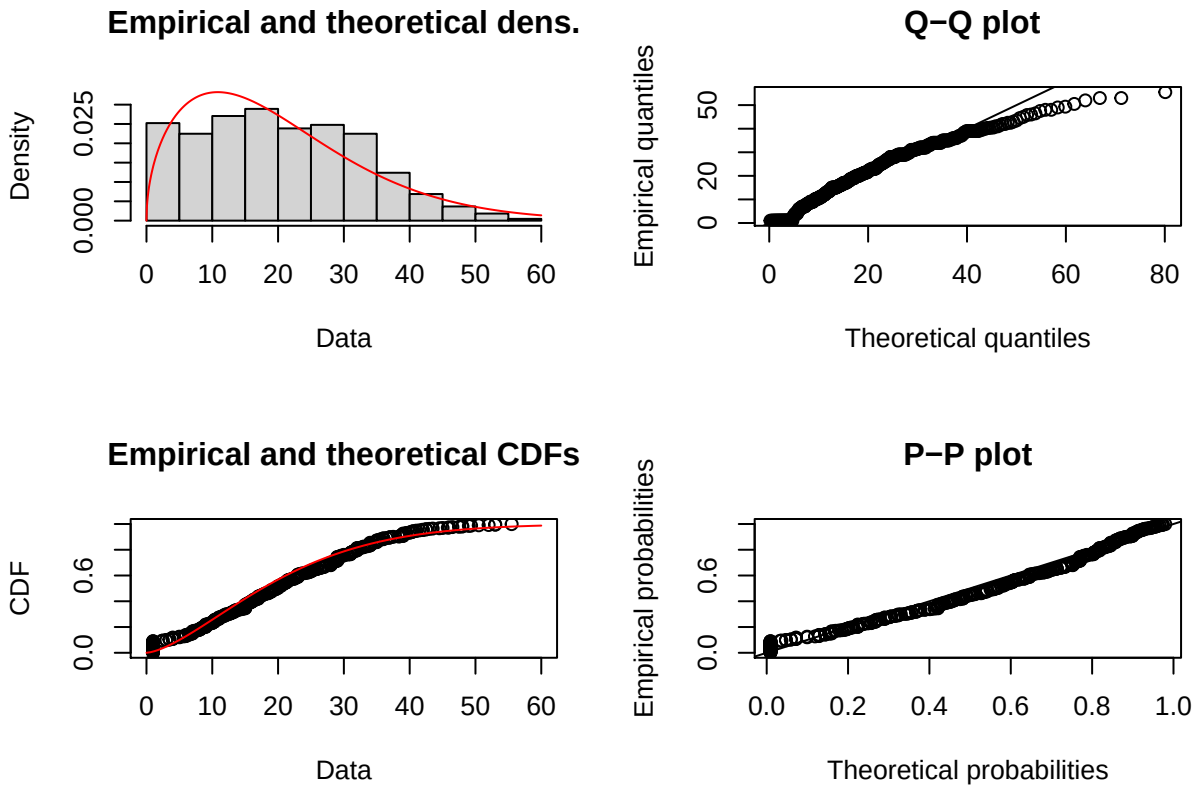
```
plot(fit.gamma)
```




```
# Weibull distribution
fit.weibull <- fitdist(kbs_flwr_plot_growthhabit$flwr_duration, "weibull")
```

```
## Error in checkparamlist(arg_startfix$start.arg, arg_startfix$fix.arg, : 'start' should not have NA o
```

```
plot(fit.weibull)
```

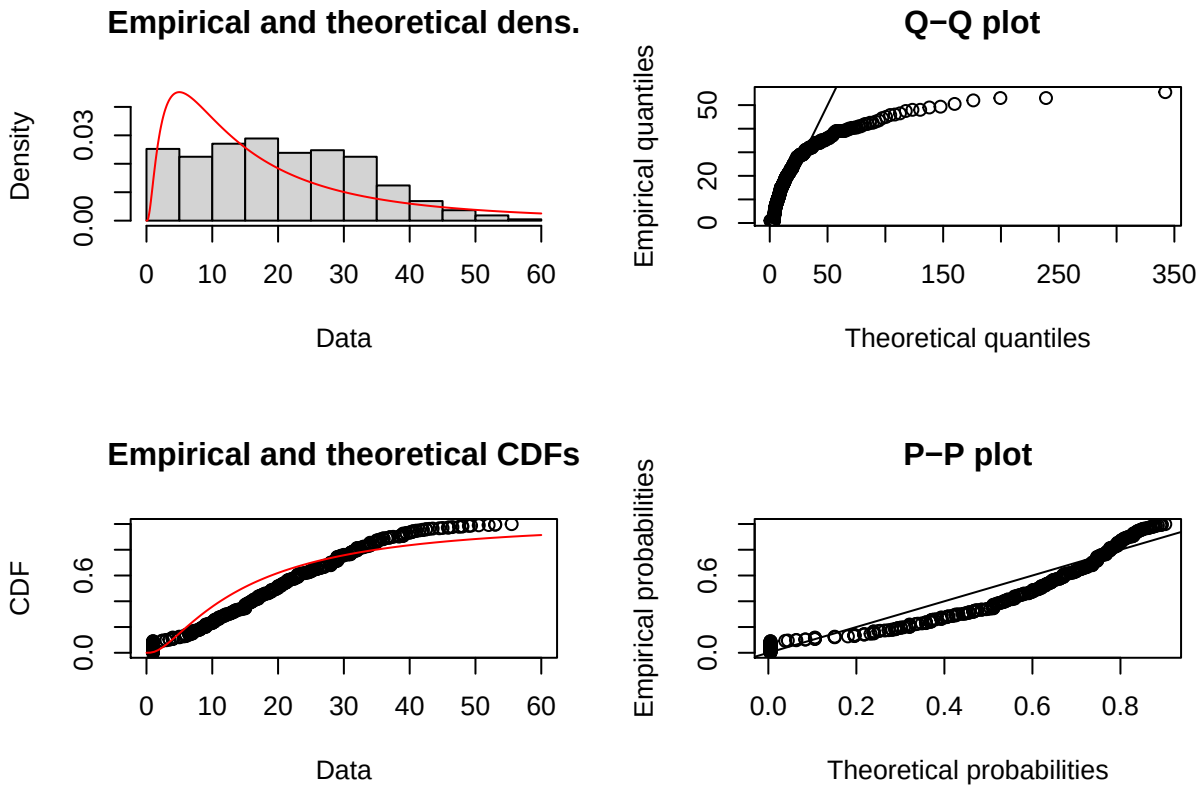



```
# Lognormal distribution
fit.ln <- fitdist(kbs_flwr_plot_growthhabit$flwr_duration, "lnorm")
```

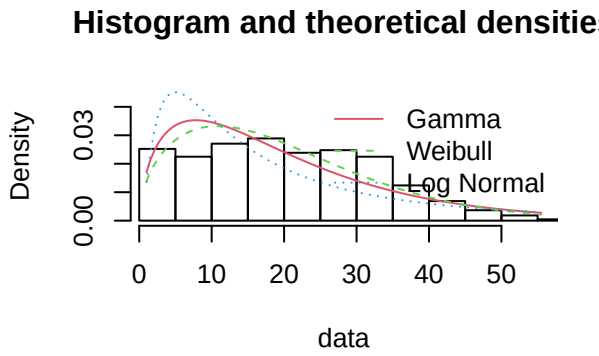
```
## Error in computing default starting values.
```

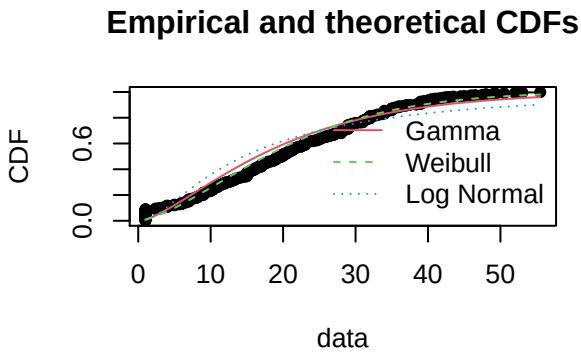
```
## Error in manageparam(start.arg = start, fix.arg = fix.arg, obs = data, : Error in start.arg.default(
##   values must be positive to fit a lognormal distribution
```

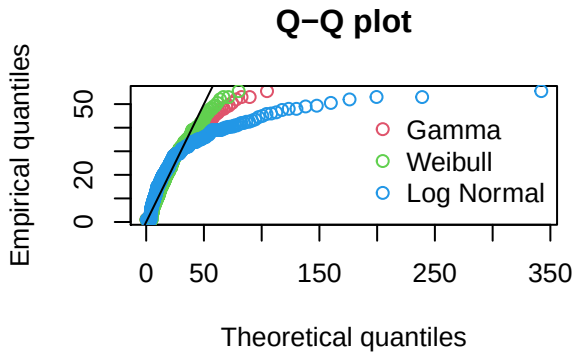
```
plot(fit.ln)
```

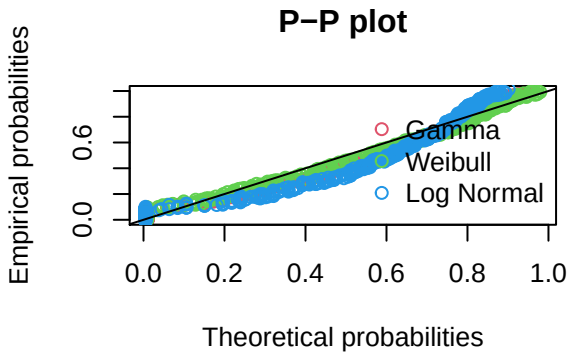



```
par(mfrow = c(2, 2))
plot.legend <- c("Gamma", "Weibull", "Log Normal")
denscomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
cdfcomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
qqcomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
ppcomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
```









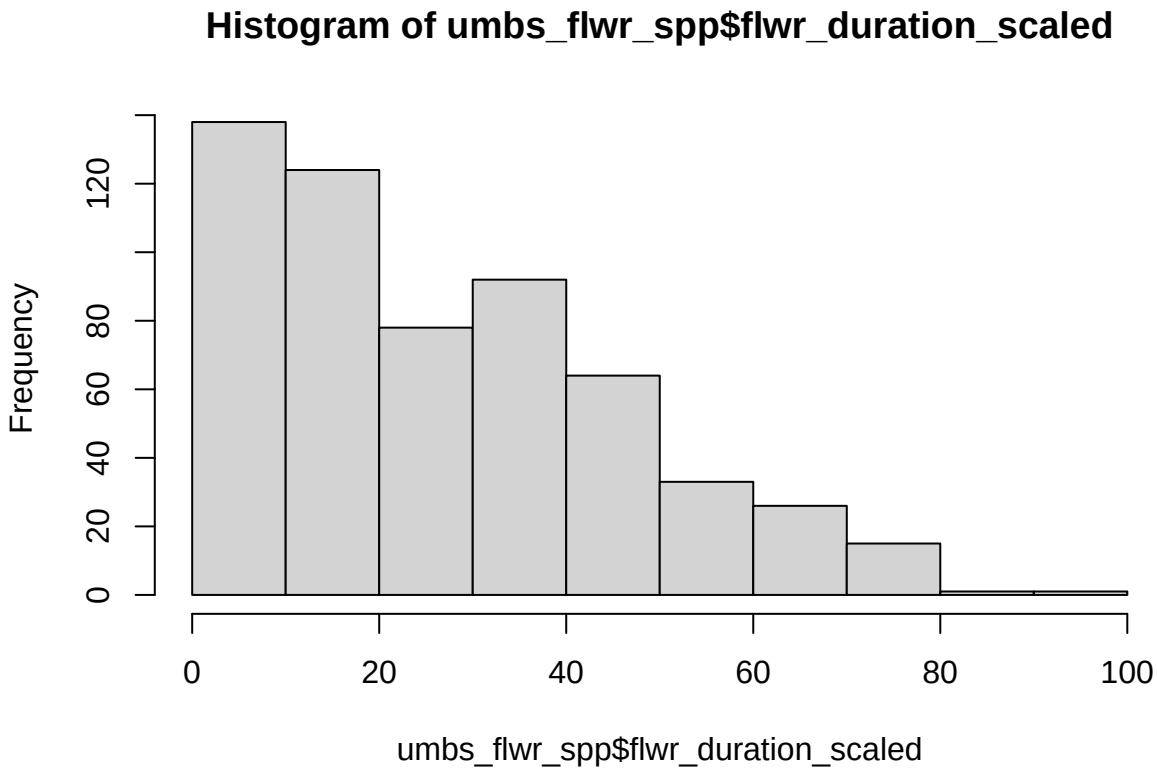

```
# Goodness of fit comparisons across fits (can't include the log normal bc it
# becomes diff response values)
gofstat(list(fit.gamma, fit.weibull, fit.ln), fitnames = c("Gamma", "Weibull", "Log Normal"))
```

```
## Goodness-of-fit statistics
##                                 Gamma    Weibull Log Normal
## Kolmogorov-Smirnov statistic  0.1139634 0.08246571  0.1671529
## Cramer-von Mises statistic    1.5552914 0.76255050  3.7540550
## Anderson-Darling statistic   11.1245128 7.55672816 25.2157916
##
## Goodness-of-fit criteria
##                                 Gamma  Weibull Log Normal
## Akaike's Information Criterion 3456.411 3422.532   3607.446
## Bayesian Information Criterion 3464.566 3430.687   3615.602
```

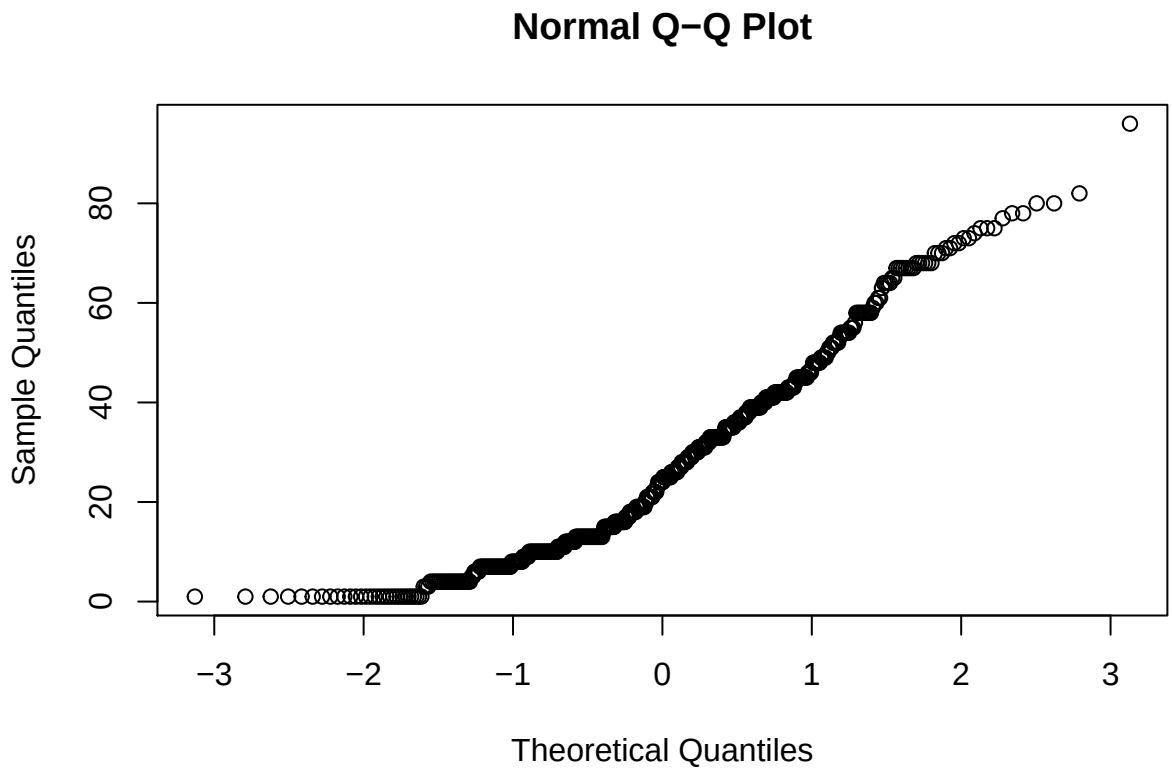
```
# weibull
```

UMBS SPECIES LEVEL - Looking at DURATION of flowering

```
### UMBS ###
hist(umbs_flwr_spp$flwr_duration_scaled)
```



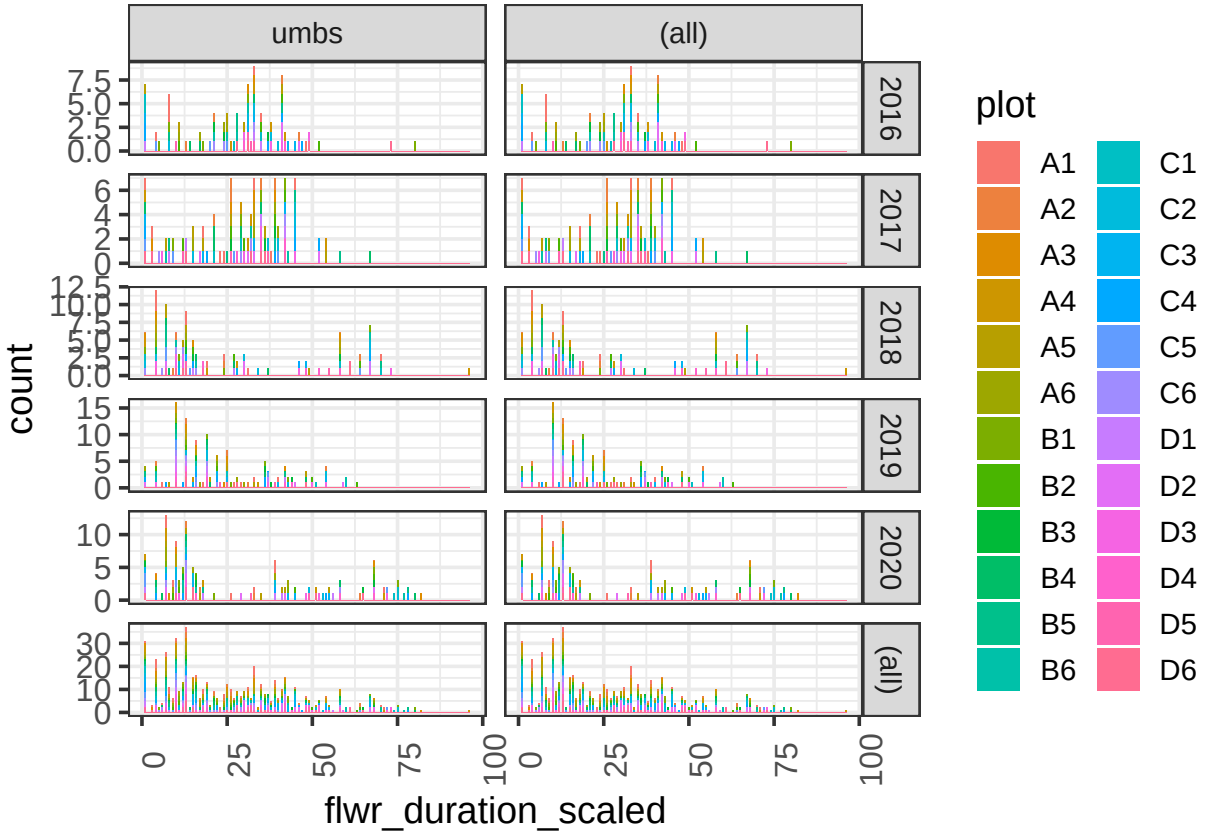

```
qqnorm(umbs_flwr_spp$flwr_duration_scaled)
```



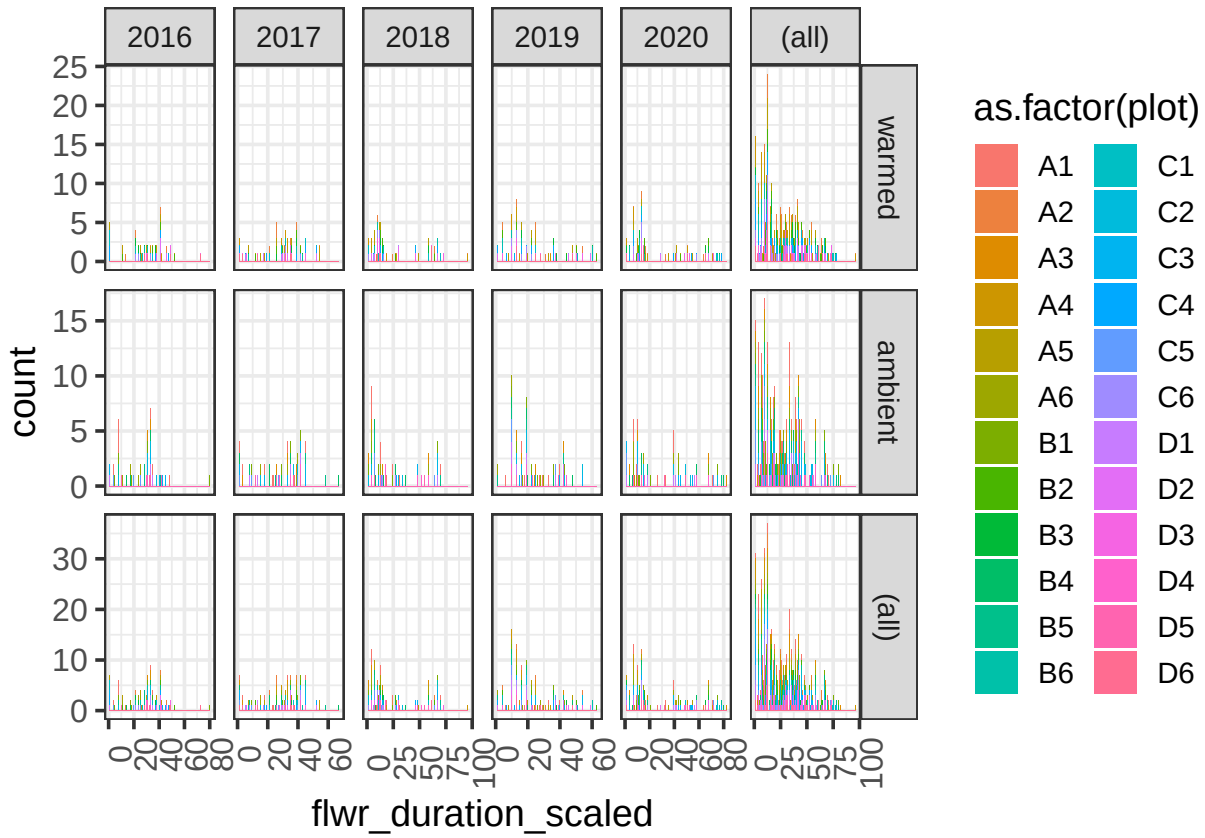
```r
shapiro.test(umbs_flwr_spp$flwr_duration_scaled)  # pvalue is < 0.05 so we reject the null hypothesis t
```

```
##
##  Shapiro-Wilk normality test
##
## data:  umbs_flwr_spp$flwr_duration_scaled
## W = 0.93603, p-value = 6.047e-15
```

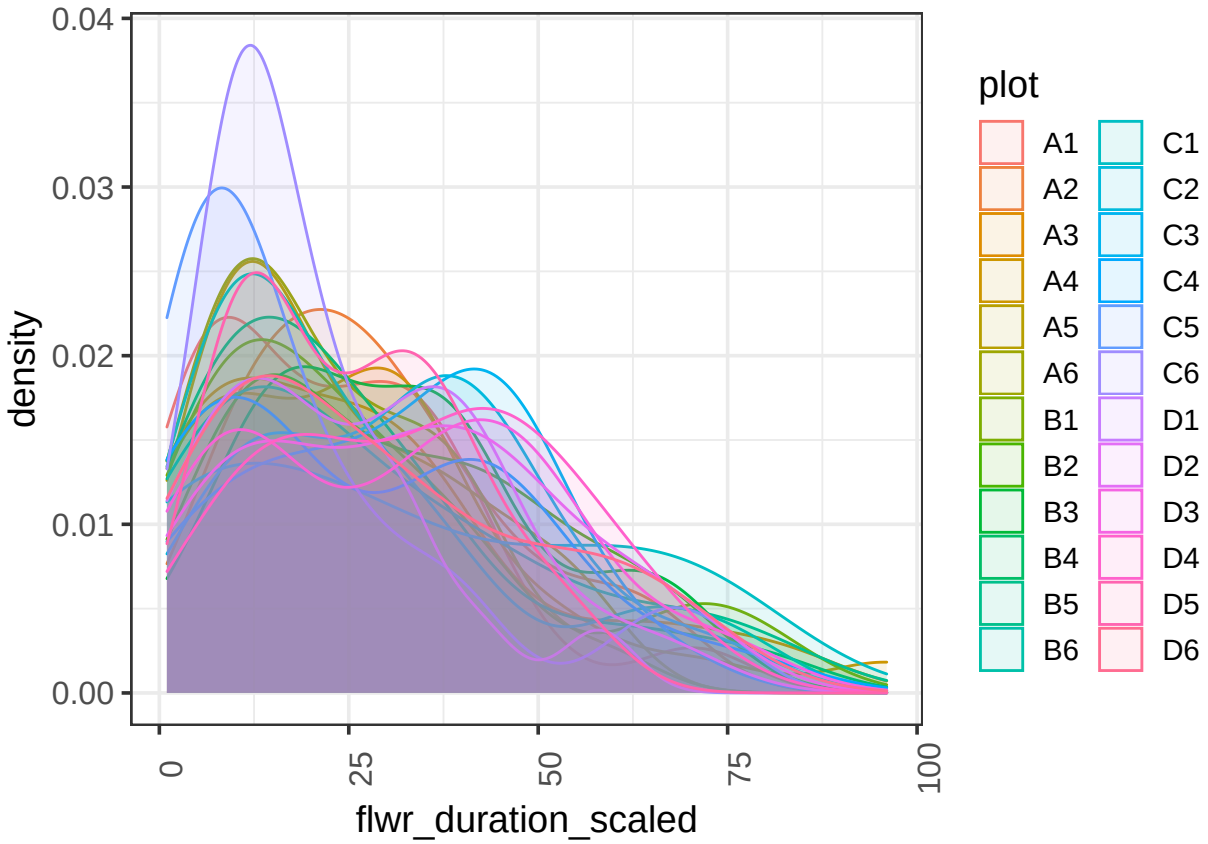
```r
# Visualizing median Julian date for umbs at the PLOT LEVEL
ggplot(umbs_flwr_spp, aes(flwr_duration_scaled, fill = plot)) + geom_histogram(binwidth = 0.5) +
    facet_grid(year ~ site, margins = TRUE, scales = "free")
```



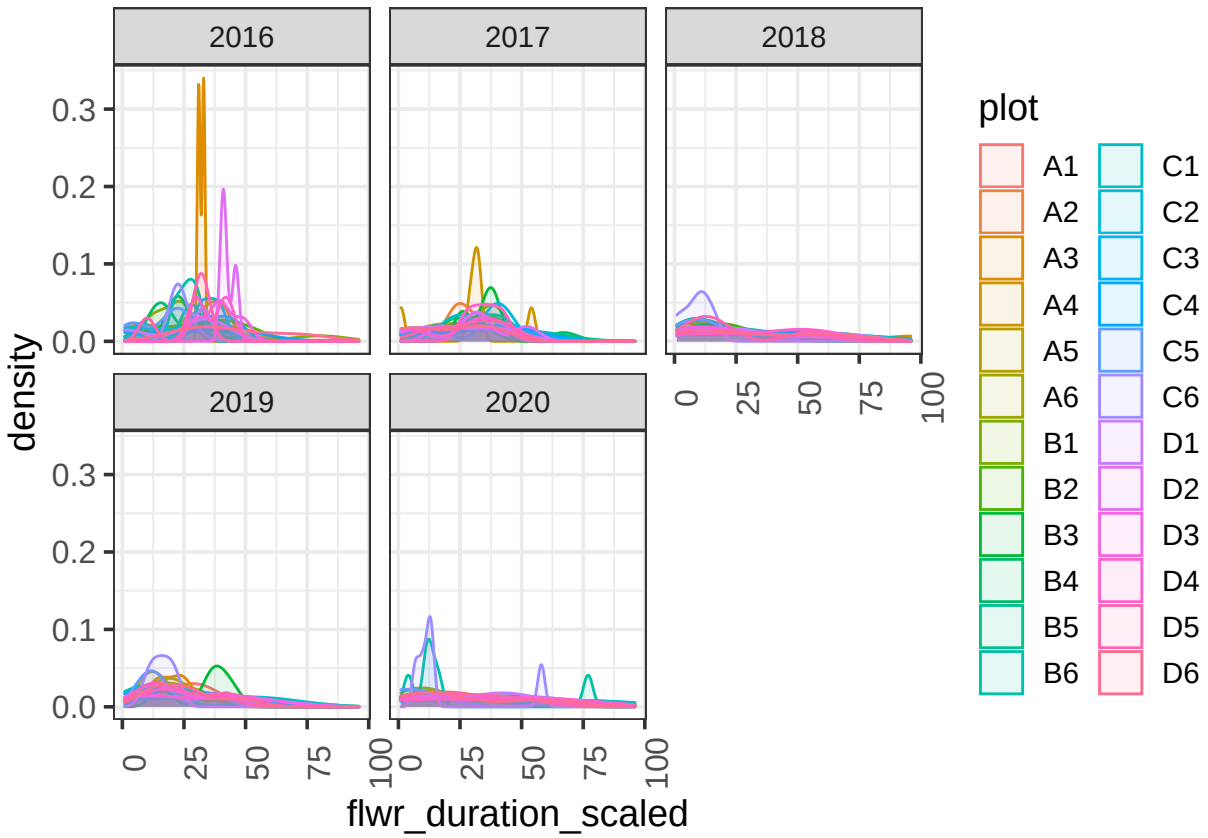

```r
ggplot(umbs_flwr_spp, aes(flwr_duration_scaled, fill = as.factor(plot))) + geom_histogram(binwidth = 0.5
    facet_grid(state ~ year, margins = TRUE, scales = "free")
```



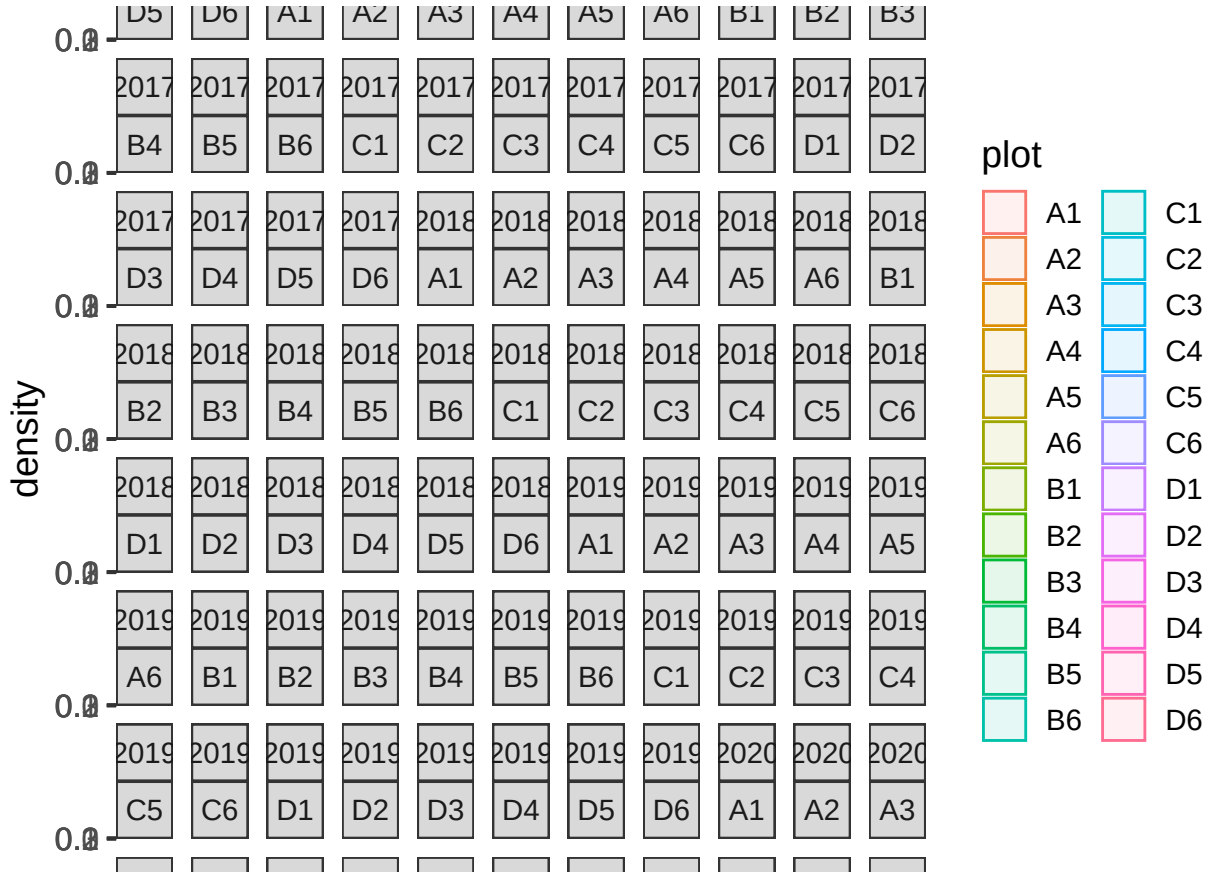

```
ggplot(umbs_flwr_spp, aes(flwr_duration_scaled, fill = plot, color = plot)) + geom_density(alpha = 0.1)
```



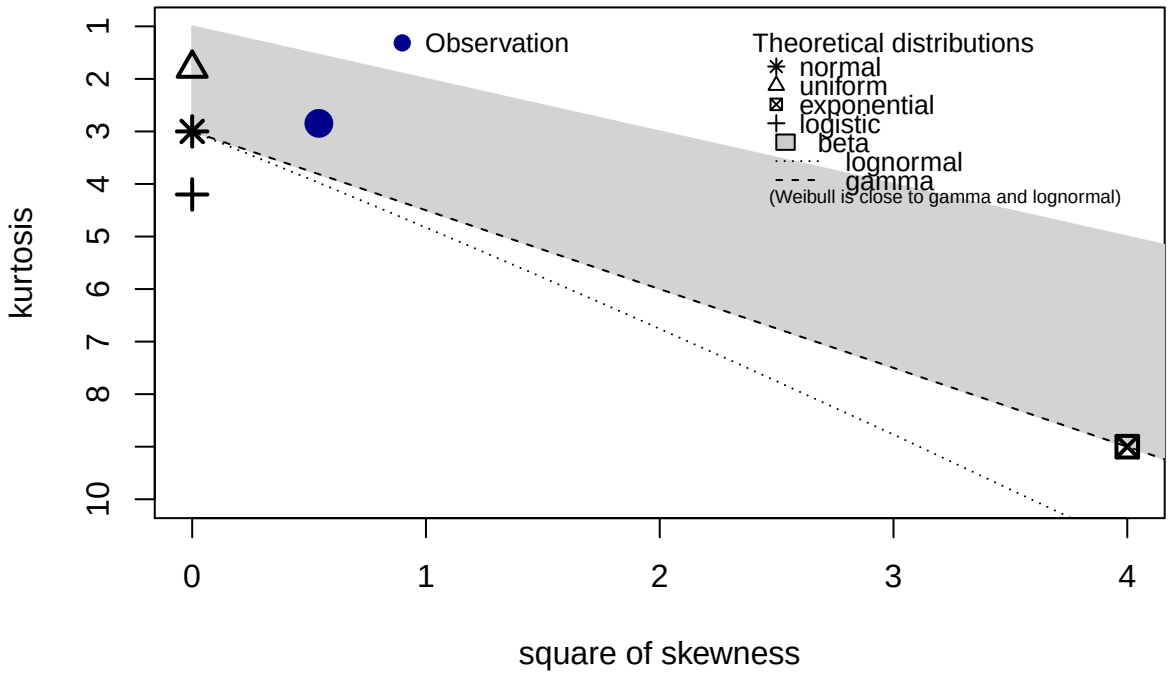

```
ggplot(umbs_flwr_spp, aes(flwr_duration_scaled, fill = plot, color = plot)) + geom_density(alpha = 0.1)
    facet_wrap(~year)
```




```
ggplot(umbs_flwr_spp, aes(flwr_duration_scaled, fill = plot, color = plot)) + geom_density(alpha = 0.1)
    facet_wrap(~year + plot)
```

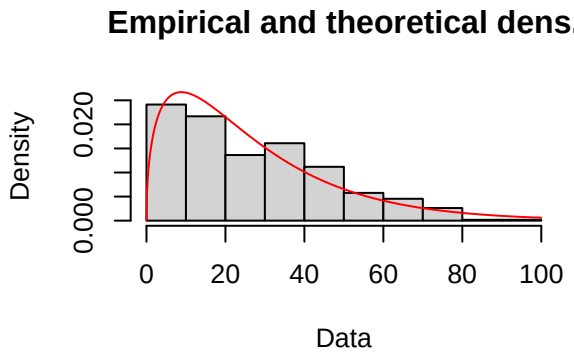


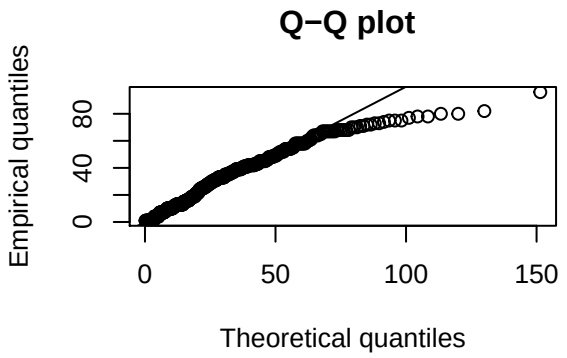

```
# Exploring distributions for these right-skewed data:
descdist(umbs_flwr_spp$flwr_duration_scaled, discrete = FALSE)
```

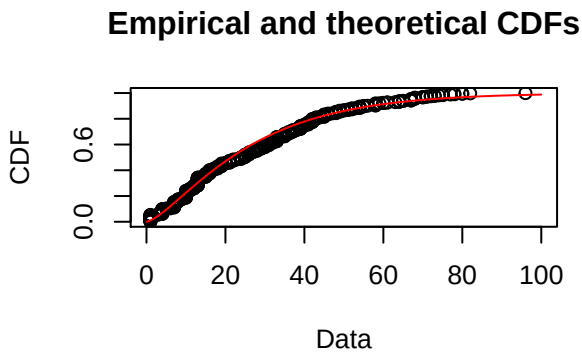


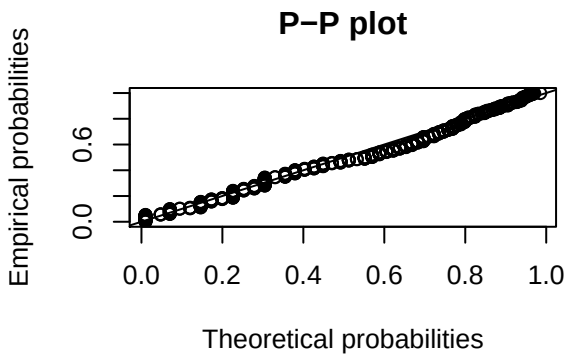

```
## summary statistics
## ------
## min:  1   max:  96
## median:  24
## mean:  27.23427
## estimated sd:  19.59612
## estimated skewness:  0.7362109
## estimated kurtosis:  2.846847
```

```
# Gamma distribution
fit.gamma <- fitdist(umbs_flwr_spp$flwr_duration_scaled, "gamma")
plot(fit.gamma)
```

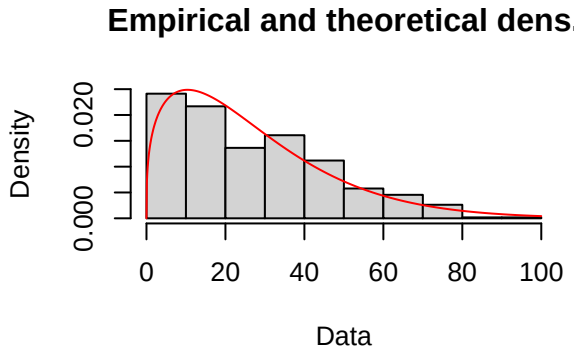


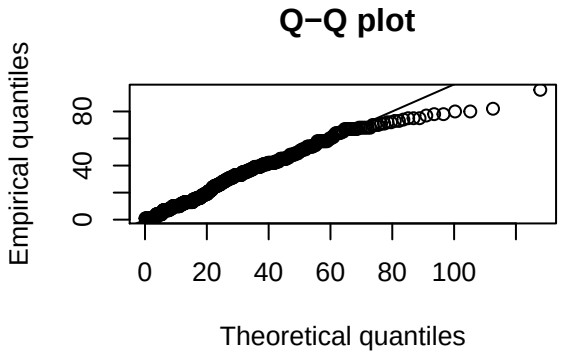


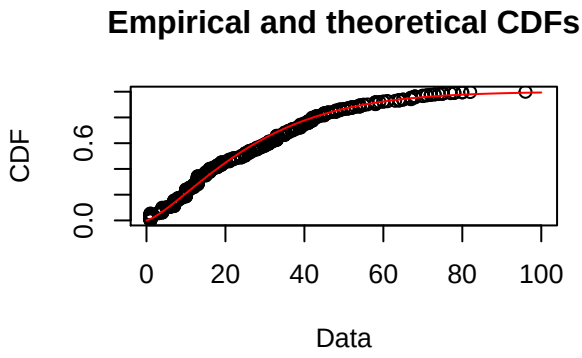


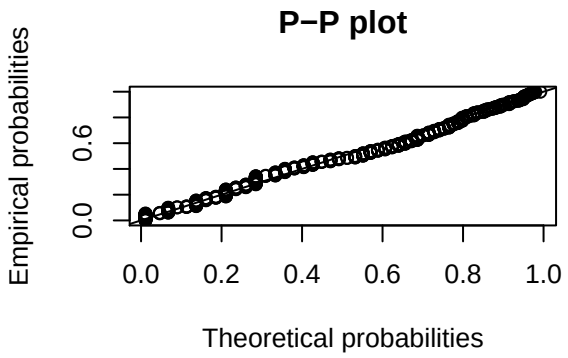



```
# Weibull distribution
fit.weibull <- fitdist(umbs_flwr_spp$flwr_duration_scaled, "weibull")
plot(fit.weibull)
```

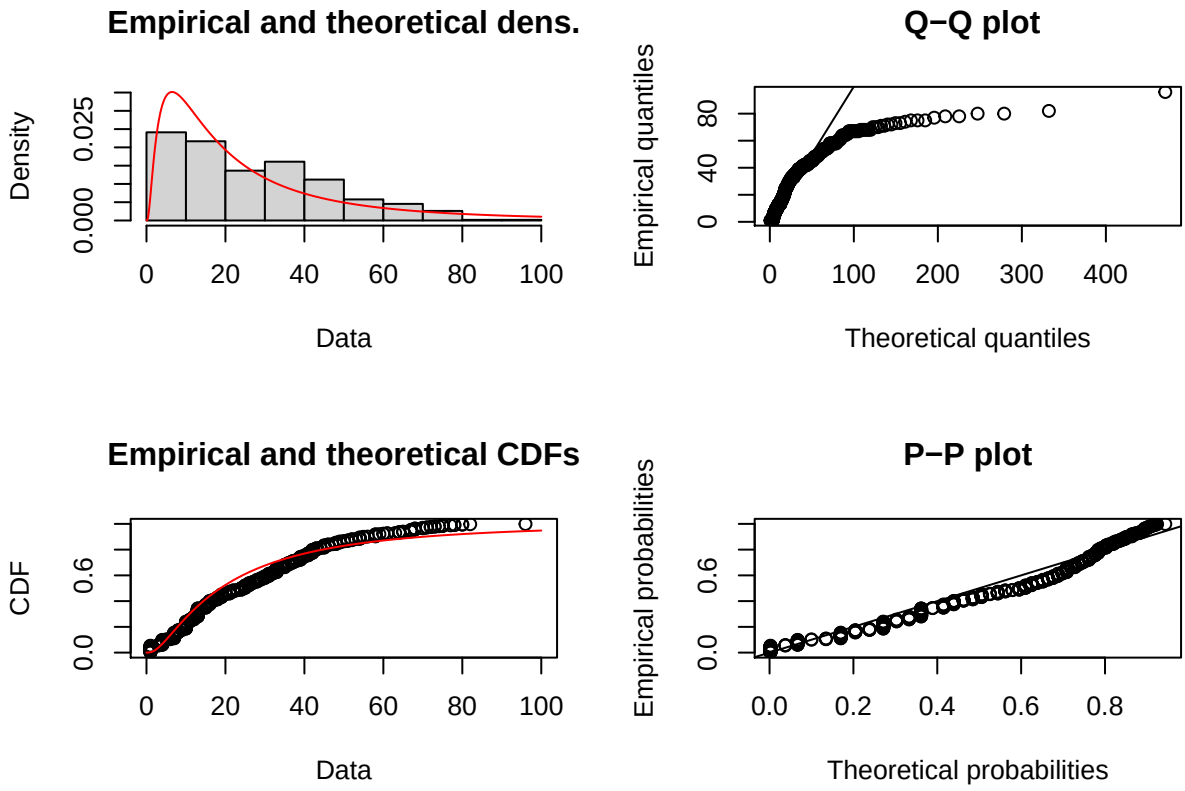




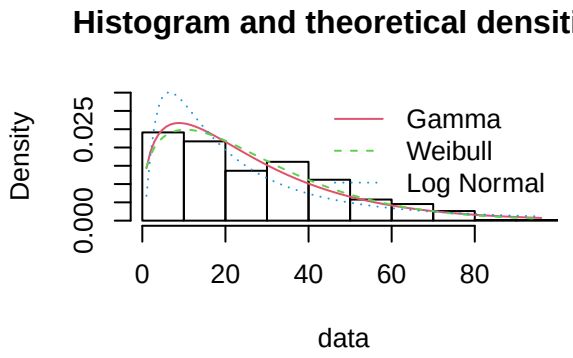


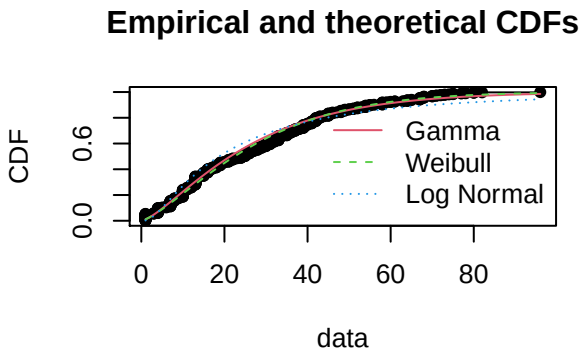


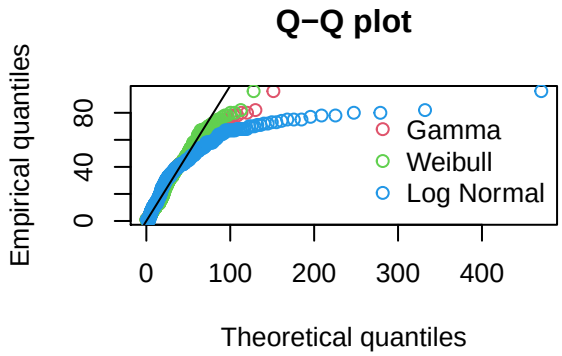
```r
# Lognormal distribution
fit.ln <- fitdist(umbs_flwr_spp$flwr_duration_scaled, "lnorm")
plot(fit.ln)
```

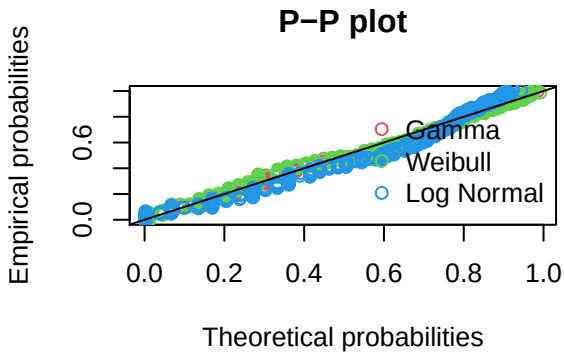



```r
par(mfrow = c(2, 2))
plot.legend <- c("Gamma", "Weibull", "Log Normal")
denscomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
cdfcomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
qqcomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
ppcomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
```









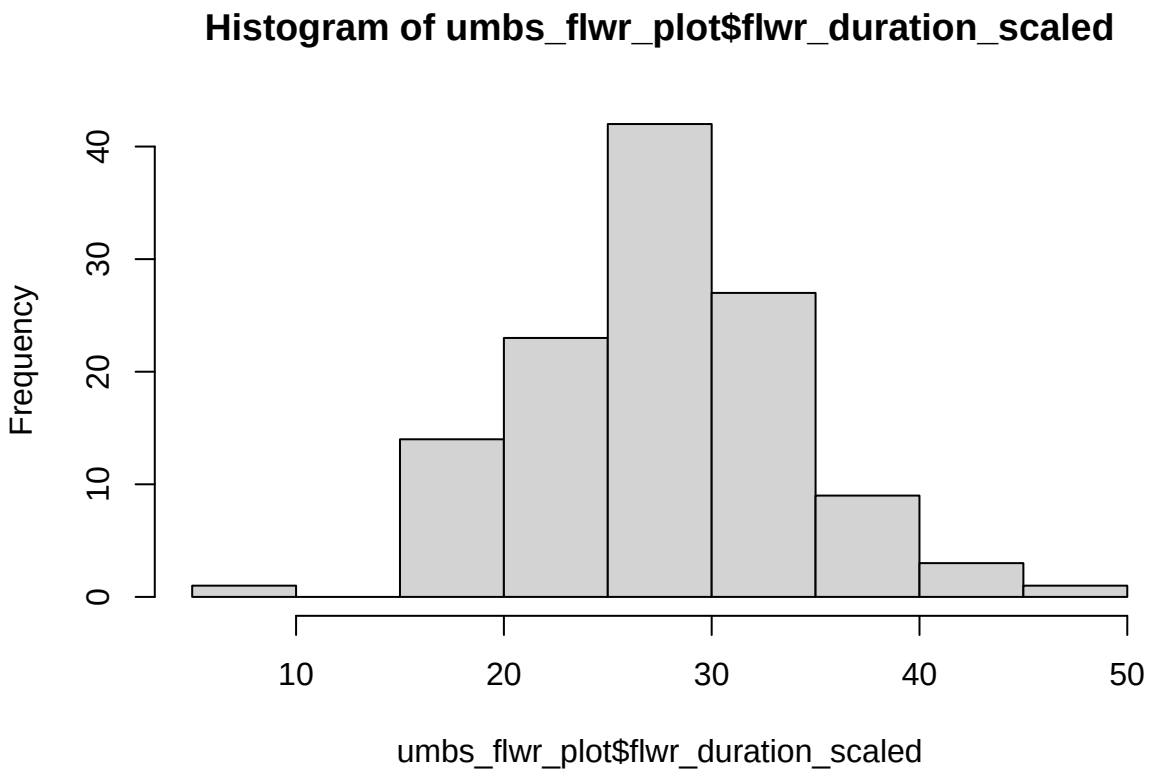

```
# Goodness of fit comparisons across fits (can't include the log normal bc it
# becomes diff response values)
gofstat(list(fit.gamma, fit.weibull, fit.ln), fitnames = c("Gamma", "Weibull", "Log Normal"))
```

```
## Goodness-of-fit statistics
##                                 Gamma    Weibull Log Normal
## Kolmogorov-Smirnov statistic 0.0748467 0.06236934  0.1086951
## Cramer-von Mises statistic   0.5742174 0.42421120  1.8679074
## Anderson-Darling statistic   4.0163011 3.02079995 13.8512346
##
## Goodness-of-fit criteria
##                                   Gamma  Weibull Log Normal
## Akaike's Information Criterion 4880.530 4865.360   5013.085
## Bayesian Information Criterion 4889.229 4874.058   5021.783
```

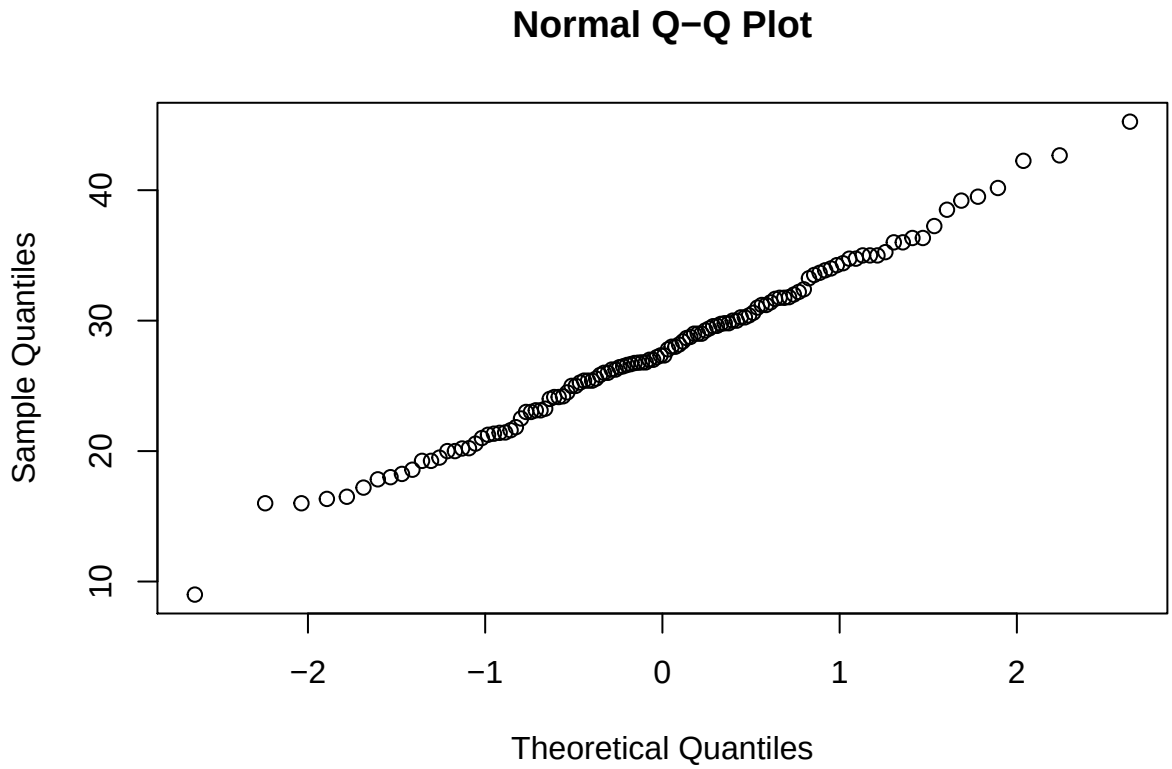
```
# weibull
```

UMBS PLOT LEVEL - Looking at DURATION of flowering

```
### UMBS ###
hist(umbs_flwr_plot$flwr_duration_scaled)
```



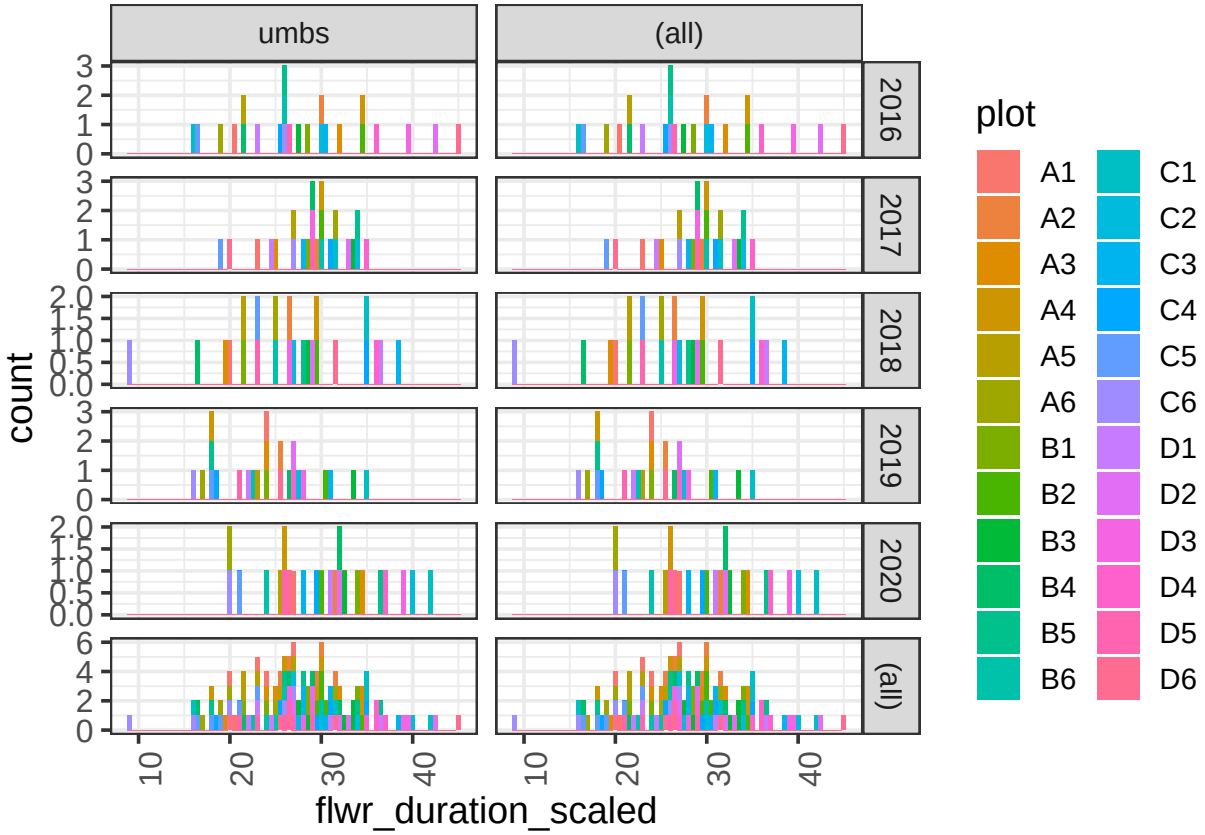

```
qqnorm(umbs_flwr_plot$flwr_duration_scaled)
```



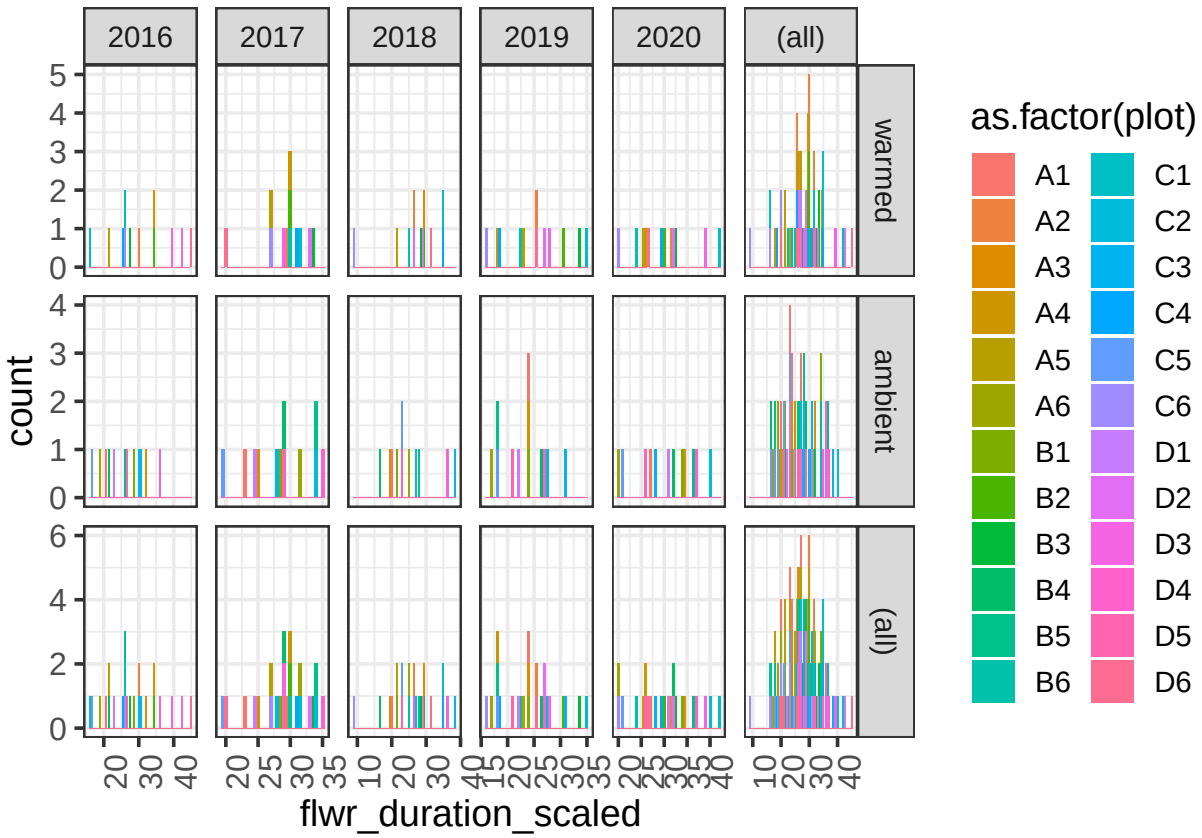
```
shapiro.test(umbs_flwr_plot$flwr_duration_scaled)  # pvalue is > 0.05 so we accept the null hypothesis
```

```
##
##  Shapiro-Wilk normality test
##
## data:  umbs_flwr_plot$flwr_duration_scaled
## W = 0.99518, p-value = 0.9573
```

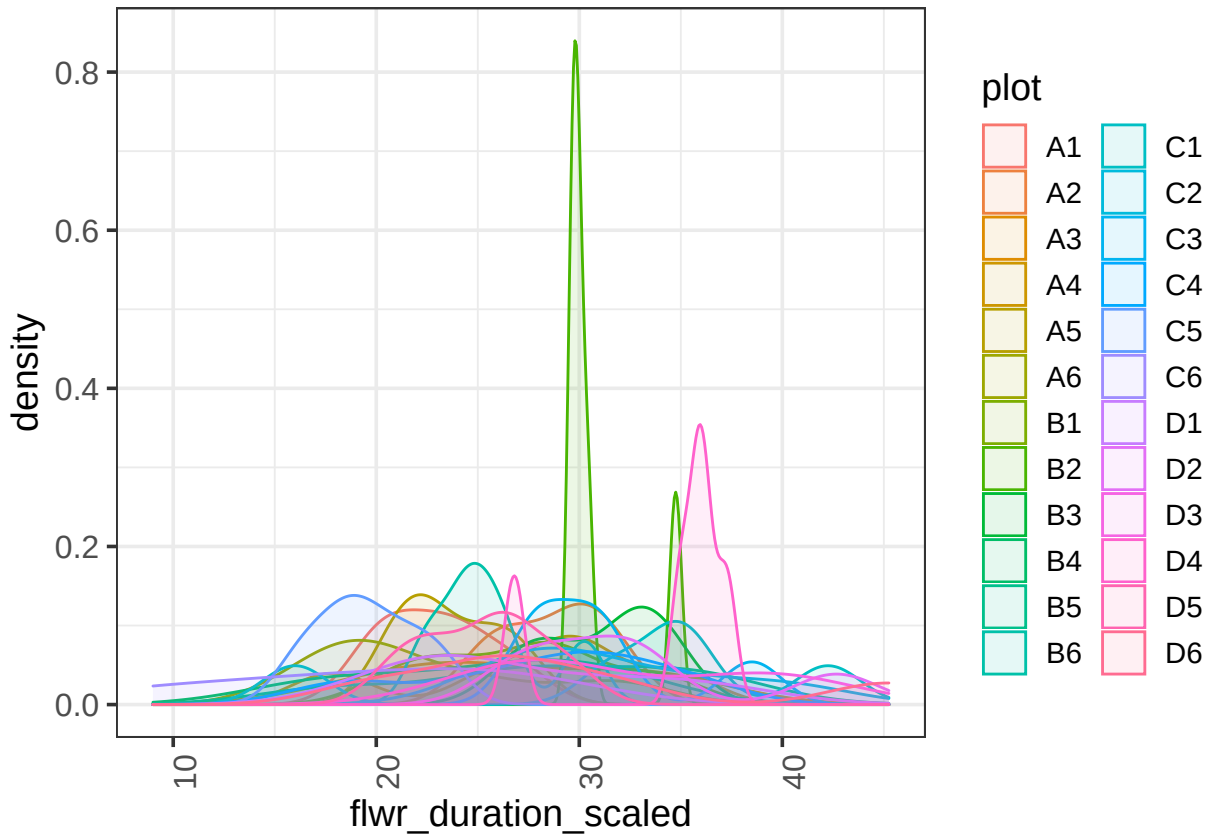
```
# Visualizing median Julian date for umbs at the PLOT LEVEL
ggplot(umbs_flwr_plot, aes(flwr_duration_scaled, fill = plot)) + geom_histogram(binwidth = 0.5) +
    facet_grid(year ~ site, margins = TRUE, scales = "free")
```




```
ggplot(umbs_flwr_plot, aes(flwr_duration_scaled, fill = as.factor(plot))) + geom_histogram(binwidth = 0
    facet_grid(state ~ year, margins = TRUE, scales = "free")
```

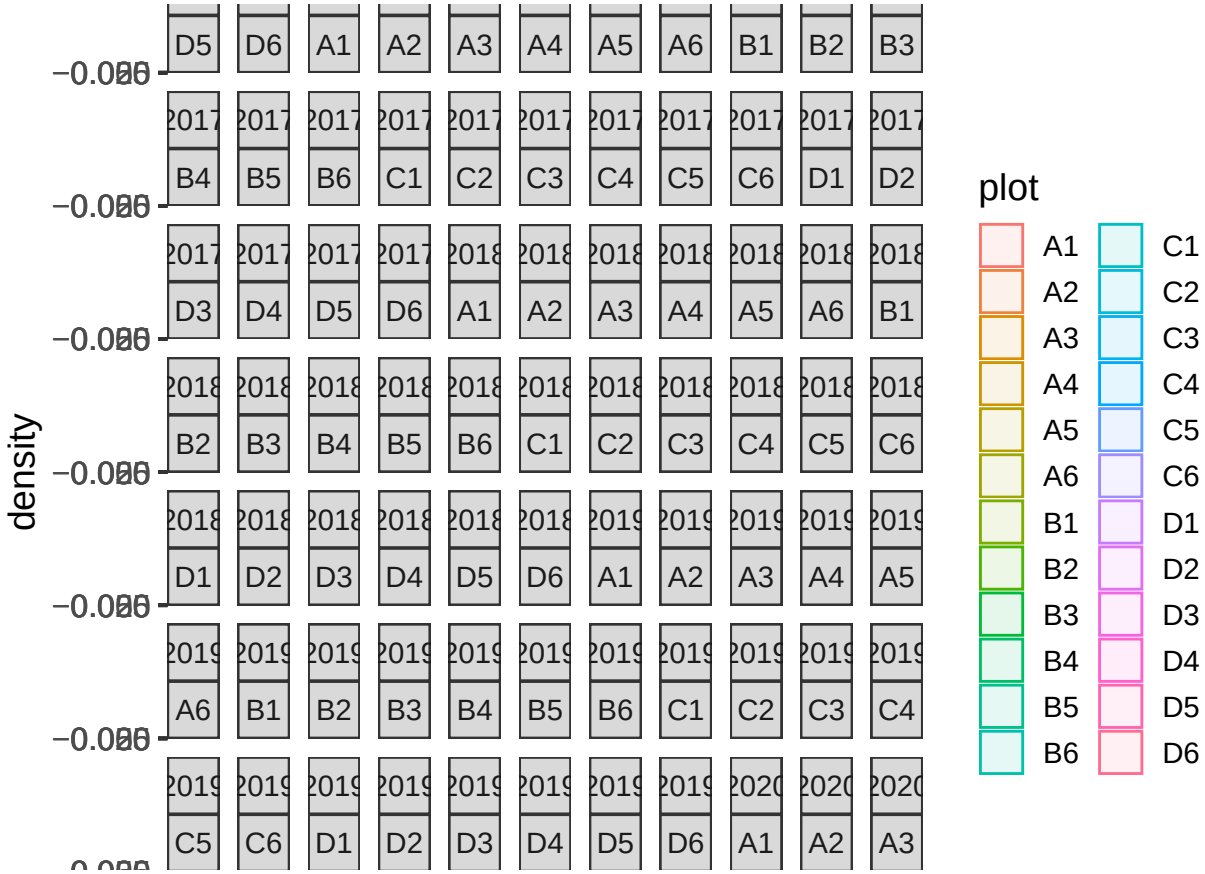



```
ggplot(umbs_flwr_plot, aes(flwr_duration_scaled, fill = plot, color = plot)) + geom_density(alpha = 0.1)
```

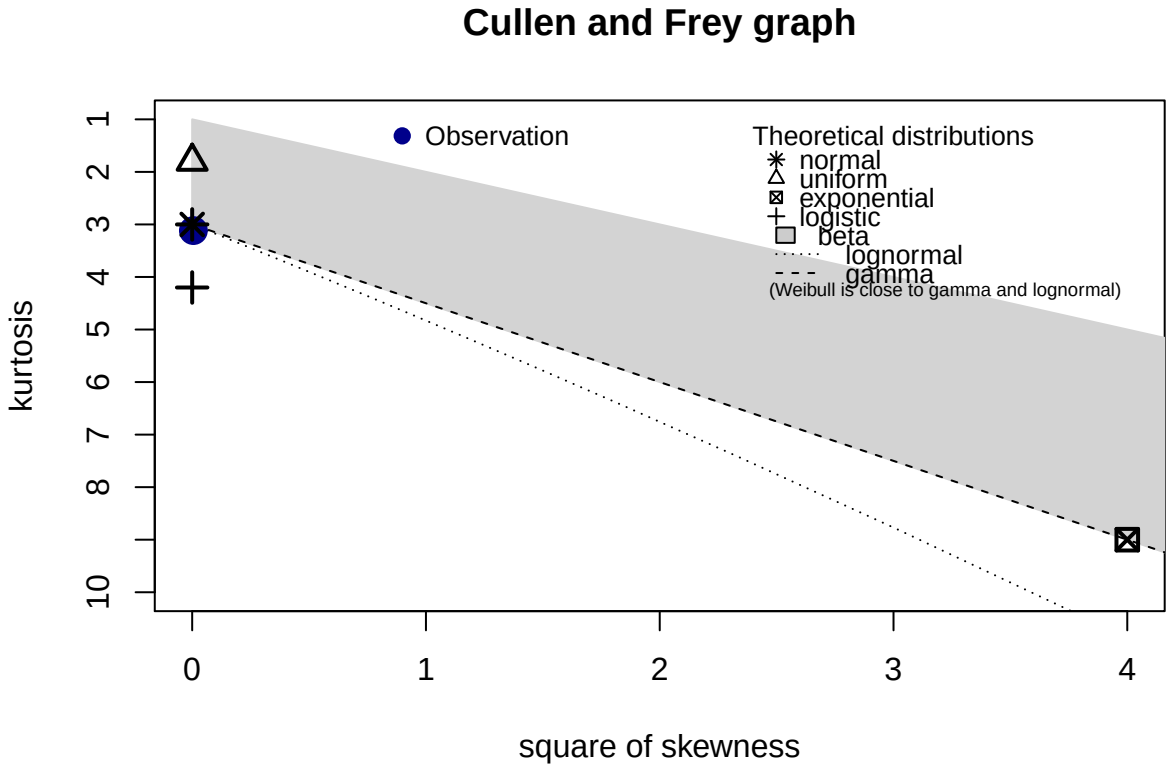



```
ggplot(umbs_flwr_plot, aes(flwr_duration_scaled, fill = plot, color = plot)) + geom_density(alpha = 0.1)
    facet_wrap(~year)
```


```
ggplot(umbs_flwr_plot, aes(flwr_duration_scaled, fill = plot, color = plot)) + geom_density(alpha = 0.1)
    facet_wrap(~year + plot)
```

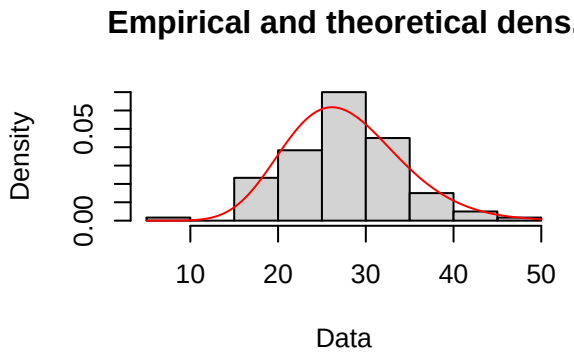


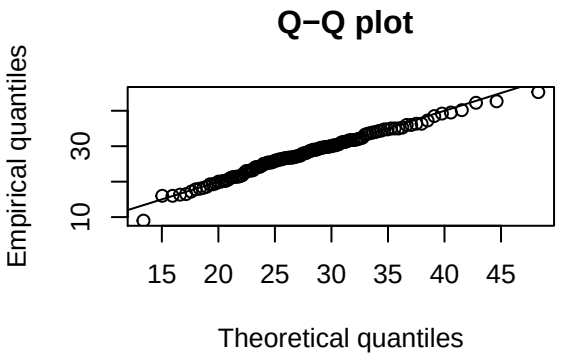

```
# Exploring distributions for these data:
descdist(umbs_flwr_plot$flwr_duration_scaled, discrete = FALSE)
```

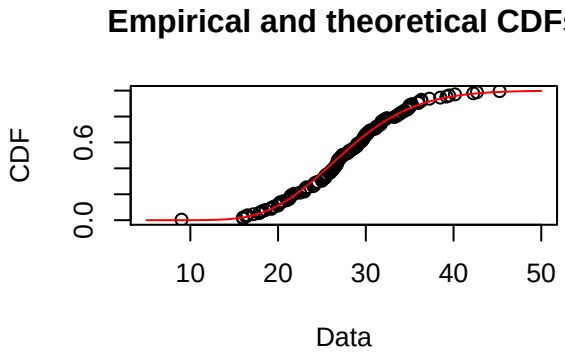


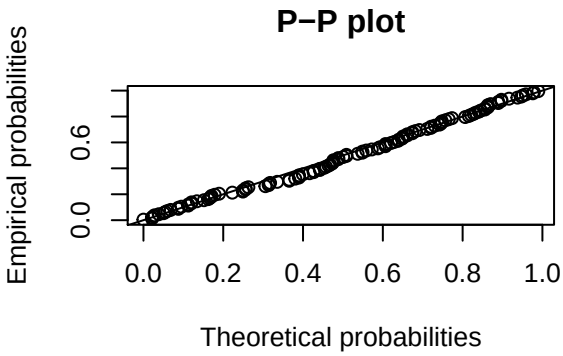

```
## summary statistics
## ------
## min:  9   max:  45.25
## median:  27.33333
## mean:  27.71655
## estimated sd:  6.401011
## estimated skewness:  0.07223297
## estimated kurtosis:  3.117377
```

```
# Gamma distribution
fit.gamma <- fitdist(umbs_flwr_plot$flwr_duration_scaled, "gamma")
plot(fit.gamma)
```

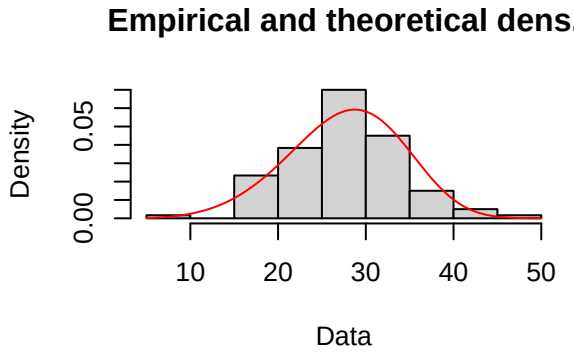


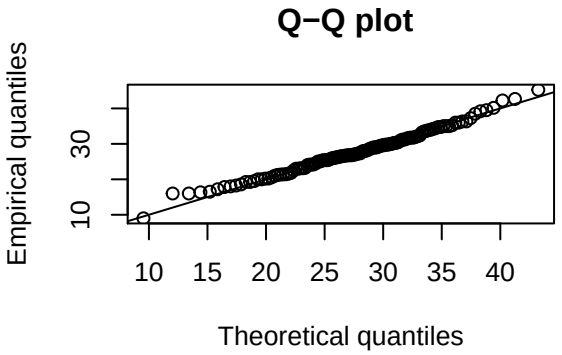


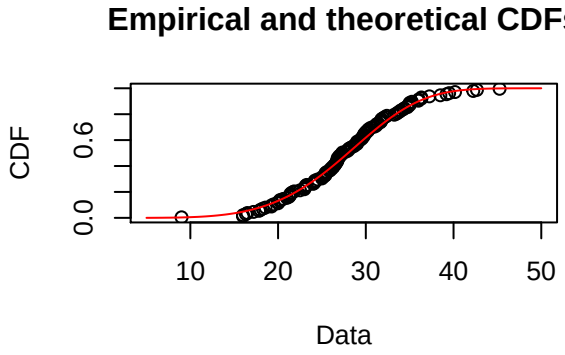


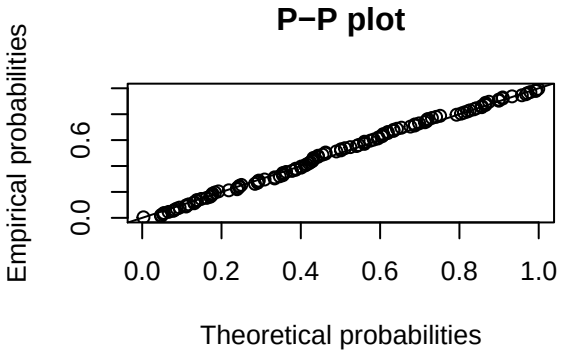



```r
# Weibull distribution
fit.weibull <- fitdist(umbs_flwr_plot$flwr_duration_scaled, "weibull")
plot(fit.weibull)
```

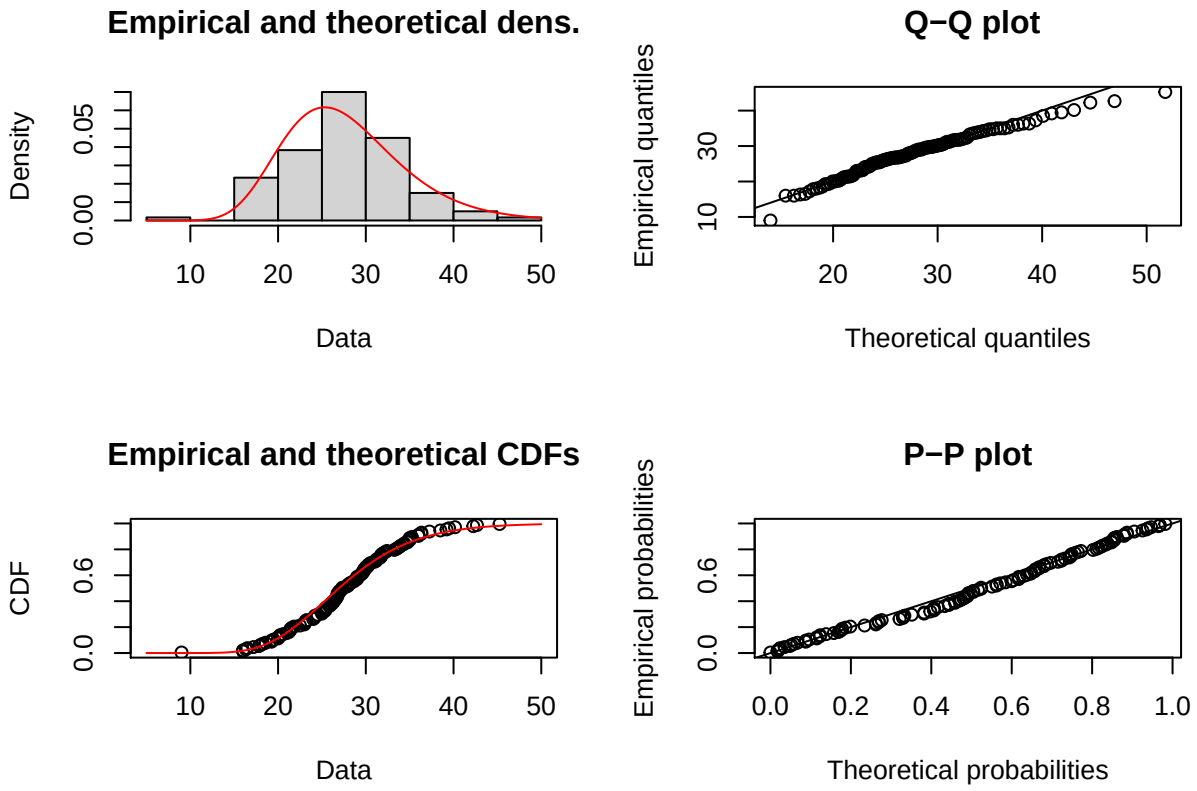




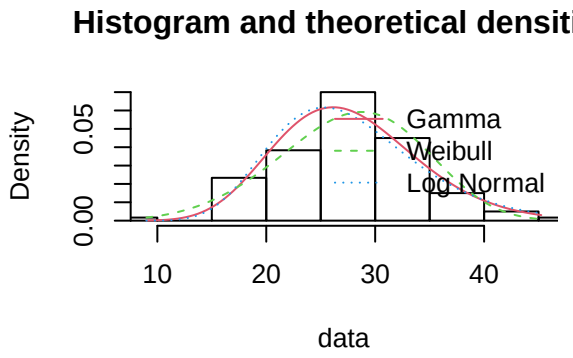


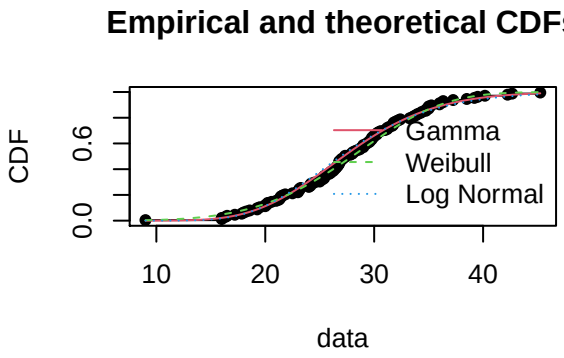


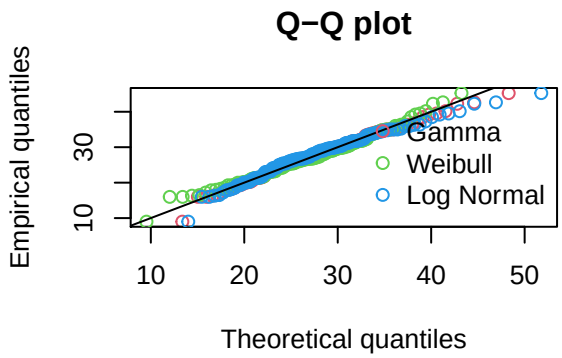
```r
# Lognormal distribution
fit.ln <- fitdist(umbs_flwr_plot$flwr_duration_scaled, "lnorm")
plot(fit.ln)
```

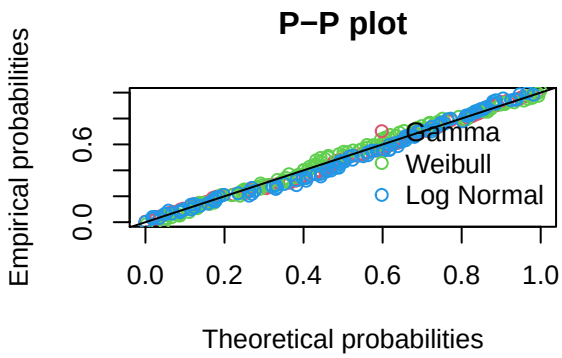



```r
par(mfrow = c(2, 2))
plot.legend <- c("Gamma", "Weibull", "Log Normal")
denscomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
cdfcomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
qqcomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
ppcomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
```









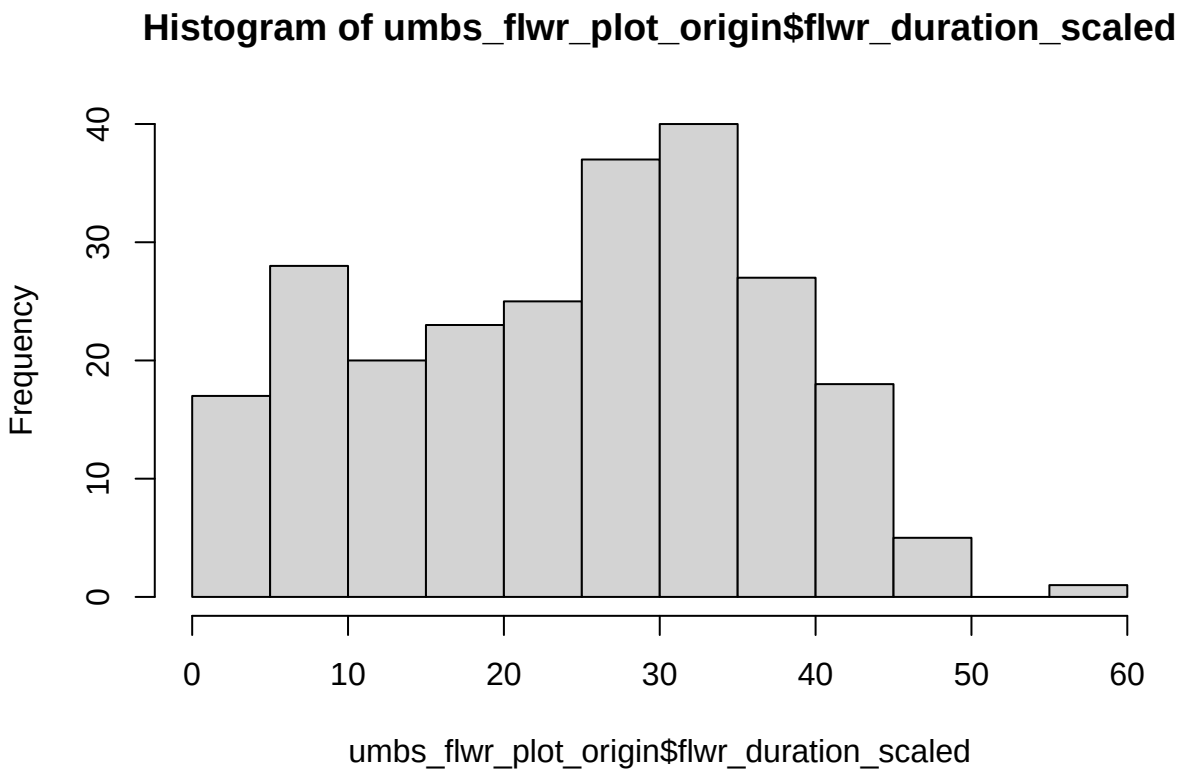

```
# Goodness of fit comparisons across fits (can't include the log normal bc it
# becomes diff response values)
gofstat(list(fit.gamma, fit.weibull, fit.ln), fitnames = c("Gamma", "Weibull", "Log Normal"))
```

```
## Goodness-of-fit statistics
##                                 Gamma    Weibull Log Normal
## Kolmogorov-Smirnov statistic 0.06535762 0.04958182 0.08203567
## Cramer-von Mises statistic   0.07403853 0.05546034 0.14077906
## Anderson-Darling statistic   0.41994696 0.40053978 0.79803372
##
## Goodness-of-fit criteria
##                                 Gamma  Weibull Log Normal
## Akaike's Information Criterion 793.4811 791.9553   800.0908
## Bayesian Information Criterion 799.0560 797.5303   805.6658
```

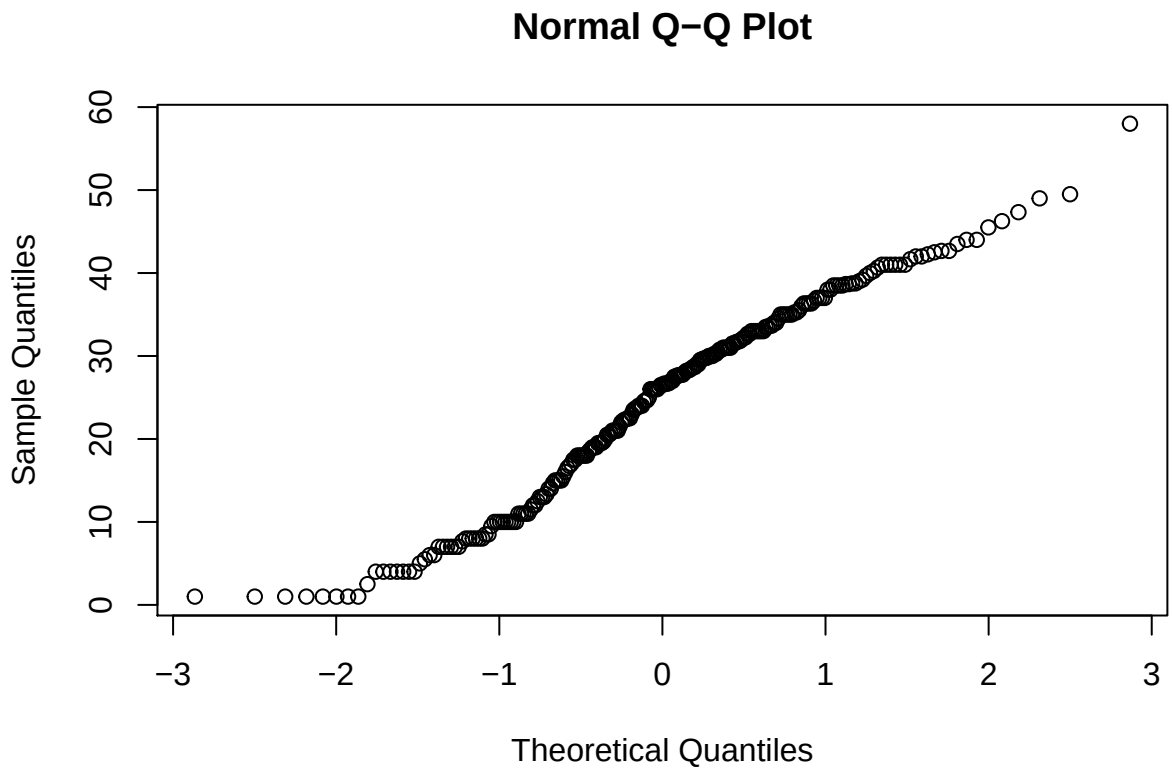
```
# Weibull
```

UMBS PLOT LEVEL ORIGIN - Looking at DURATION of flowering

```
### UMBS ###
hist(umbs_flwr_plot_origin$flwr_duration_scaled)
```



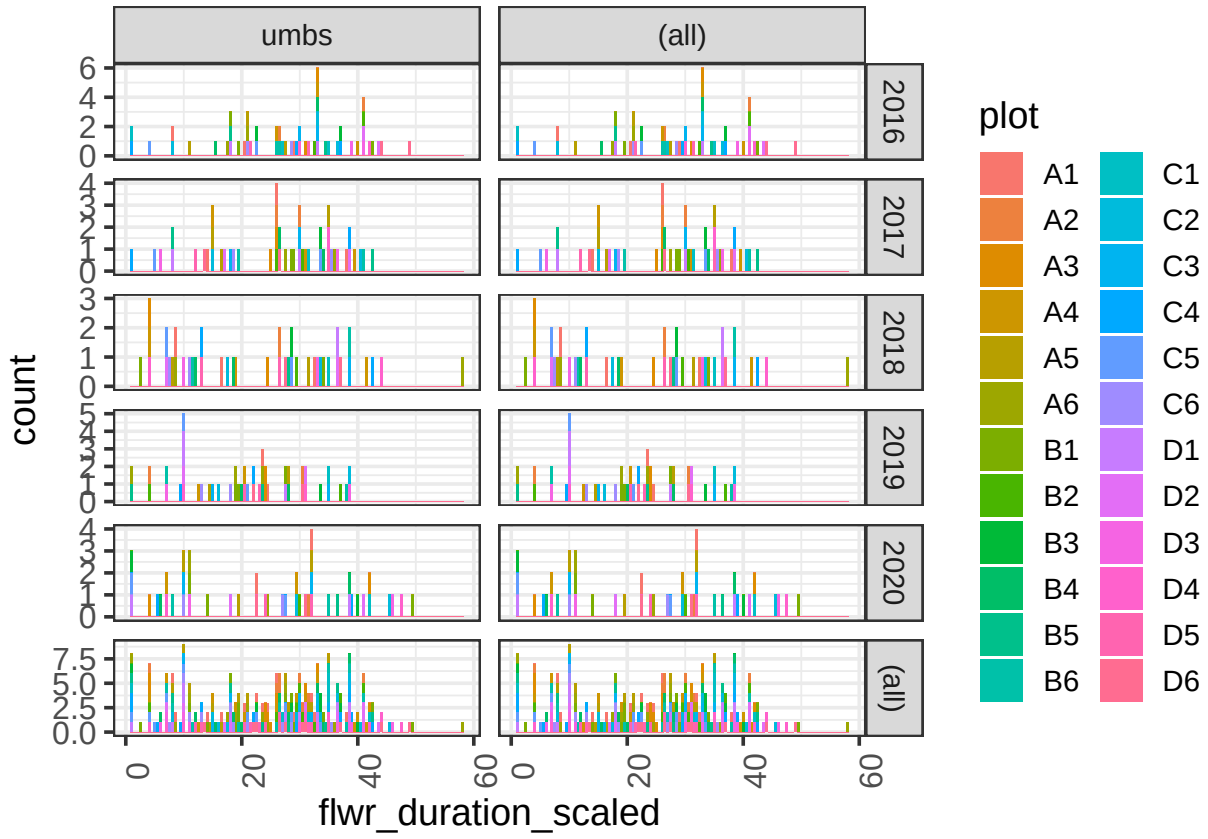

```
qqnorm(umbs_flwr_plot_origin$flwr_duration_scaled)
```



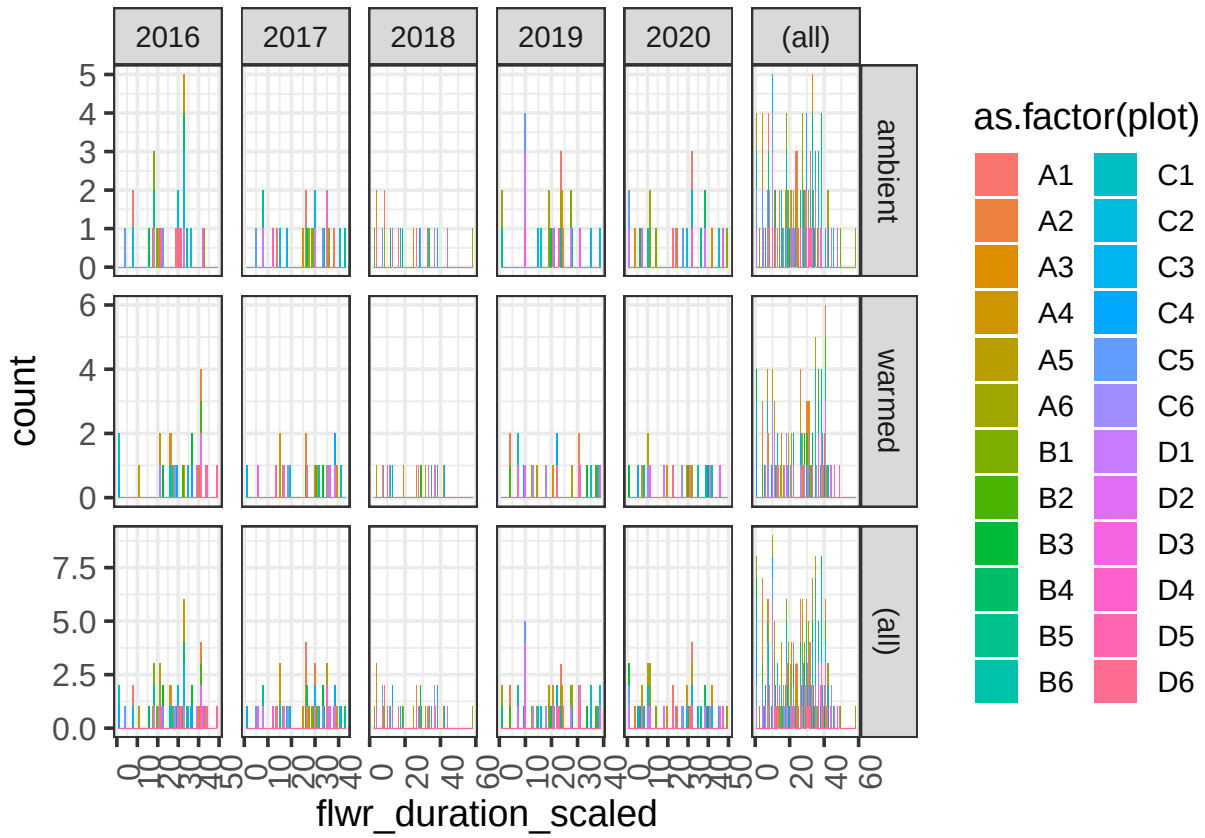
```
shapiro.test(kbs_flwr_plot_origin$flwr_duration_scaled)  # pvalue is < 0.05 so we reject the null hypot
```

```
##
##  Shapiro-Wilk normality test
##
## data:  kbs_flwr_plot_origin$flwr_duration_scaled
## W = 0.97267, p-value = 2.782e-07
```

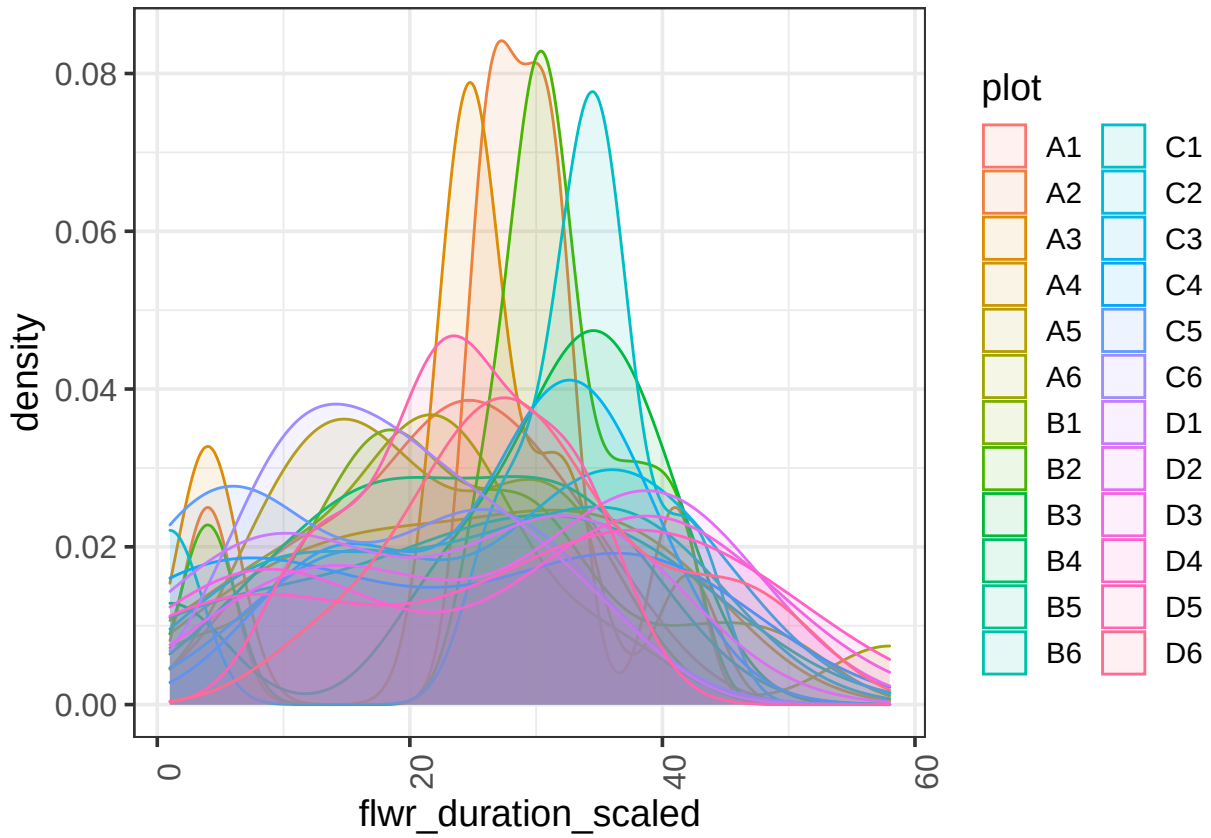
```
# Visualizing median Julian date for umbs at the PLOT LEVEL
ggplot(umbs_flwr_plot_origin, aes(flwr_duration_scaled, fill = plot)) + geom_histogram(binwidth = 0.5) +
    facet_grid(year ~ site, margins = TRUE, scales = "free")
```



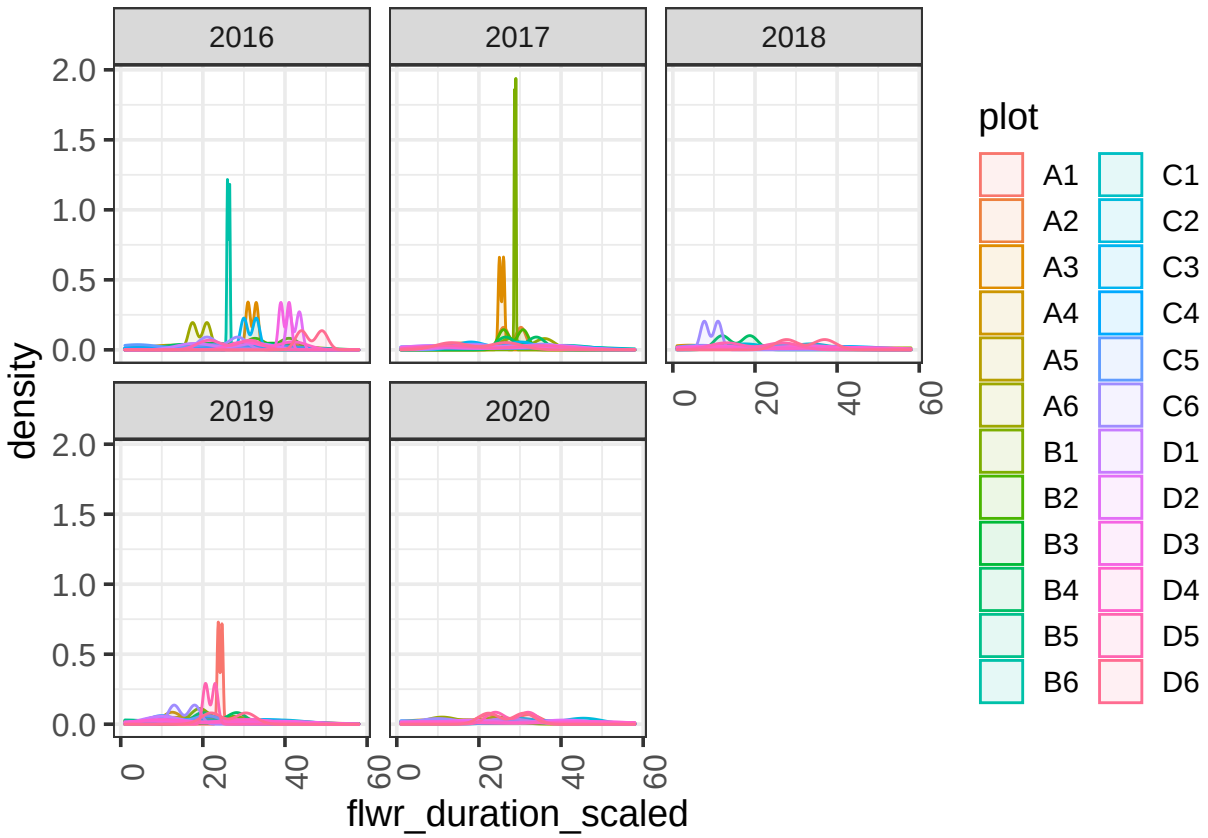

```
ggplot(umbs_flwr_plot_origin, aes(flwr_duration_scaled, fill = as.factor(plot))) +
    geom_histogram(binwidth = 0.5) + facet_grid(state ~ year, margins = TRUE, scales = "free")
```



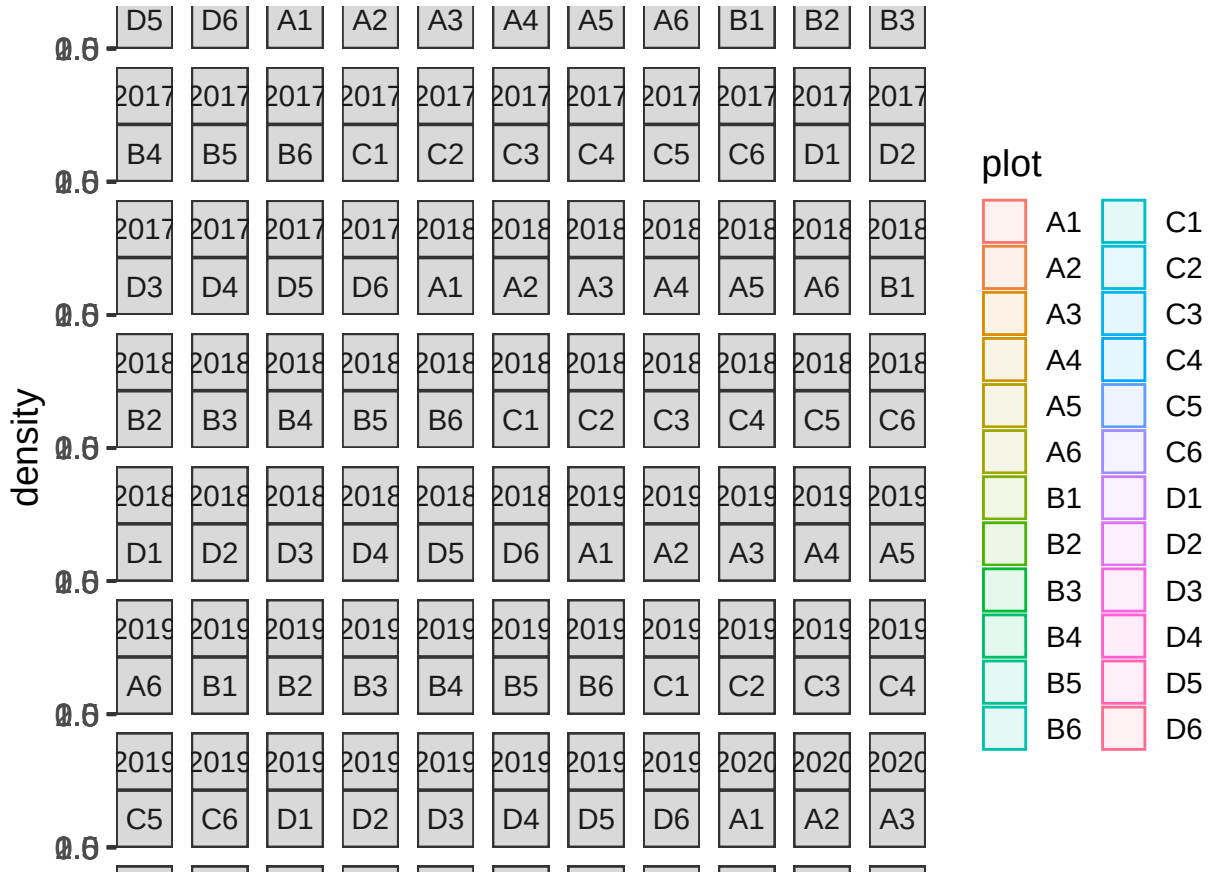

```
ggplot(umbs_flwr_plot_origin, aes(flwr_duration_scaled, fill = plot, color = plot)) +
    geom_density(alpha = 0.1)
```



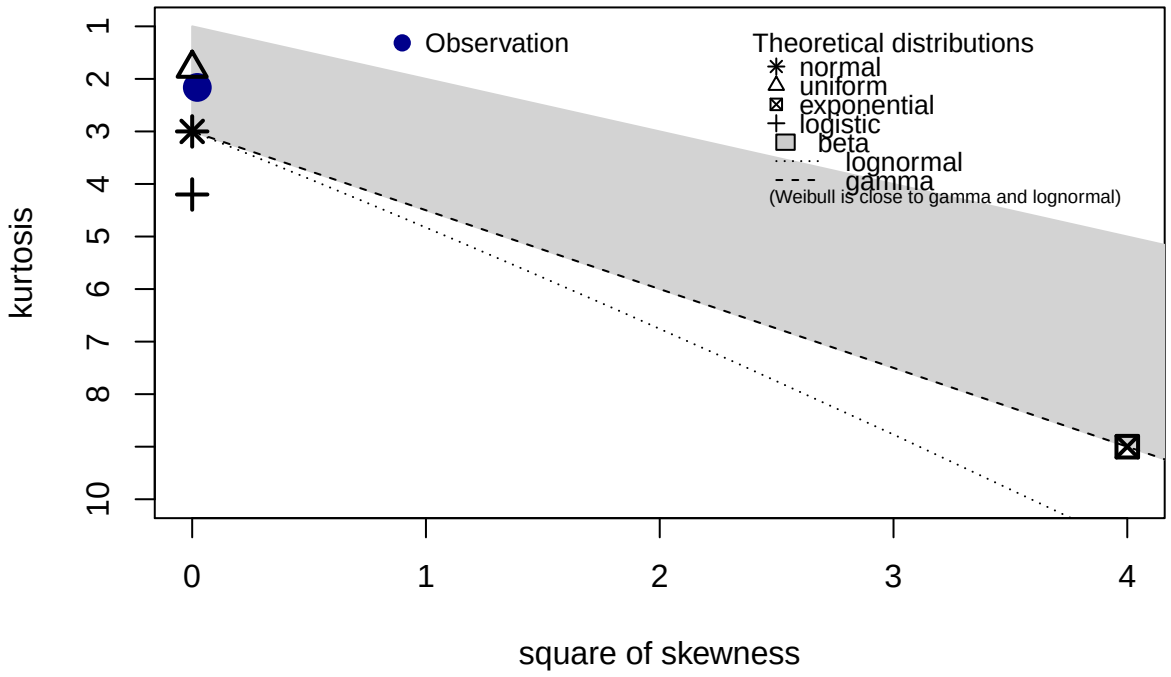

```
ggplot(umbs_flwr_plot_origin, aes(flwr_duration_scaled, fill = plot, color = plot)) +
    geom_density(alpha = 0.1) + facet_wrap(~year)
```




```
ggplot(umbs_flwr_plot_origin, aes(flwr_duration_scaled, fill = plot, color = plot)) +
    geom_density(alpha = 0.1) + facet_wrap(~year + plot)
```

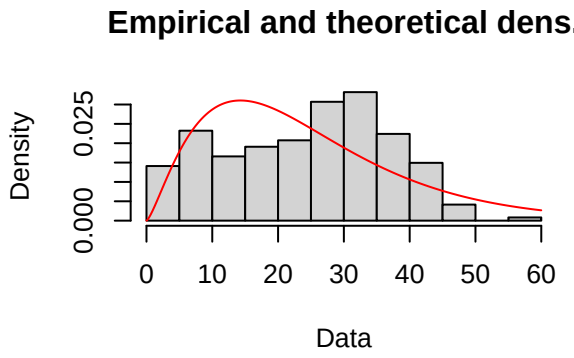


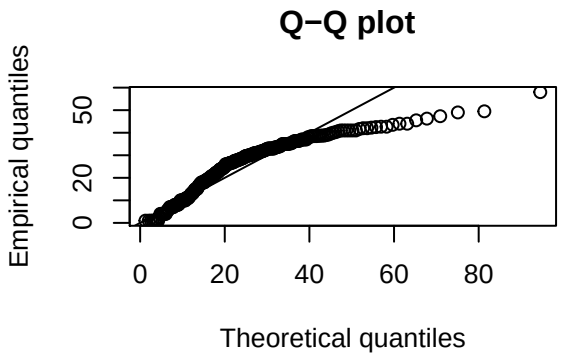

```
# Exploring distributions for these data:
descdist(umbs_flwr_plot_origin$flwr_duration_scaled, discrete = FALSE)
```

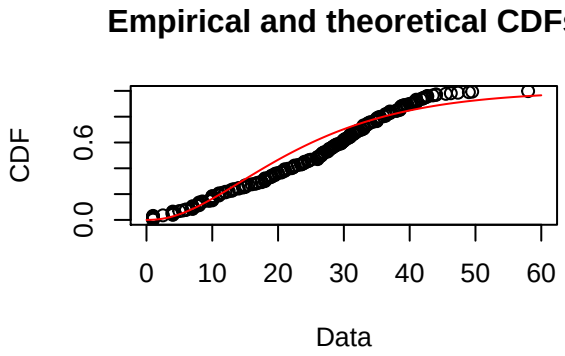


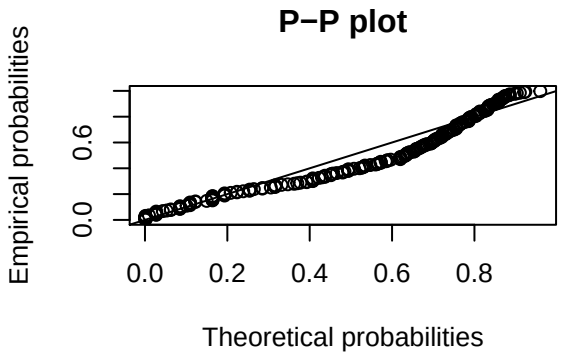

```
## summary statistics
## ------
## min:  1   max:  58
## median:  26.5
## mean:  24.55076
## estimated sd:  12.35444
## estimated skewness:  -0.1481378
## estimated kurtosis:  2.162458
```

```
# Gamma distribution
fit.gamma <- fitdist(umbs_flwr_plot_origin$flwr_duration_scaled, "gamma")
plot(fit.gamma)
```

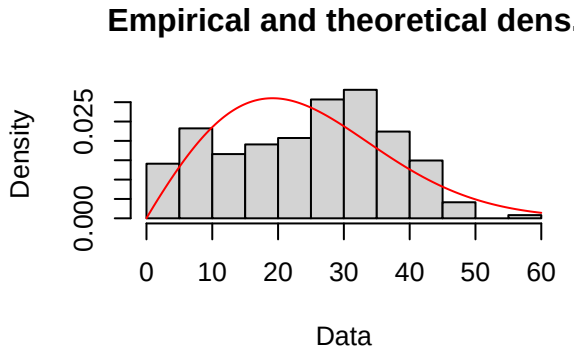


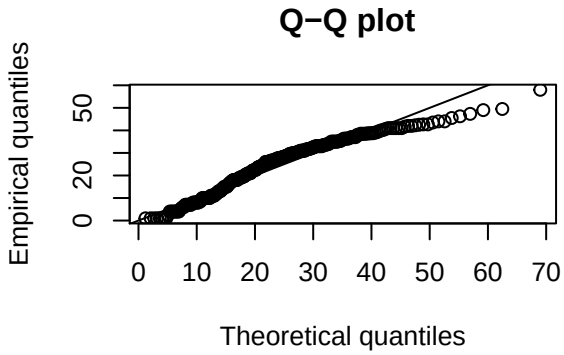


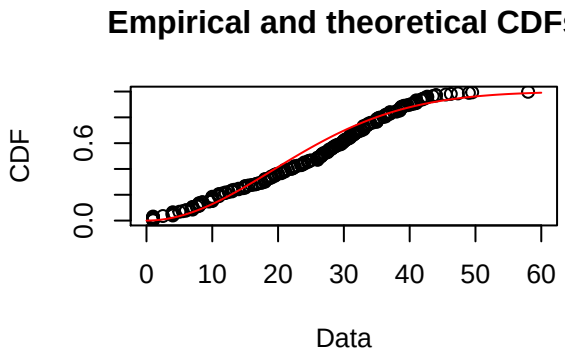


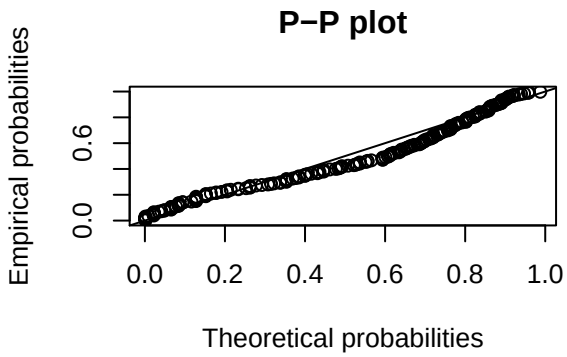



```r
# Weibull distribution
fit.weibull <- fitdist(umbs_flwr_plot_origin$flwr_duration_scaled, "weibull")
plot(fit.weibull)
```

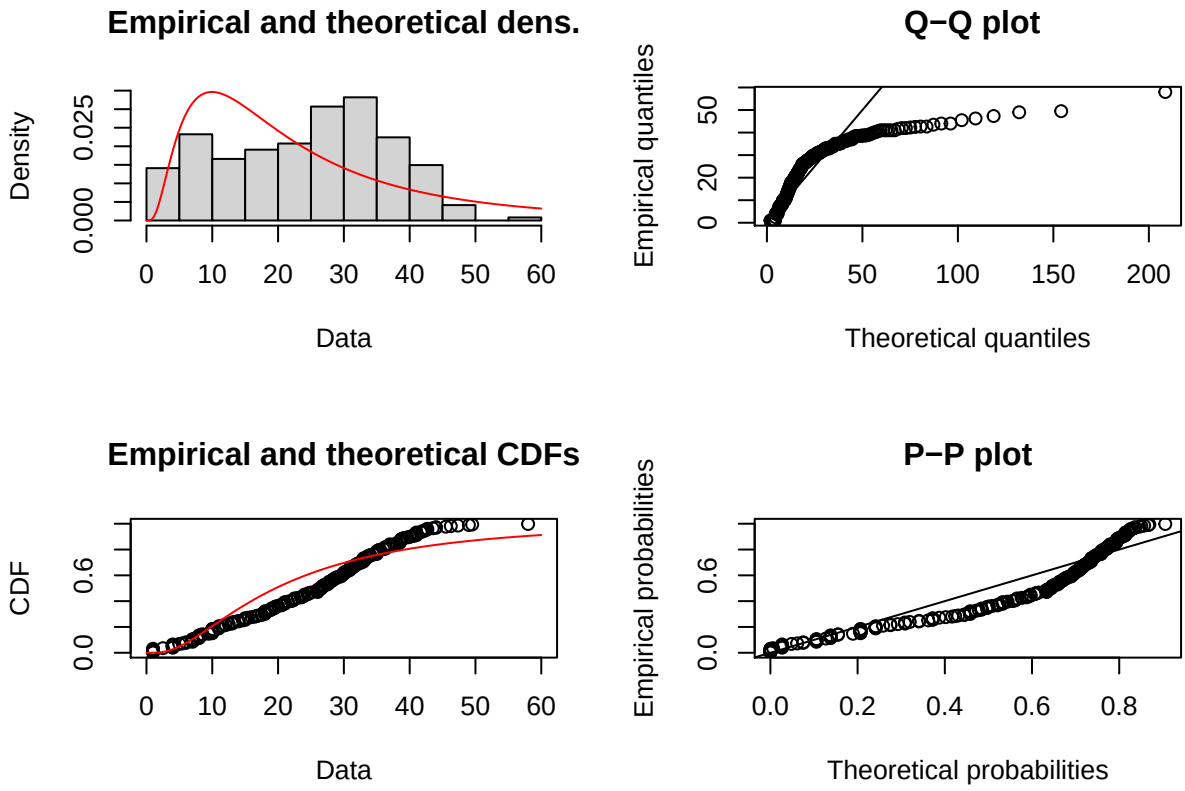




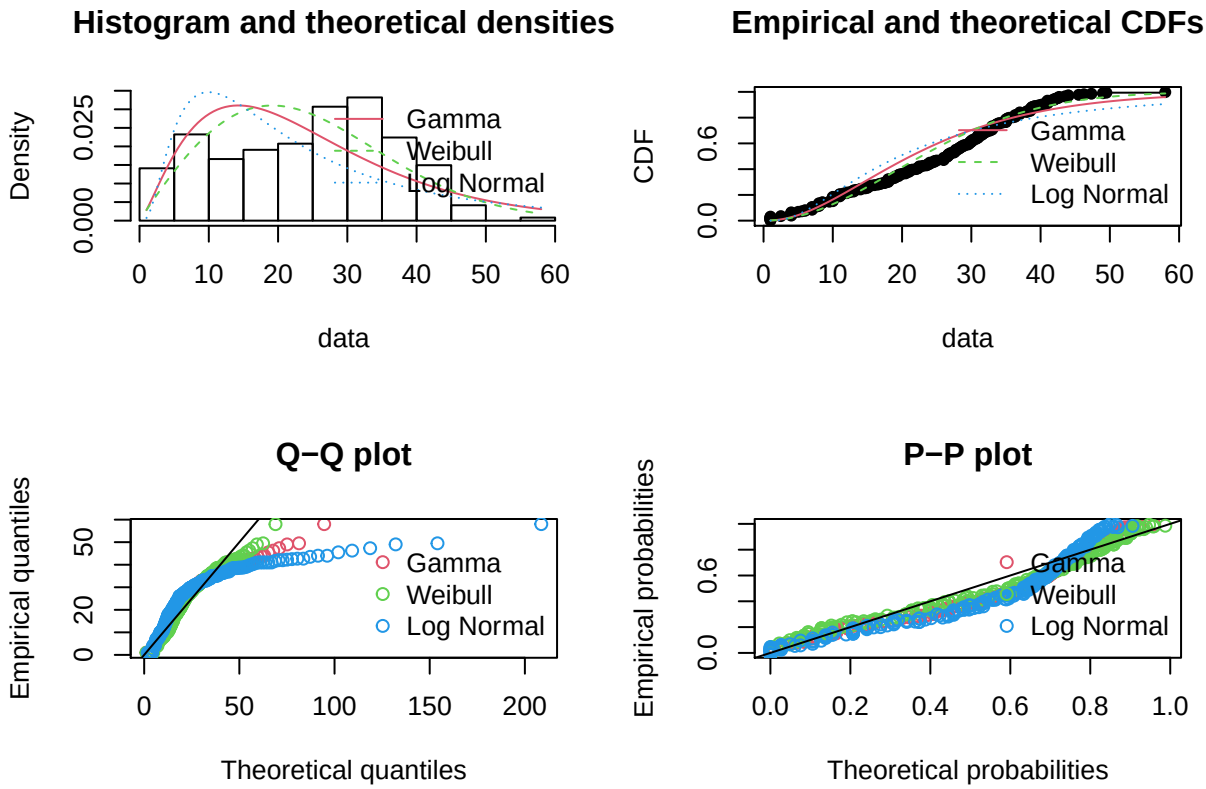




```r
# Lognormal distribution
fit.ln <- fitdist(umbs_flwr_plot_origin$flwr_duration_scaled, "lnorm")
plot(fit.ln)
```




```r
par(mfrow = c(2, 2))
plot.legend <- c("Gamma", "Weibull", "Log Normal")
denscomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
cdfcomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
qqcomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
ppcomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
```



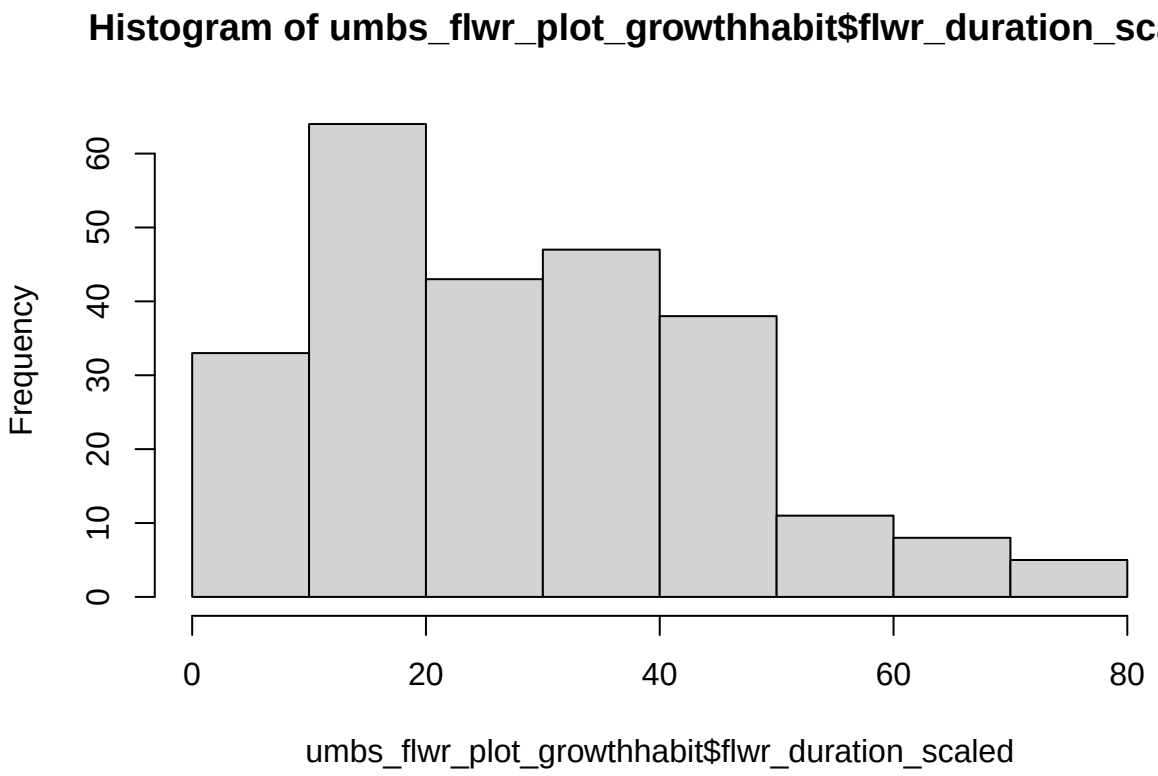

```
# Goodness of fit comparisons across fits (can't include the log normal bc it
# becomes diff response values)
gofstat(list(fit.gamma, fit.weibull, fit.ln), fitnames = c("Gamma", "Weibull", "Log Normal"))
```

```
## Goodness-of-fit statistics
##                                 Gamma   Weibull Log Normal
## Kolmogorov-Smirnov statistic 0.1511545 0.1250207  0.1645848
## Cramer-von Mises statistic   1.3375199 0.7760939  2.2455104
## Anderson-Darling statistic   7.5647601 4.8379344 13.0405617
##
## Goodness-of-fit criteria
##                                   Gamma  Weibull Log Normal
## Akaike's Information Criterion 1946.388 1910.885   2029.791
## Bayesian Information Criterion 1953.358 1917.854   2036.760
```

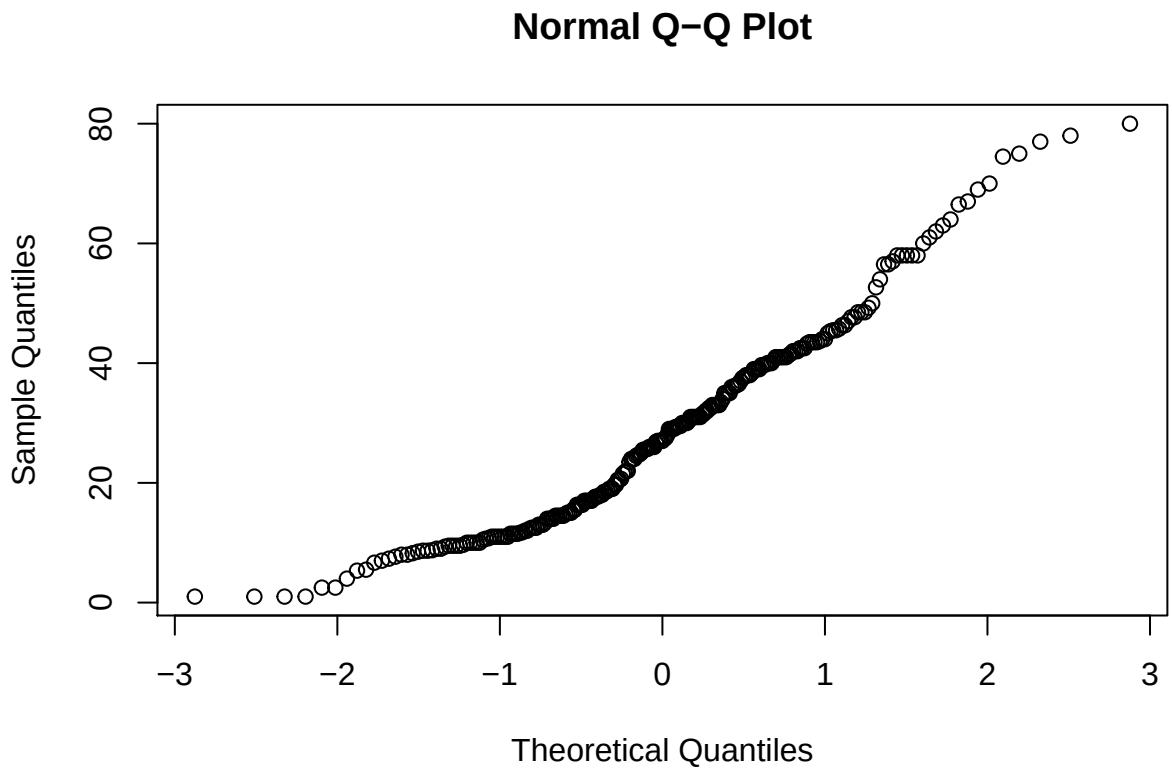
```
# weibull
```

UMBS PLOT LEVEL GROWTH HABIT - Looking at DURATION of flowering

```
### KBS ###
hist(umbs_flwr_plot_growthhabit$flwr_duration_scaled)
```



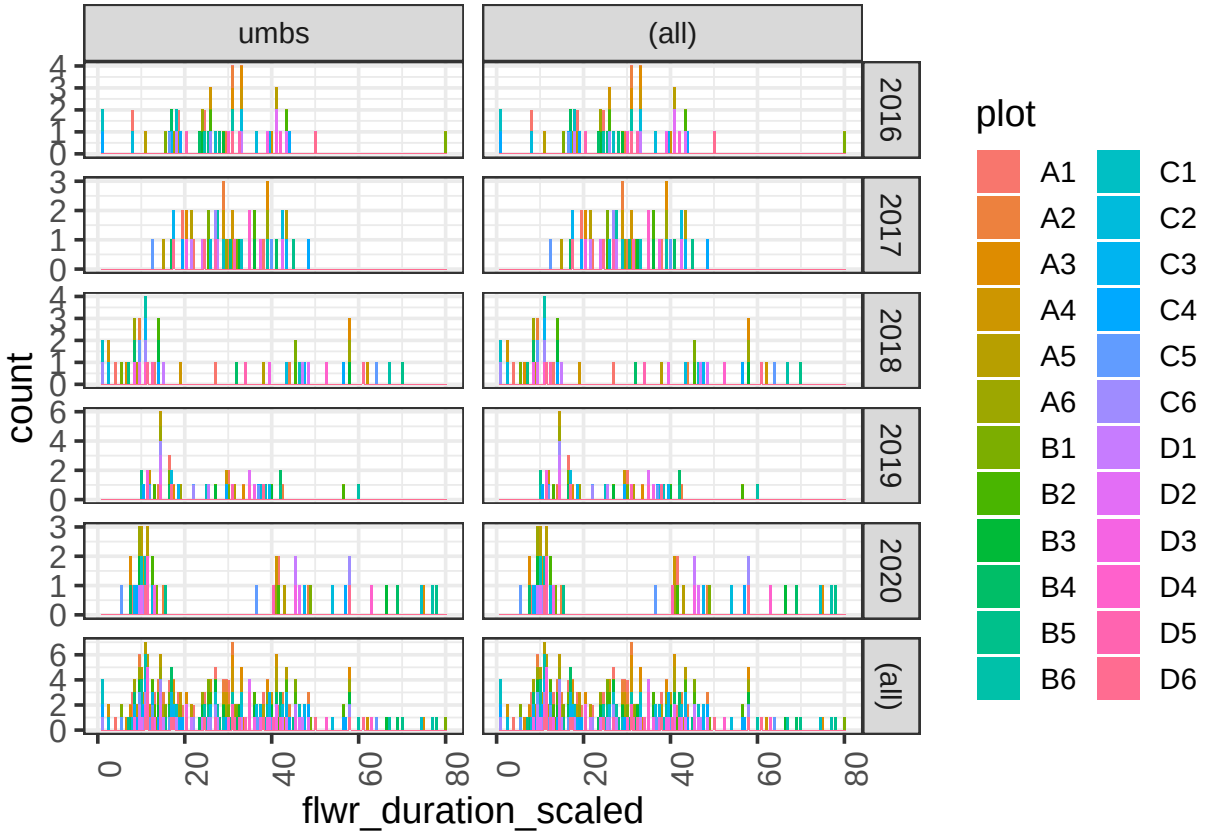

```
qqnorm(umbs_flwr_plot_growthhabit$flwr_duration_scaled)
```



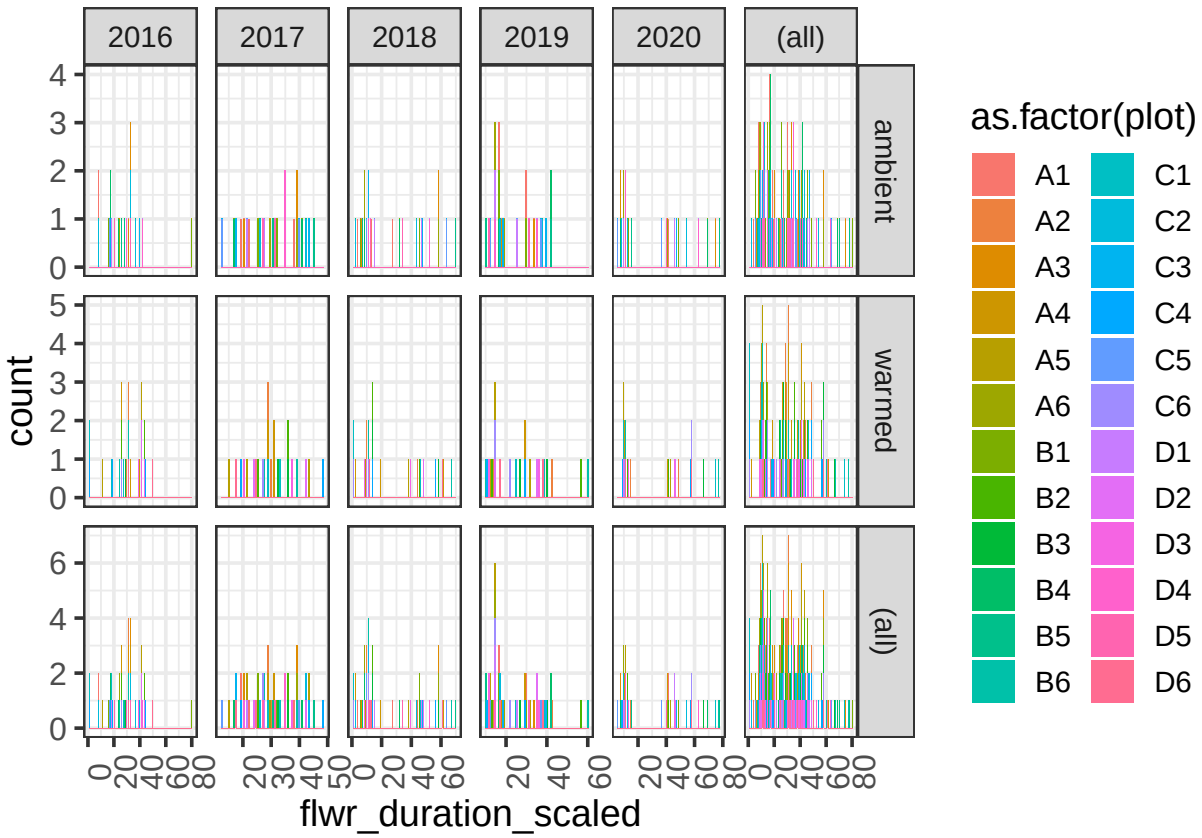
```
shapiro.test(umbs_flwr_plot_growthhabit$flwr_duration_scaled)  # pvalue is < 0.05 so we reject the null
```

```
##
##  Shapiro-Wilk normality test
##
## data:  umbs_flwr_plot_growthhabit$flwr_duration_scaled
## W = 0.95215, p-value = 2.605e-07
```

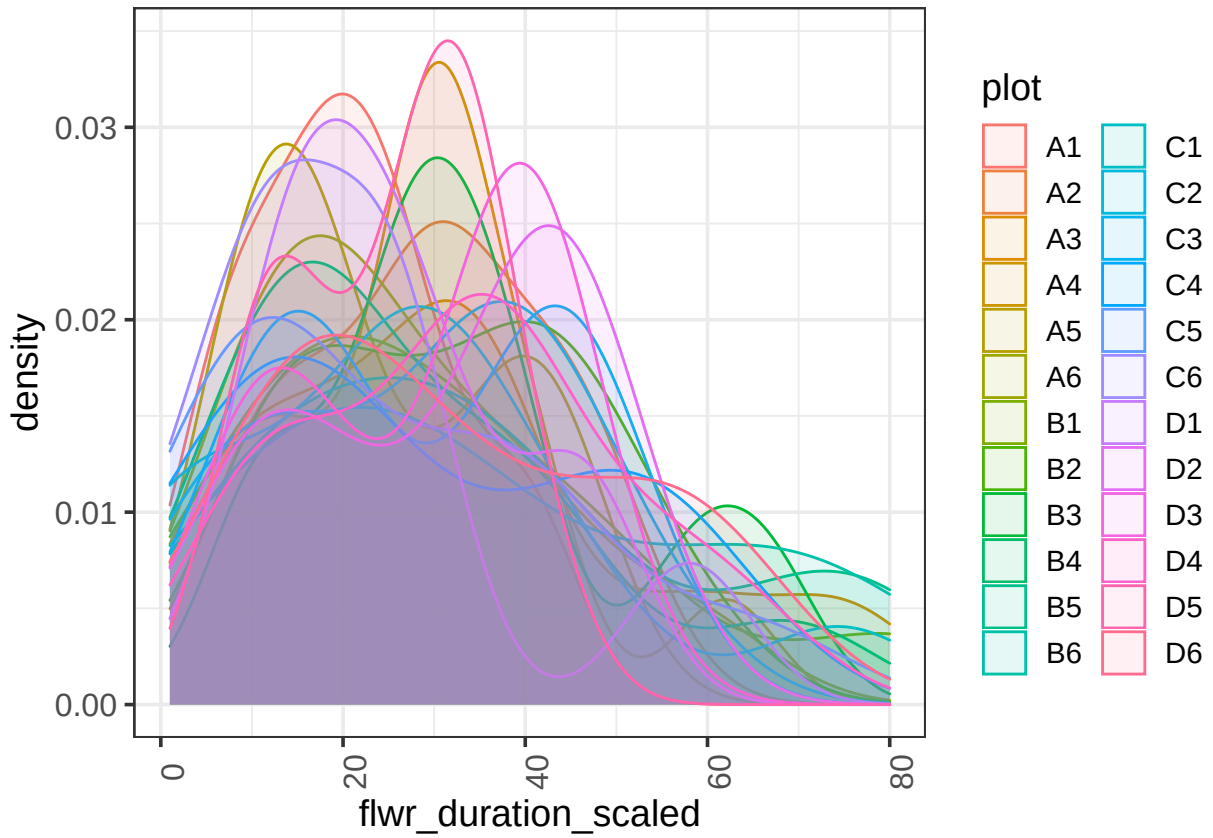
```
# Visualizing median Julian date for umbs at the PLOT LEVEL
ggplot(umbs_flwr_plot_growthhabit, aes(flwr_duration_scaled, fill = plot)) + geom_histogram(binwidth = 
    facet_grid(year ~ site, margins = TRUE, scales = "free")
```



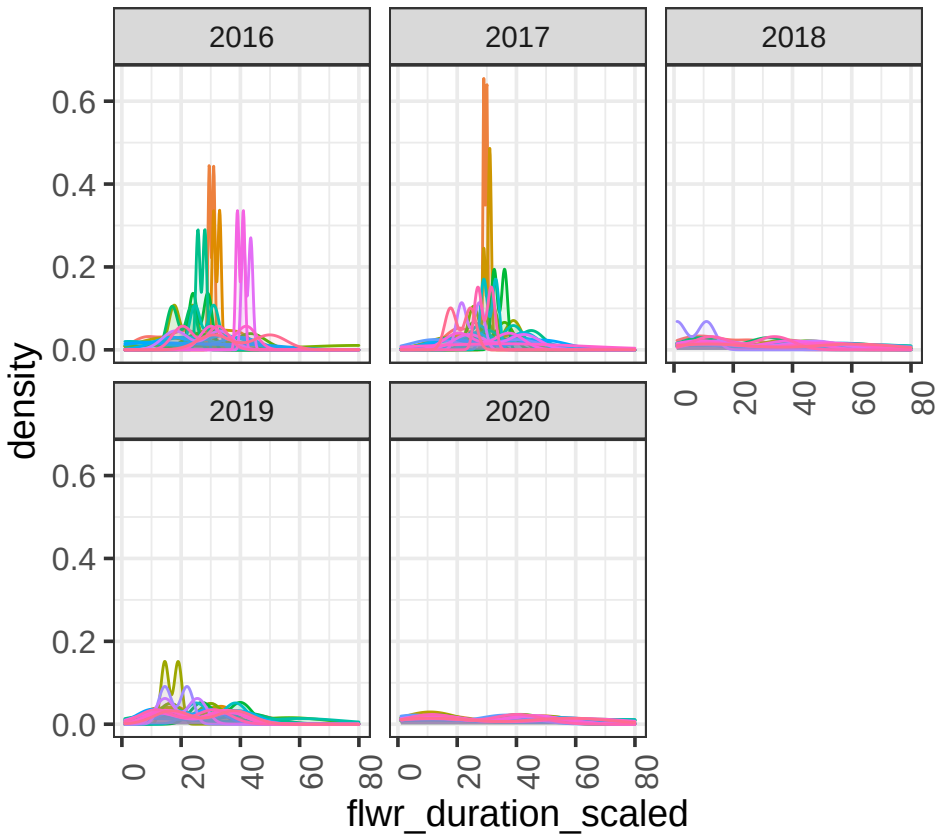

```
ggplot(umbs_flwr_plot_growthhabit, aes(flwr_duration_scaled, fill = as.factor(plot))) +
    geom_histogram(binwidth = 0.5) + facet_grid(state ~ year, margins = TRUE, scales = "free")
```



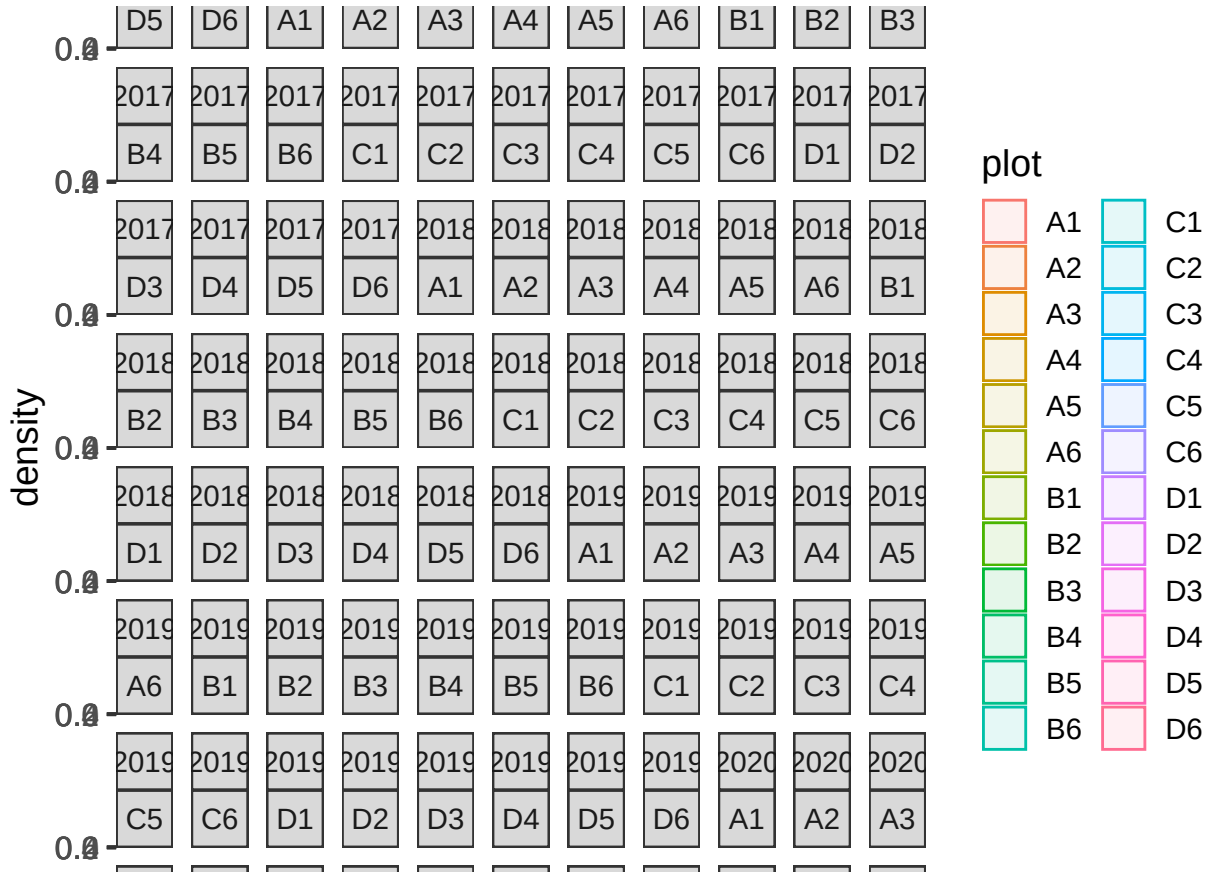

```
ggplot(umbs_flwr_plot_growthhabit, aes(flwr_duration_scaled, fill = plot, color = plot)) +
    geom_density(alpha = 0.1)
```



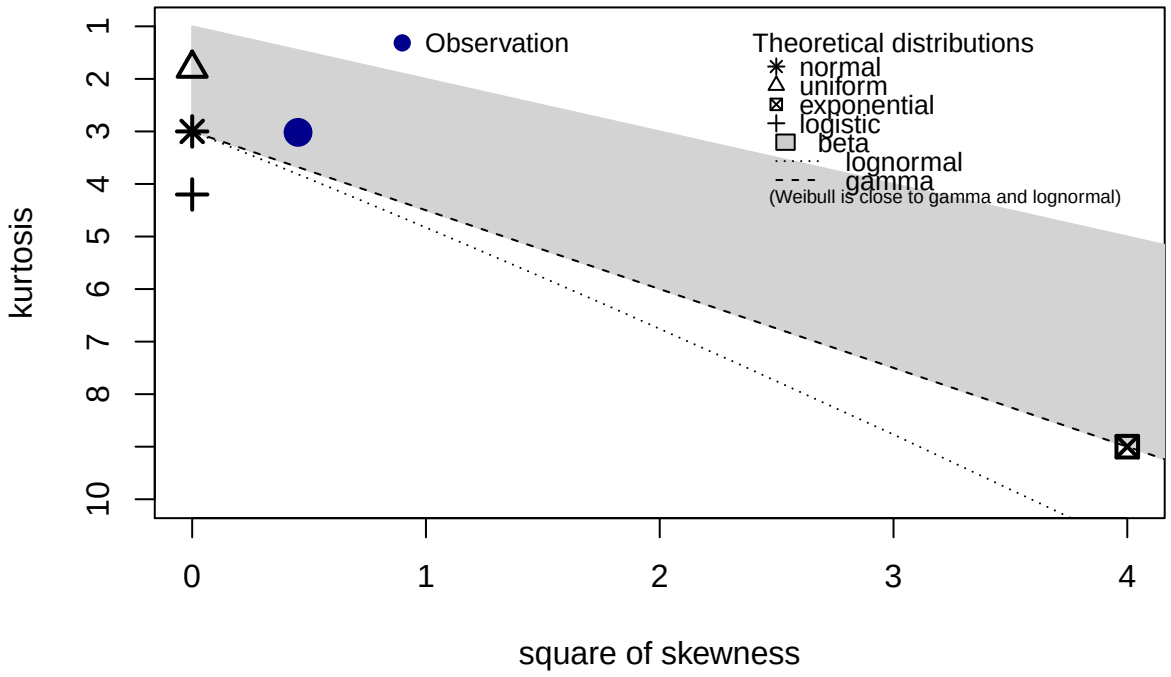

```
ggplot(umbs_flwr_plot_growthhabit, aes(flwr_duration_scaled, fill = plot, color = plot)) +
    geom_density(alpha = 0.1) + facet_wrap(~year)
```




```
ggplot(umbs_flwr_plot_growthhabit, aes(flwr_duration_scaled, fill = plot, color = plot)) +
    geom_density(alpha = 0.1) + facet_wrap(~year + plot)
```

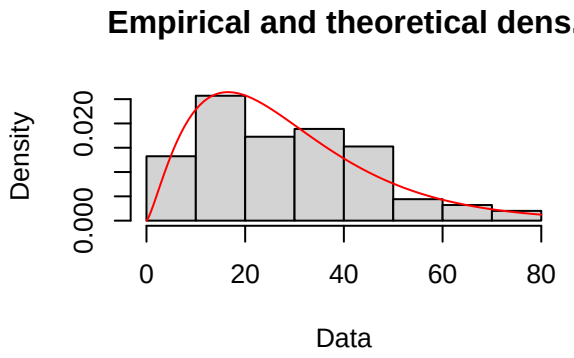


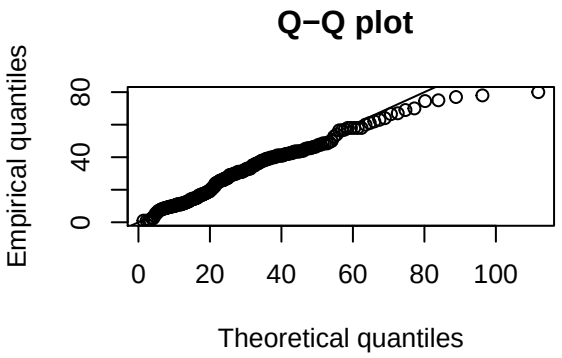

```
# Exploring distributions for these data:
descdist(umbs_flwr_plot_growthhabit$flwr_duration_scaled, discrete = FALSE)
```

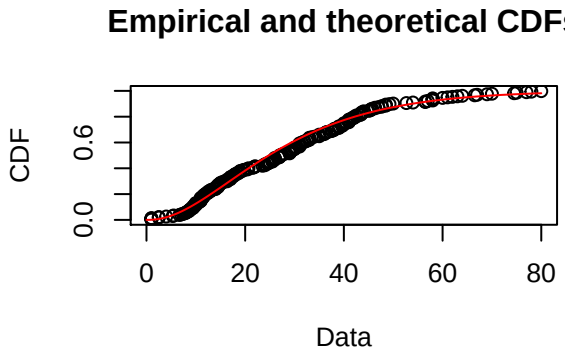


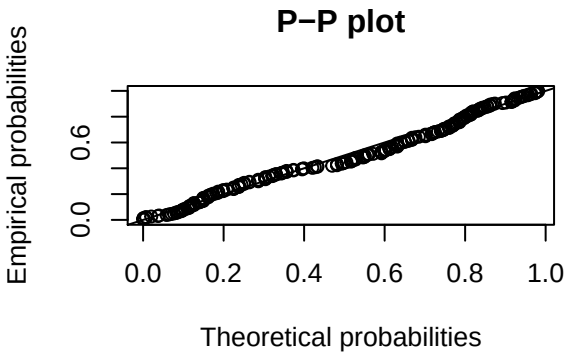

```
## summary statistics
## ------
## min:  1   max:  80
## median:  27
## mean:  28.73367
## estimated sd:  17.11158
## estimated skewness:  0.6729593
## estimated kurtosis:  3.017893
```

```
# none of these work below and idk why Gamma distribution
fit.gamma <- fitdist(umbs_flwr_plot_growthhabit$flwr_duration_scaled, "gamma")
plot(fit.gamma)
```

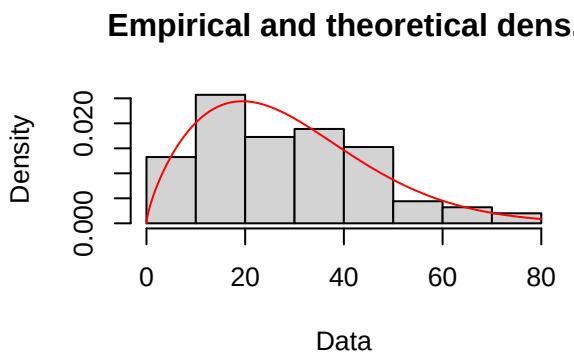


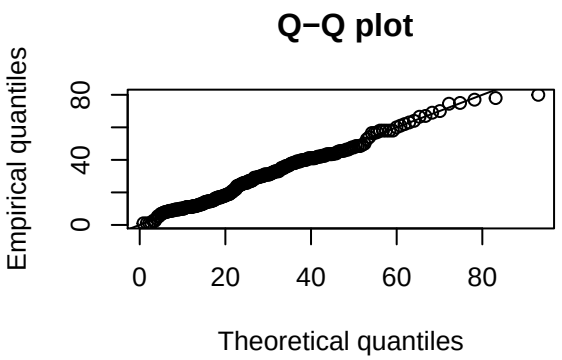


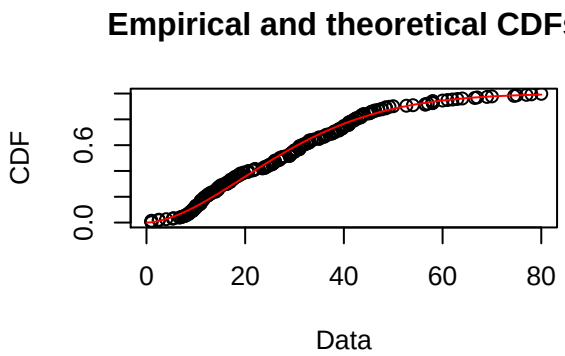


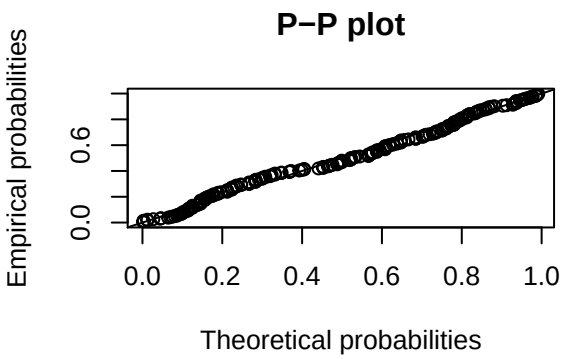



```
# Weibull distribution
fit.weibull <- fitdist(umbs_flwr_plot_growthhabit$flwr_duration_scaled, "weibull")
plot(fit.weibull)
```

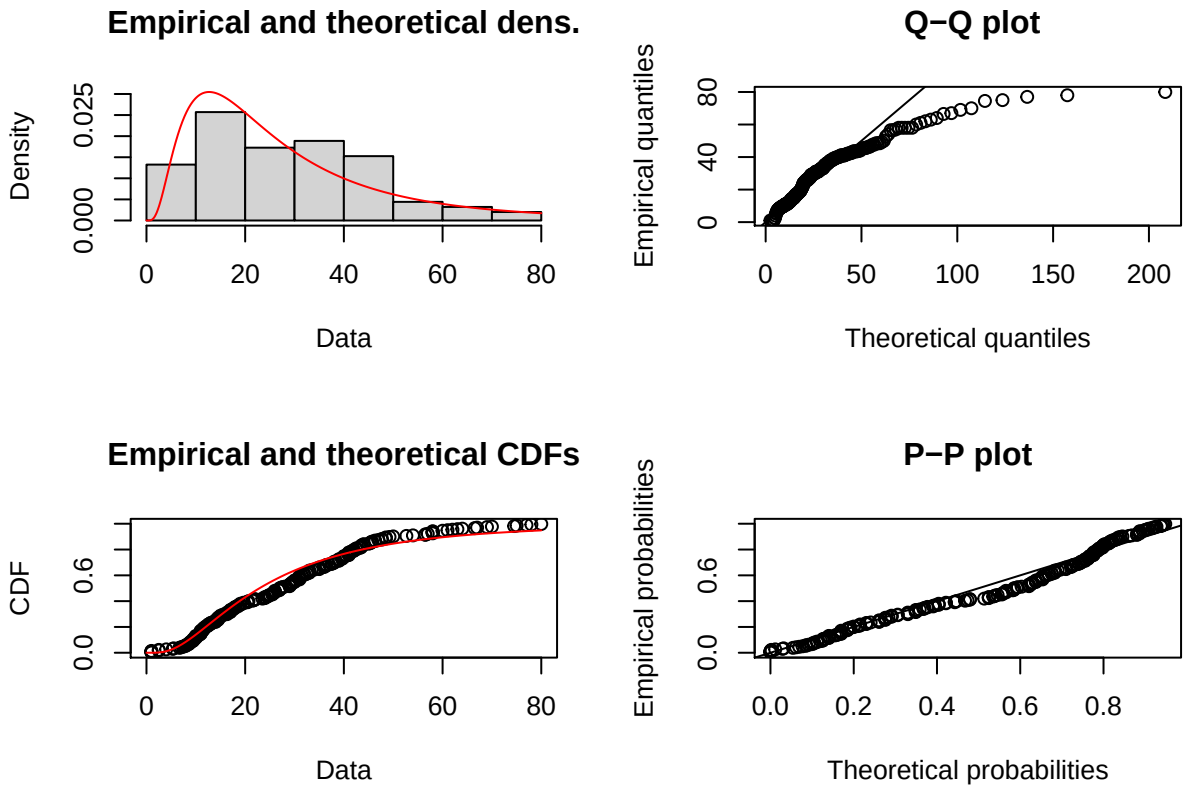




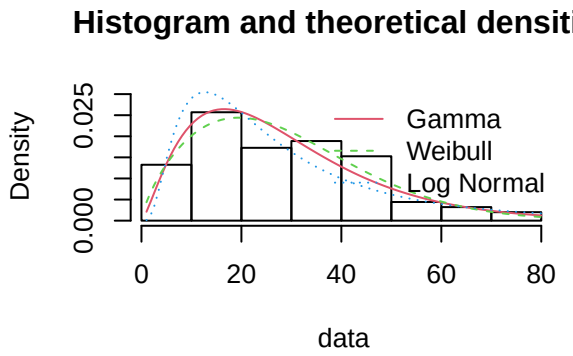


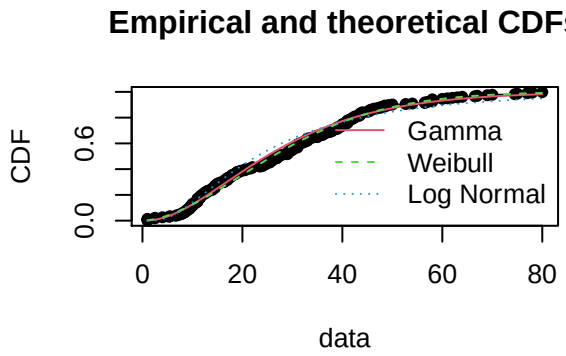


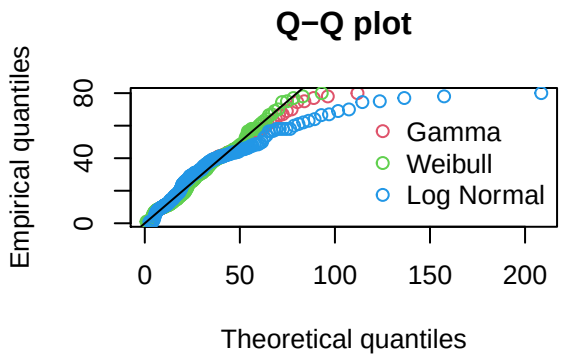
```r
# Lognormal distribution
fit.ln <- fitdist(umbs_flwr_plot_growthhabit$flwr_duration_scaled, "lnorm")
plot(fit.ln)
```

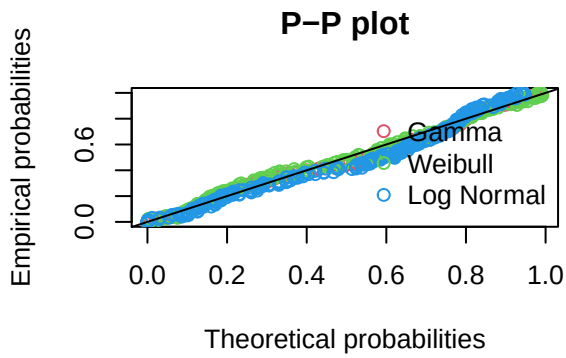



```r
par(mfrow = c(2, 2))
plot.legend <- c("Gamma", "Weibull", "Log Normal")
denscomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
cdfcomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
qqcomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
ppcomp(list(fit.gamma, fit.weibull, fit.ln), legendtext = plot.legend)
```










```
# Goodness of fit comparisons across fits (can't include the log normal bc it
# becomes diff response values)
gofstat(list(fit.gamma, fit.weibull, fit.ln), fitnames = c("Gamma", "Weibull", "Log Normal"))
```

```
## Goodness-of-fit statistics
##                                 Gamma    Weibull Log Normal
## Kolmogorov-Smirnov statistic 0.07811737 0.05364025  0.1068128
## Cramer-von Mises statistic   0.27856859 0.18481059  0.6128336
## Anderson-Darling statistic   1.59467921 1.10749869  3.9839635
##
## Goodness-of-fit criteria
##                                 Gamma  Weibull Log Normal
## Akaike's Information Criterion 2091.435 2083.161   2138.317
## Bayesian Information Criterion 2098.470 2090.196   2145.352
```

```
# weibull
```

Leverage plots and detecting Outliers. https://www.statmethods.net/stats/rdiagnostics.html

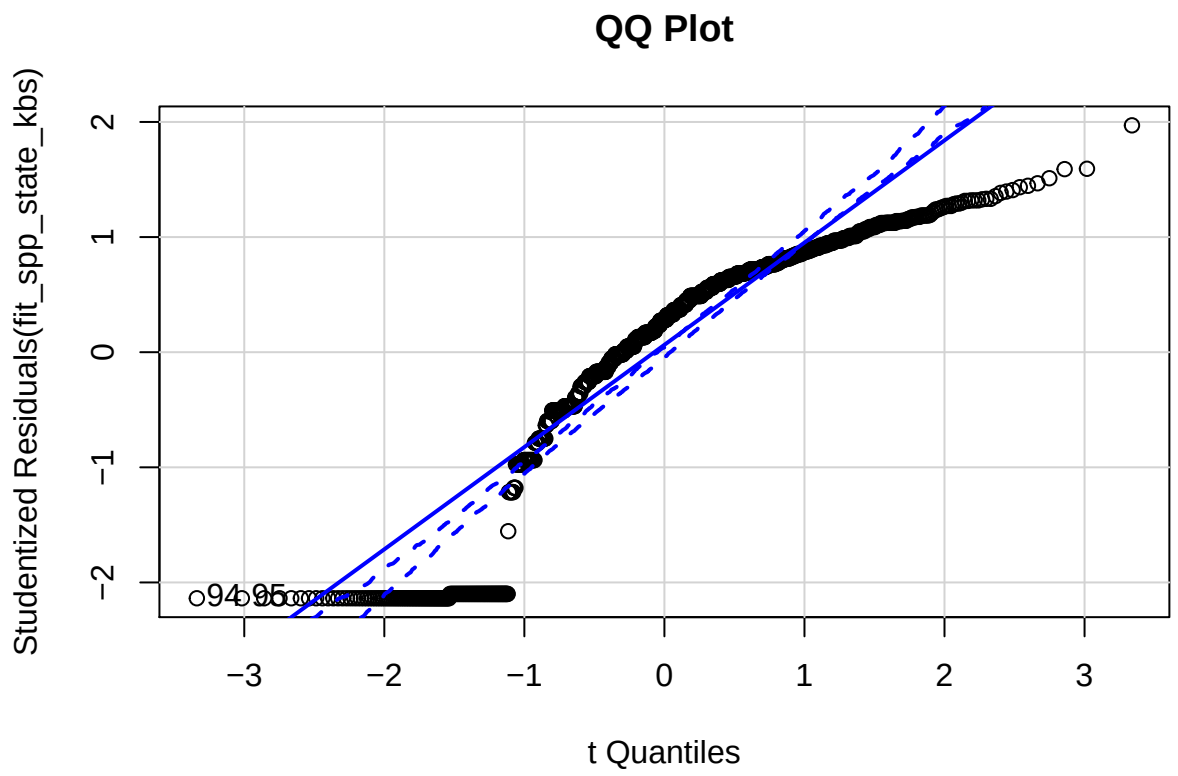
These illustrate whether certain data points have more leverage (more influence), and thus could be outliers. It's a way of detecting outliers. Leverage plots can help identify whether a point has high or low influence, based on its leverage and residual and determining model fit with and without the point in question. Ultimately you decide whether the points are outliers or not, based on the knowledge of the system and how much it changes the model when included vs. excluded from the data used to fit the model. Here is a good overview of the combination of leverage and residual: scroll down to sections beginning at "13.3 Unusual Observations": https://daviddalpiaz.github.io/appliedstats/model-diagnostics.html

KBS

```
# species level data KBS State-only model
fit_spp_state_kbs <- lm(log(flwr_duration_scaled) ~ state, data = kbs_flwr_spp)
outlierTest(fit_spp_state_kbs)  # no outliers
```

```
## No Studentized residuals with Bonferroni p < 0.05
## Largest |rstudent|:
##    rstudent unadjusted p-value Bonferroni p
## 94 -2.13733           0.032782           NA
```

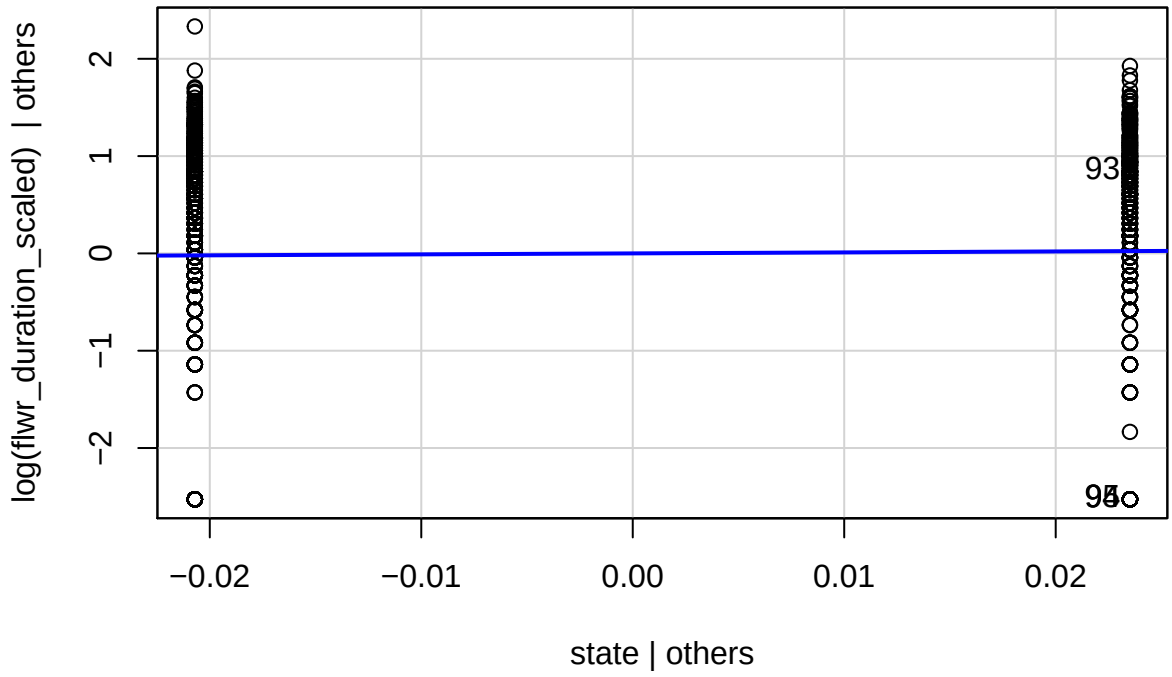
```
qqPlot(fit_spp_state_kbs, main = "QQ Plot")
```




```
## 94 95
## 54 55
```

```
hist(fit_spp_state_kbs$residuals)
```

```r
leveragePlots(fit_spp_state_kbs)
```




```r
ols_test_normality(fit_spp_state_kbs)
```

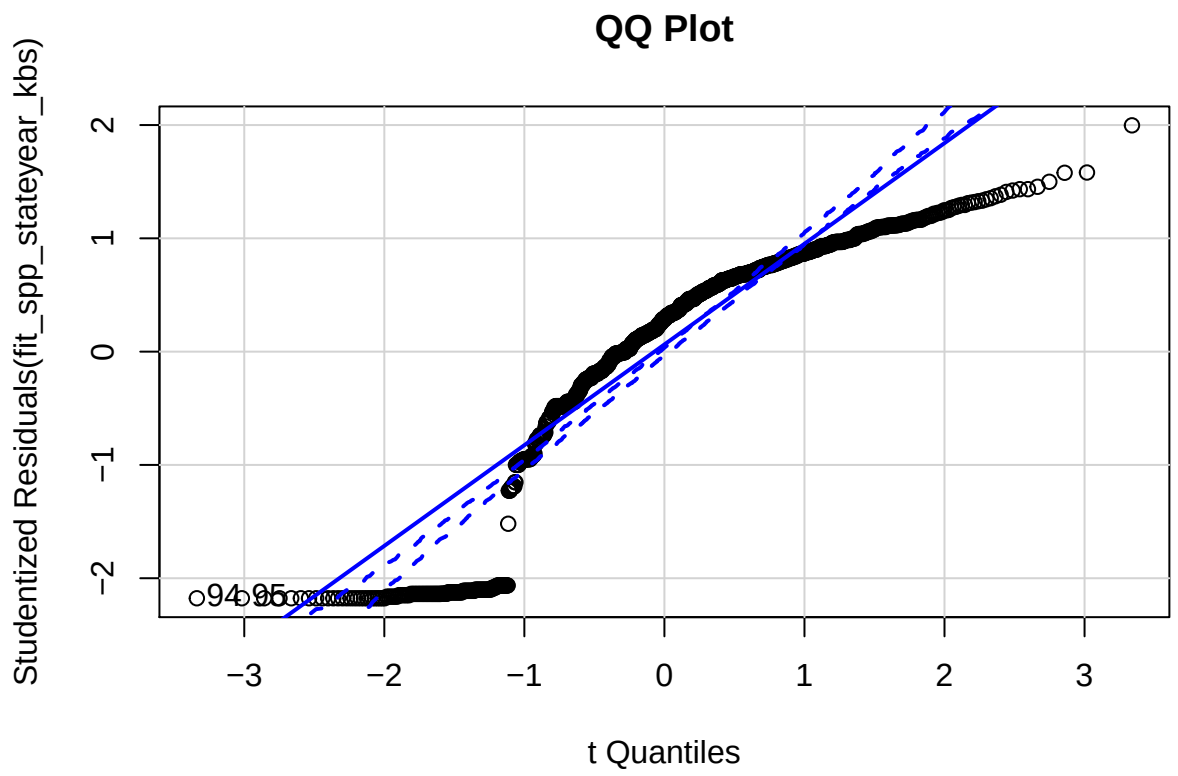
```
## Warning in ks.test(y, "pnorm", mean(y), sd(y)): ties should not be present for
## the Kolmogorov-Smirnov test
```

```
## -----------------------------------------------
##        Test             Statistic       pvalue
## -----------------------------------------------
## Shapiro-Wilk              0.868          0.0000
## Kolmogorov-Smirnov        0.1304         0.0000
## Cramer-von Mises         38.2293         0.0000
## Anderson-Darling         51.5221         0.0000
## -----------------------------------------------
```

```r
# KBS State and year model
fit_spp_stateyear_kbs <- lm(log(flwr_duration_scaled) ~ state + year_factor, data = kbs_flwr_spp)
outlierTest(fit_spp_stateyear_kbs)  # no outliers
```

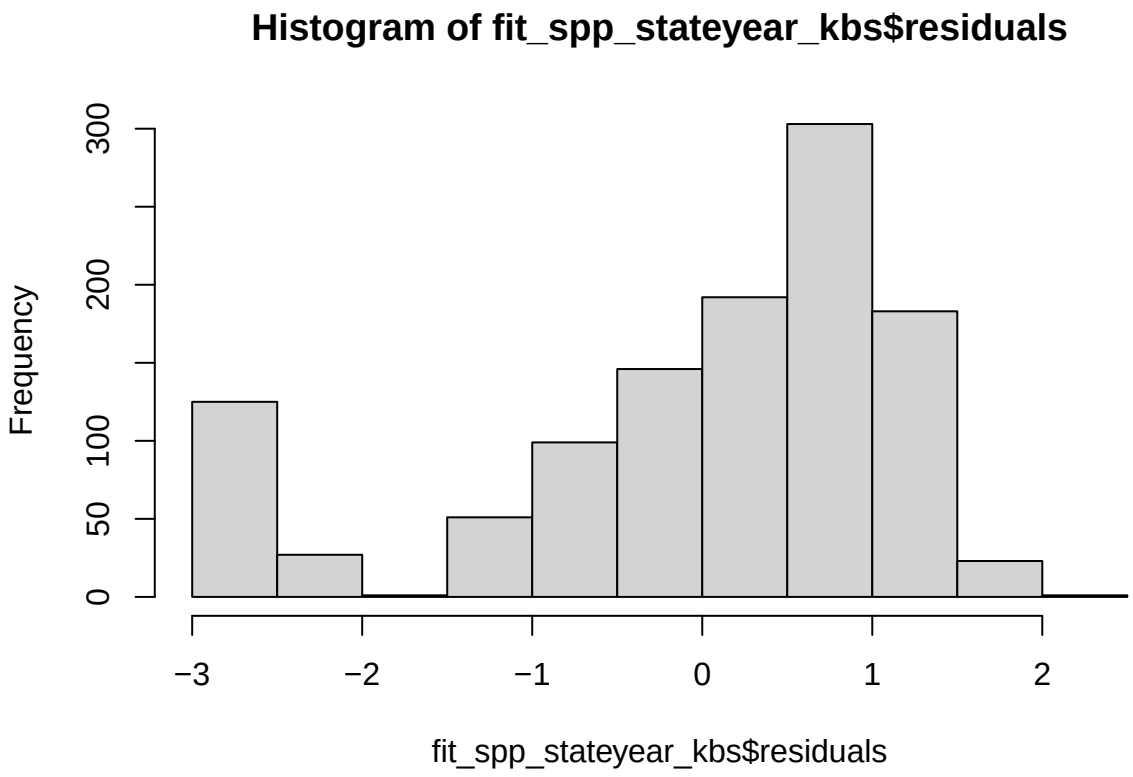
```
## No Studentized residuals with Bonferroni p < 0.05
## Largest |rstudent|:
##     rstudent unadjusted p-value Bonferroni p
## 94 -2.176698           0.029707           NA
```

```r
qqPlot(fit_spp_stateyear_kbs, main = "QQ Plot")
```

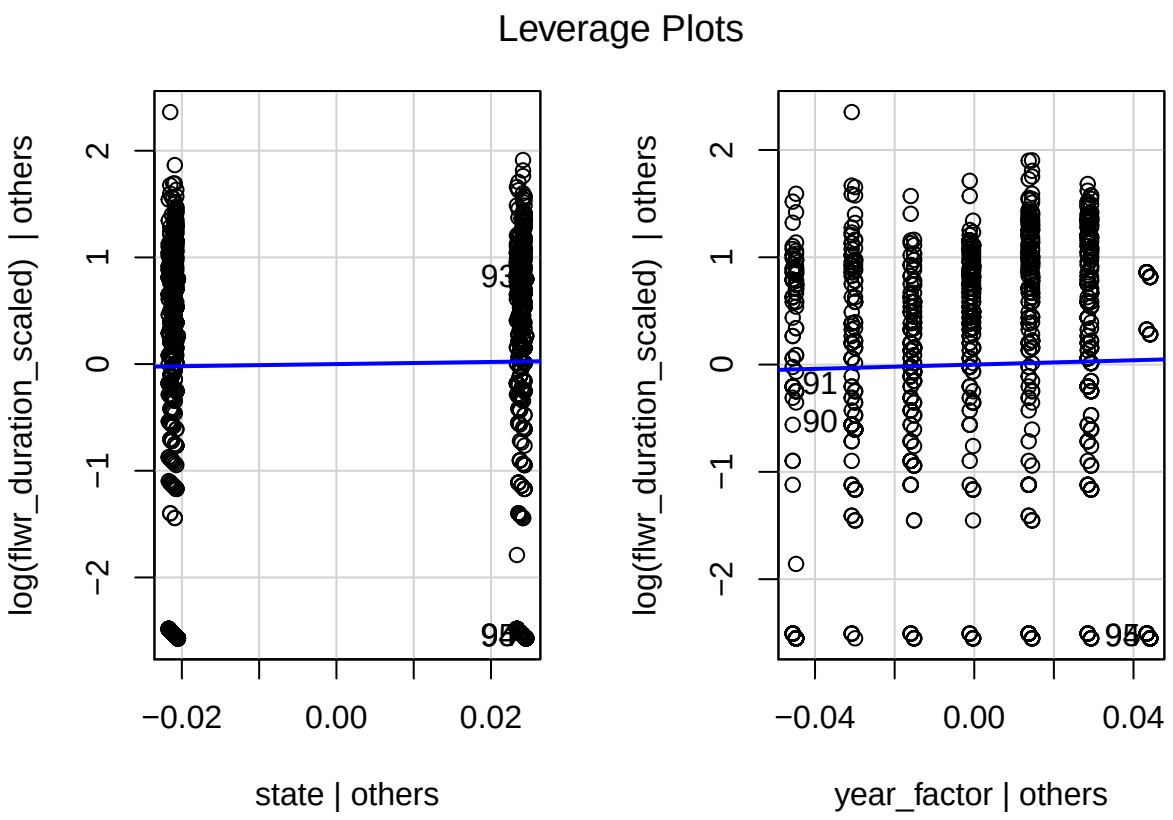



```
## 94 95
## 54 55
```

```
hist(fit_spp_stateyear_kbs$residuals)
```



```
leveragePlots(fit_spp_stateyear_kbs)
```




```
ols_test_normality(fit_spp_stateyear_kbs)
```

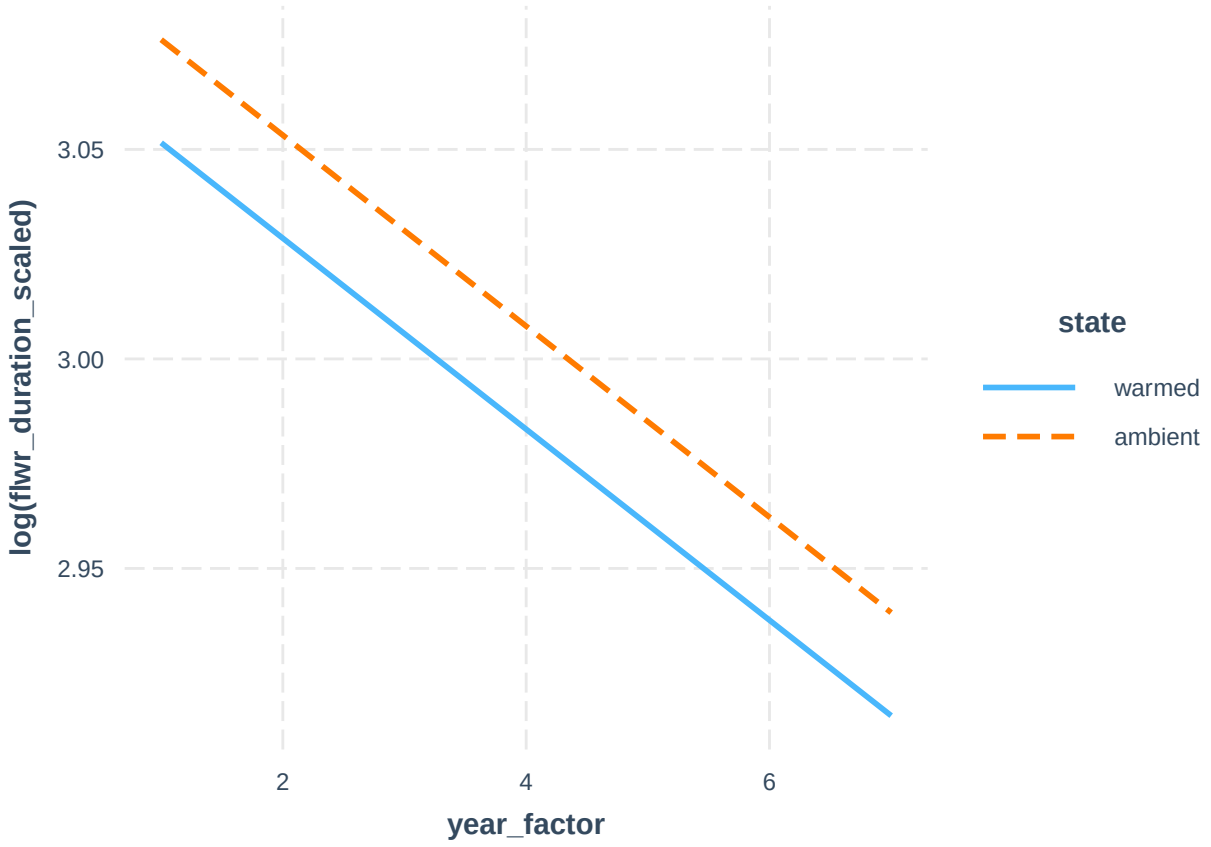
```
## Warning in ks.test(y, "pnorm", mean(y), sd(y)): ties should not be present for
## the Kolmogorov-Smirnov test
```

```
## -----------------------------------------------
##        Test             Statistic       pvalue
## -----------------------------------------------
## Shapiro-Wilk              0.8674         0.0000
## Kolmogorov-Smirnov        0.1297         0.0000
## Cramer-von Mises         38.3089         0.0000
## Anderson-Darling         52.0009         0.0000
## -----------------------------------------------
```

```
# Interaction plot (ignore for now the repeated measures with species); see:
# https://cran.r-project.org/web/packages/interactions/vignettes/interactions.html
# and: https://interactions.jacob-long.com/

fit3 <- lm(log(flwr_duration_scaled) ~ state + year_factor + species, data = kbs_flwr_spp)
interact_plot(fit3, pred = year_factor, modx = state)
```

```
## Using data kbs_flwr_spp from global environment. This could cause incorrect
## results if kbs_flwr_spp has been altered since the model was fit. You can
## manually provide the data to the "data =" argument.
```

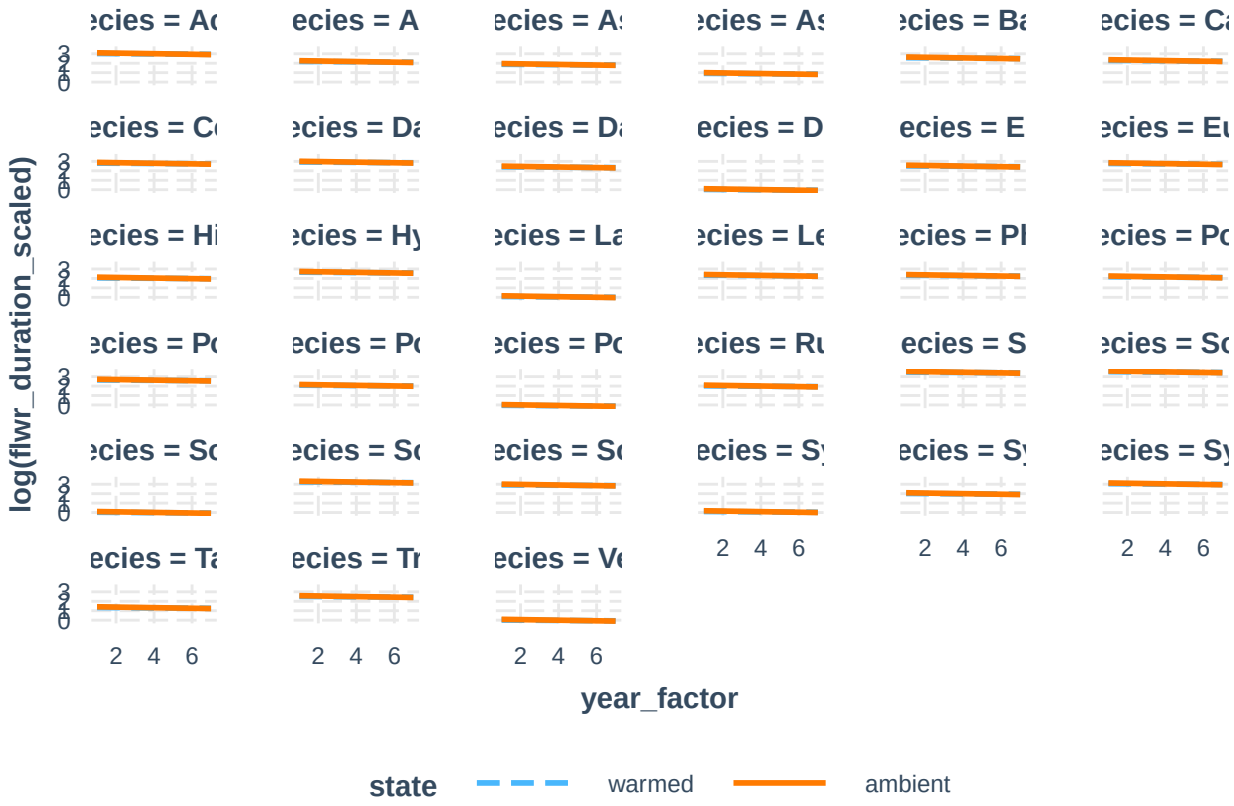
```
## Warning: year_factor and state are not included in an interaction with one another
## in the model.
```




```
fit4 <- lm(log(flwr_duration_scaled) ~ state * year_factor + species, data = kbs_flwr_spp)
interact_plot(fit4, pred = year_factor, modx = state, mod2 = species)
```

```
## Using data kbs_flwr_spp from global environment. This could cause incorrect
## results if kbs_flwr_spp has been altered since the model was fit. You can
## manually provide the data to the "data =" argument.
```

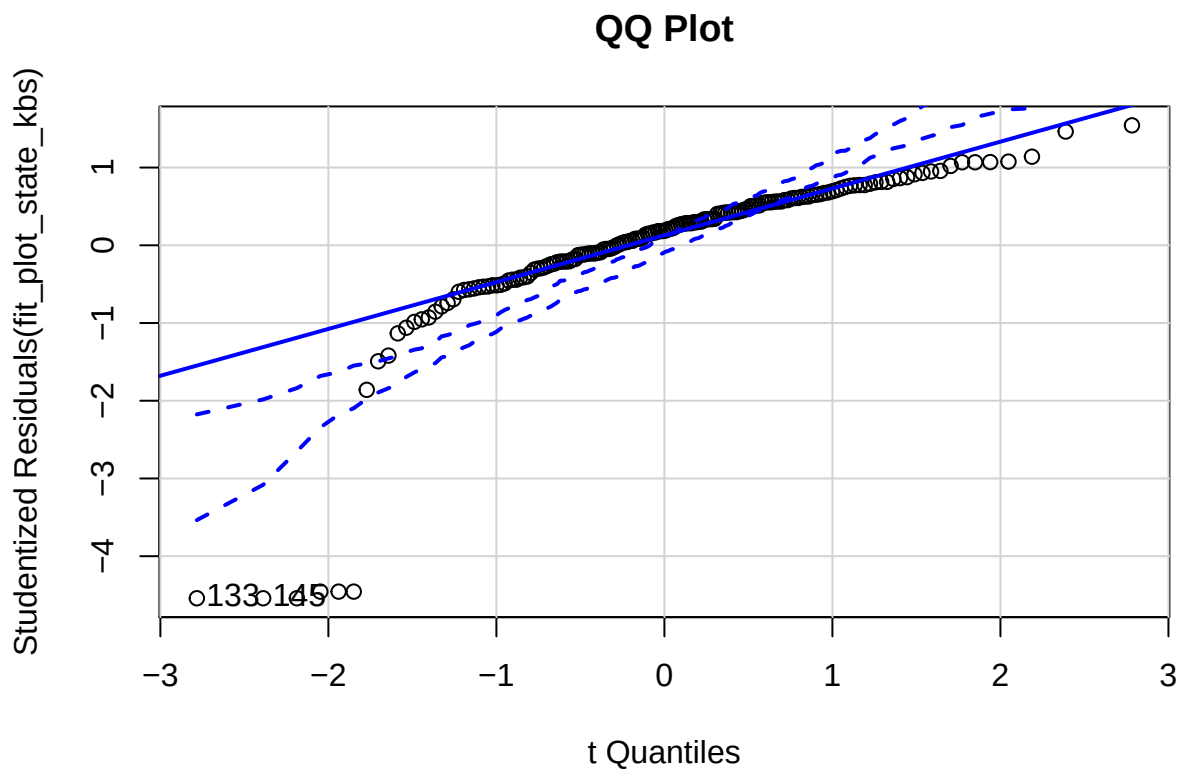
```
## Warning: year_factor and state and species are not included in an interaction with
## one another in the model.
```




```
# Plot level data KBS State-only model
fit_plot_state_kbs <- lm(log(flwr_duration_scaled) ~ state, data = kbs_flwr_plot)
outlierTest(fit_plot_state_kbs)  # outliers
```

```
##      rstudent unadjusted p-value Bonferroni p
## 133 -4.540917         1.0840e-05    0.0017995
## 145 -4.540917         1.0840e-05    0.0017995
## 205 -4.540917         1.0840e-05    0.0017995
## 109 -4.455768         1.5476e-05    0.0025691
## 193 -4.455768         1.5476e-05    0.0025691
## 253 -4.455768         1.5476e-05    0.0025691
```

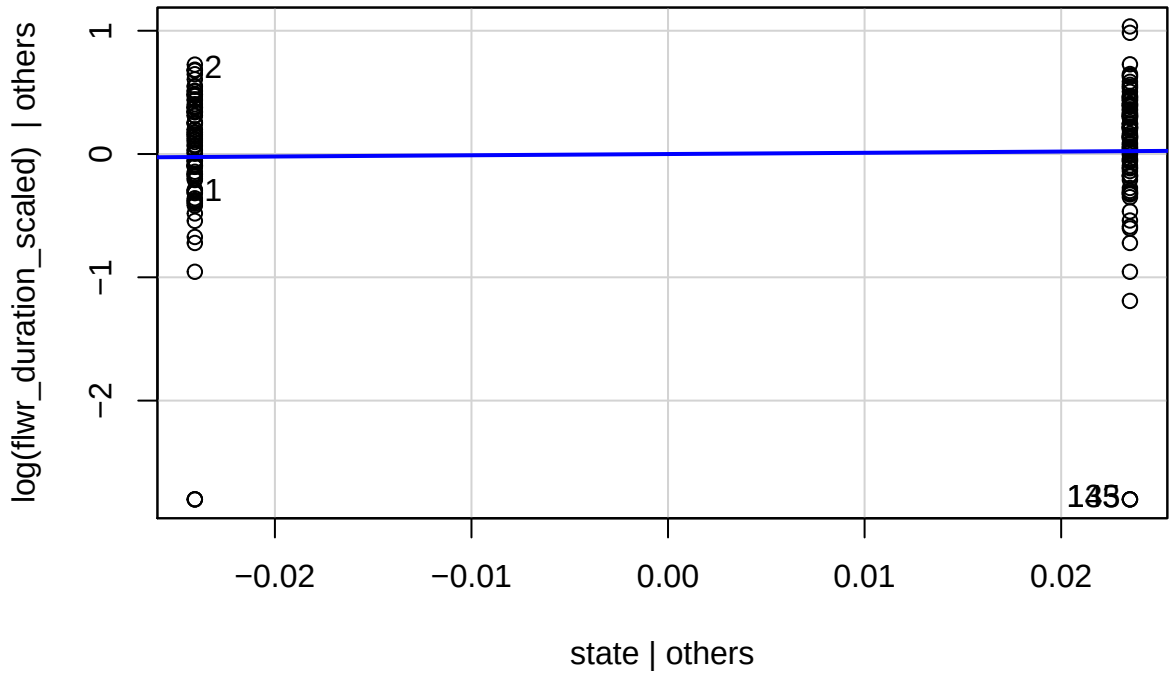
```
qqPlot(fit_plot_state_kbs, main = "QQ Plot")
```




```
## 133 145
##  78  85
```

```
hist(fit_plot_state_kbs$residuals)
```

```r
leveragePlots(fit_plot_state_kbs)
```




```r
ols_test_normality(fit_plot_state_kbs)  # looks ok besides Kolmogorov-Smirnov test
```

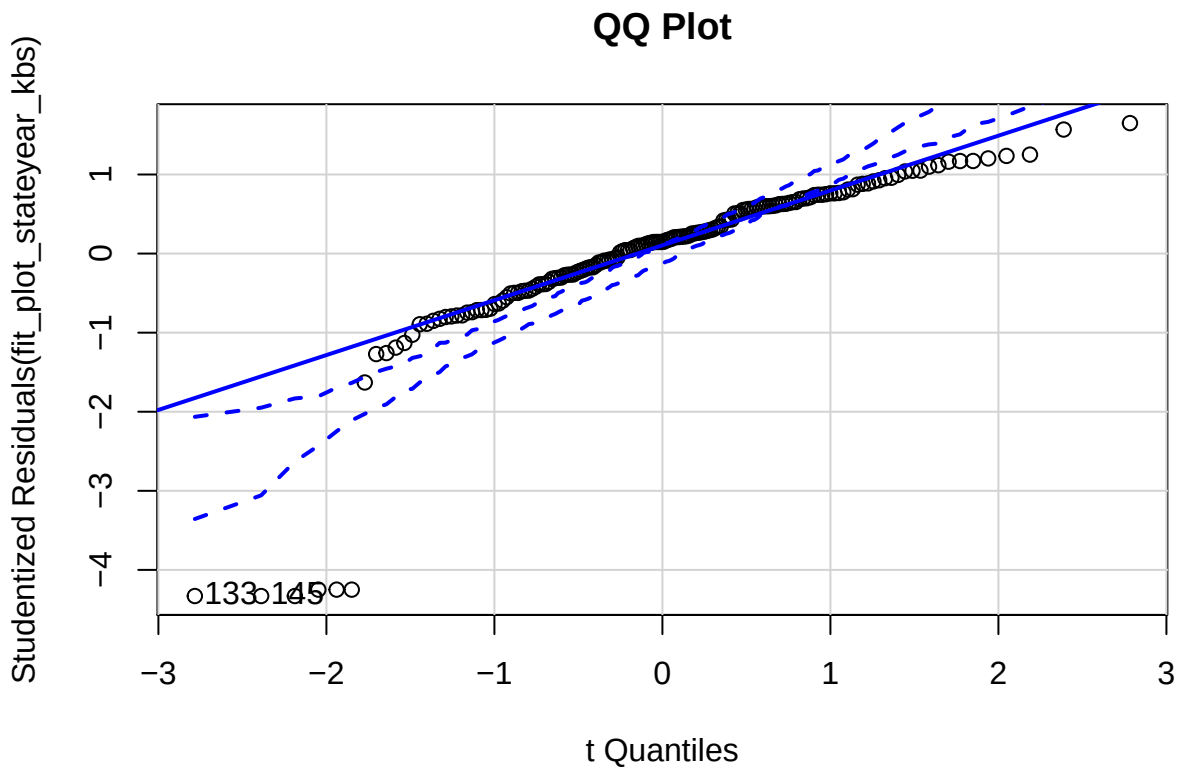
```
## Warning in ks.test(y, "pnorm", mean(y), sd(y)): ties should not be present for
## the Kolmogorov-Smirnov test
```

```
## -----------------------------------------------
##        Test             Statistic       pvalue
## -----------------------------------------------
## Shapiro-Wilk              0.7219         0.0000
## Kolmogorov-Smirnov        0.1684          2e-04
## Cramer-von Mises         16.6029         0.0000
## Anderson-Darling         10.5052         0.0000
## -----------------------------------------------
```

```r
# KBS State and year model
fit_plot_stateyear_kbs <- lm(log(flwr_duration_scaled) ~ state + year_factor, data = kbs_flwr_plot)
outlierTest(fit_plot_stateyear_kbs)  # outliers
```

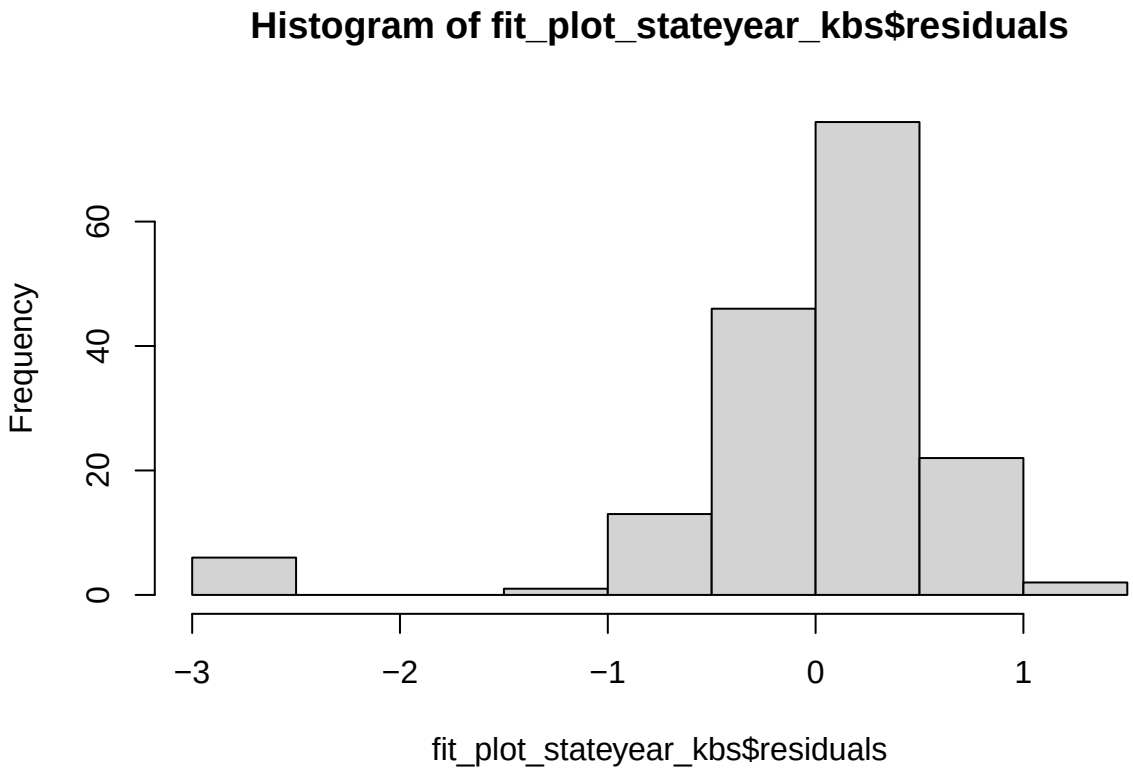
```
##      rstudent unadjusted p-value Bonferroni p
## 133 -4.330288         2.6012e-05    0.0043179
## 145 -4.330288         2.6012e-05    0.0043179
## 205 -4.330288         2.6012e-05    0.0043179
## 109 -4.249572         3.6045e-05    0.0059834
## 193 -4.249572         3.6045e-05    0.0059834
## 253 -4.249572         3.6045e-05    0.0059834
```

```r
qqPlot(fit_plot_stateyear_kbs, main = "QQ Plot")
```

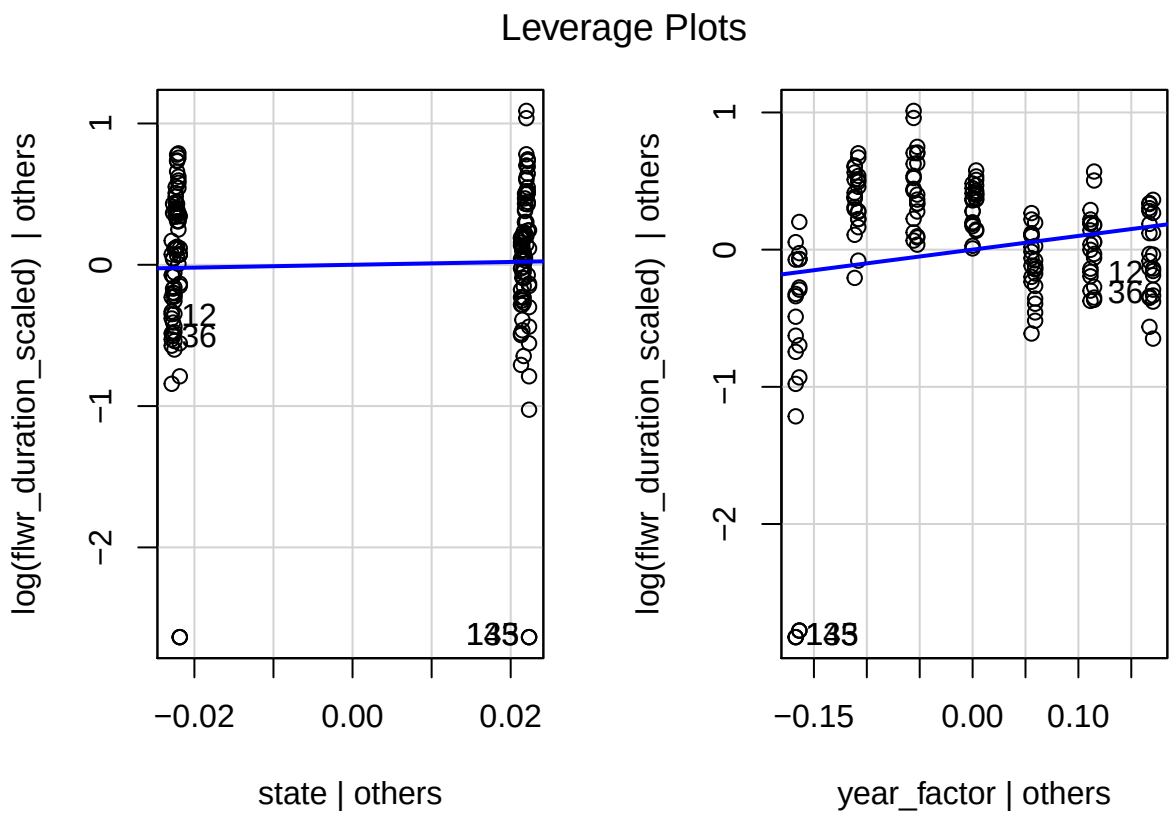



```
## 133 145
##  78  85
```

```r
hist(fit_plot_stateyear_kbs$residuals)
```




```
leveragePlots(fit_plot_stateyear_kbs)
```



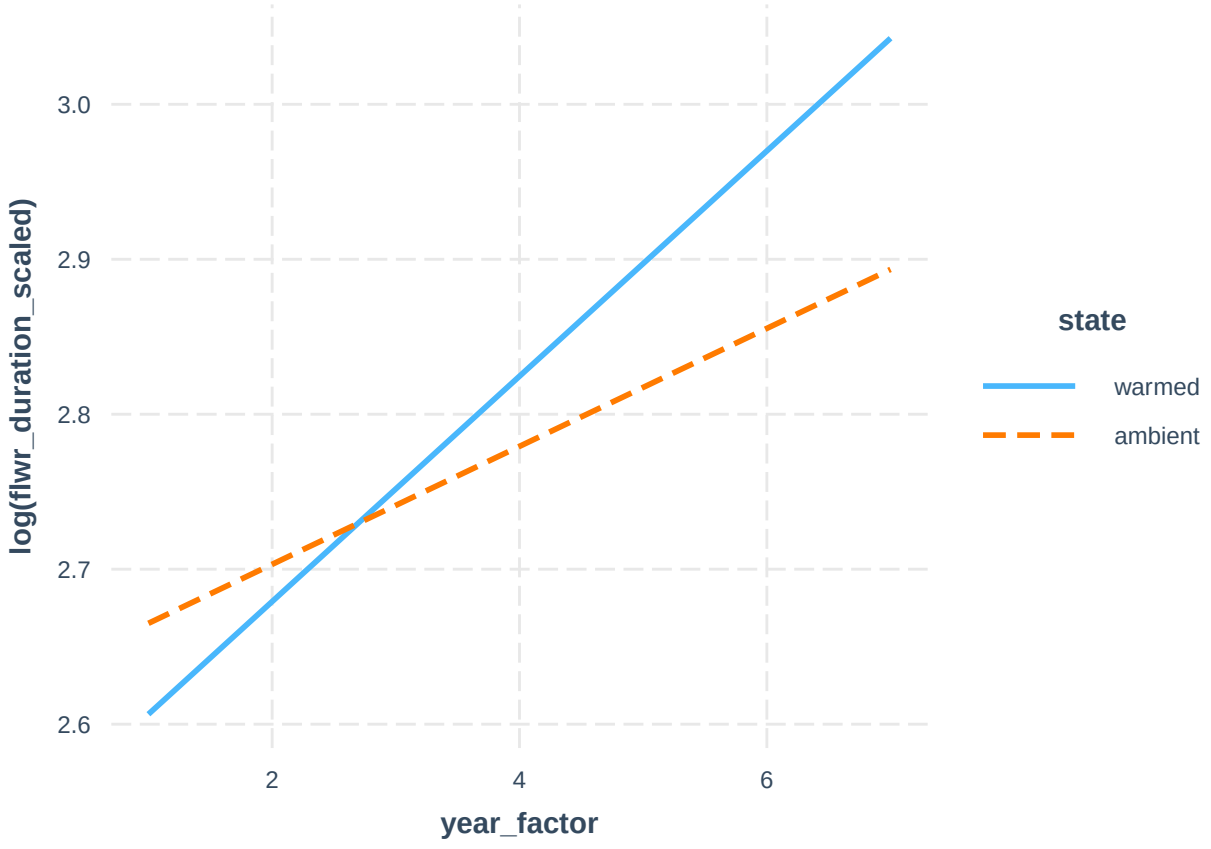
```
ols_test_normality(fit_plot_stateyear_kbs)  # a couple tests say not normal
```

```
## Warning in ks.test(y, "pnorm", mean(y), sd(y)): ties should not be present for
## the Kolmogorov-Smirnov test
```

```
## -----------------------------------------------
##        Test             Statistic       pvalue
## -----------------------------------------------
## Shapiro-Wilk              0.7854         0.0000
## Kolmogorov-Smirnov        0.1272         0.0093
## Cramer-von Mises         15.8138         0.0000
## Anderson-Darling          7.0546         0.0000
## -----------------------------------------------
```

```
# Interaction plot (ignore for now the repeated measures with species); see:
# https://cran.r-project.org/web/packages/interactions/vignettes/interactions.html
# and: https://interactions.jacob-long.com/

fit3 <- lm(log(flwr_duration_scaled) ~ state * year_factor, data = kbs_flwr_plot)
interact_plot(fit3, pred = year_factor, modx = state)  # this looks very strange to me
```

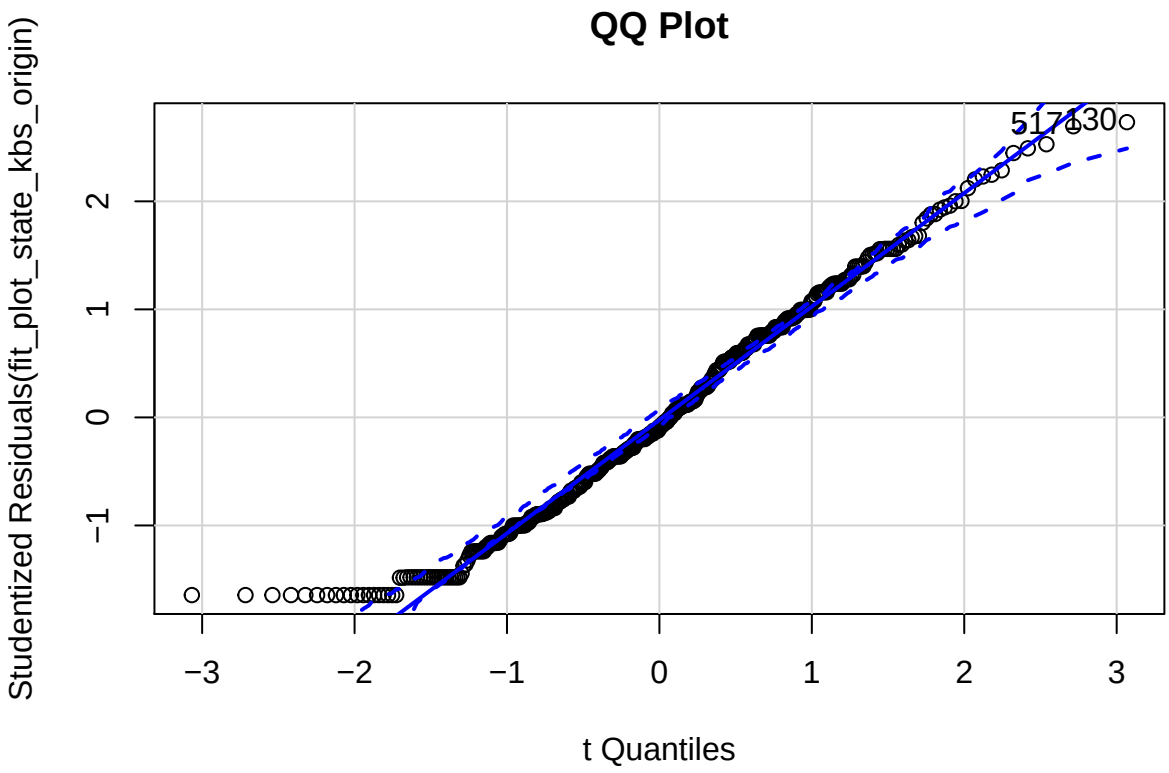
```
## Using data kbs_flwr_plot from global environment. This could cause
## incorrect results if kbs_flwr_plot has been altered since the model was
## fit. You can manually provide the data to the "data =" argument.
```



```r
# Plot level ORIGIN data KBS State-only model
fit_plot_state_kbs_origin <- lm(flwr_duration_scaled ~ state, data = kbs_flwr_plot_origin)
outlierTest(fit_plot_state_kbs_origin)  # no outliers
```

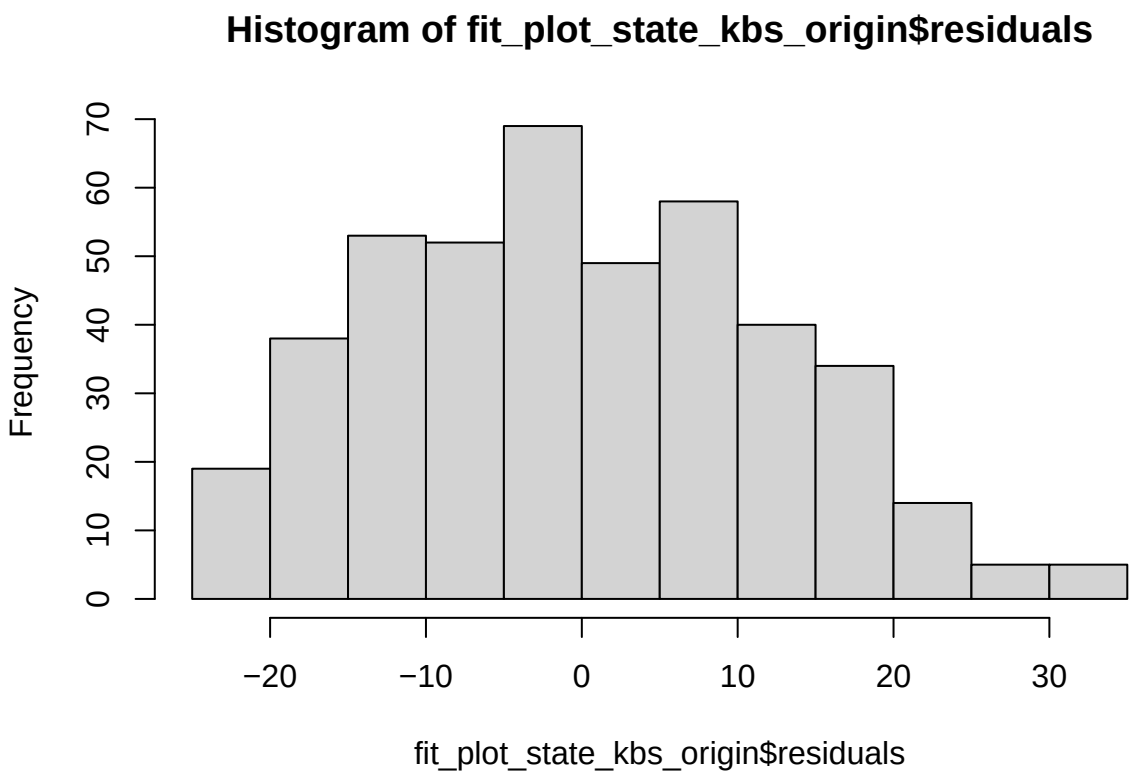
```
## No Studentized residuals with Bonferroni p < 0.05
## Largest |rstudent|:
##     rstudent unadjusted p-value Bonferroni p
## 130  2.73272          0.0065385           NA
```

```r
qqPlot(fit_plot_state_kbs_origin, main = "QQ Plot")
```

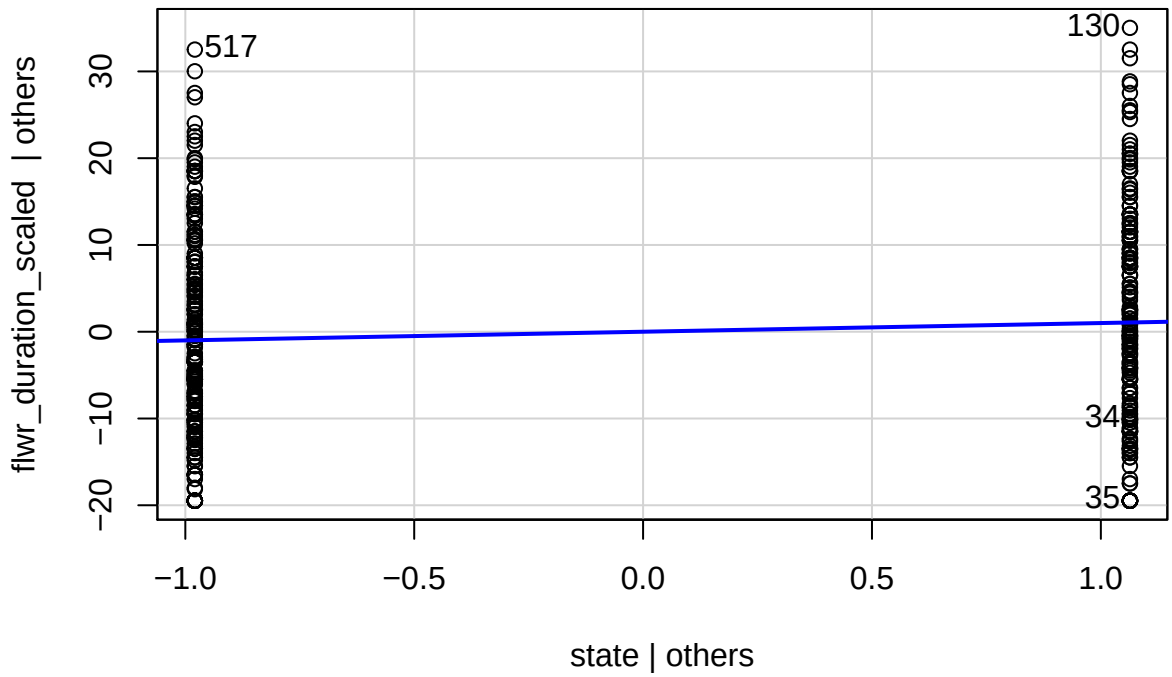



```
## 130 517
##  83 335
```

```r
hist(fit_plot_state_kbs_origin$residuals)
```




```
leveragePlots(fit_plot_state_kbs_origin)
```




```
ols_test_normality(fit_plot_state_kbs_origin)  # looks ok besides Kolmogorov-Smirnov test
```

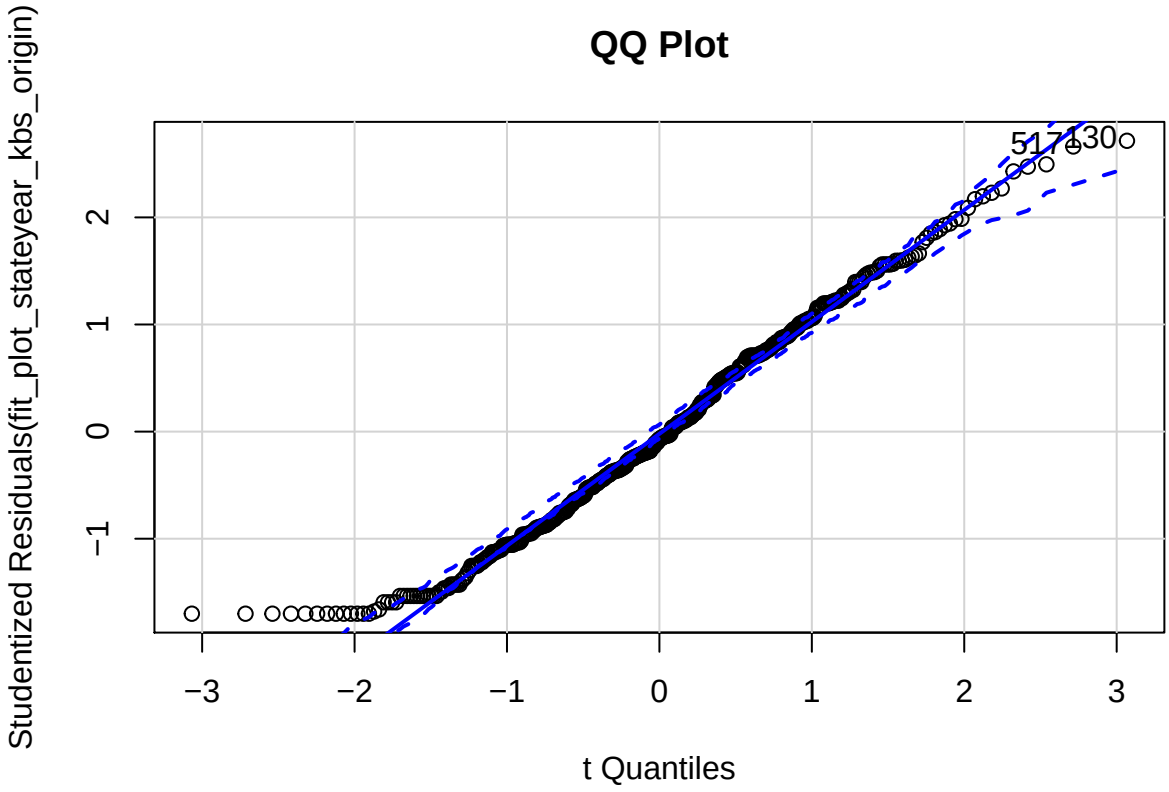
```
## Warning in ks.test(y, "pnorm", mean(y), sd(y)): ties should not be present for
## the Kolmogorov-Smirnov test
```

```
## ------------------------------------------------
##        Test             Statistic       pvalue
## ------------------------------------------------
## Shapiro-Wilk              0.977          0.0000
## Kolmogorov-Smirnov        0.0506         0.2145
## Cramer-von Mises          35.657         0.0000
## Anderson-Darling          1.965           1e-04
## ------------------------------------------------
```

```
# KBS State and year model
fit_plot_stateyear_kbs_origin <- lm(flwr_duration_scaled ~ state + year_factor, data = kbs_flwr_plot_ori
outlierTest(fit_plot_stateyear_kbs_origin)  # no outliers
```

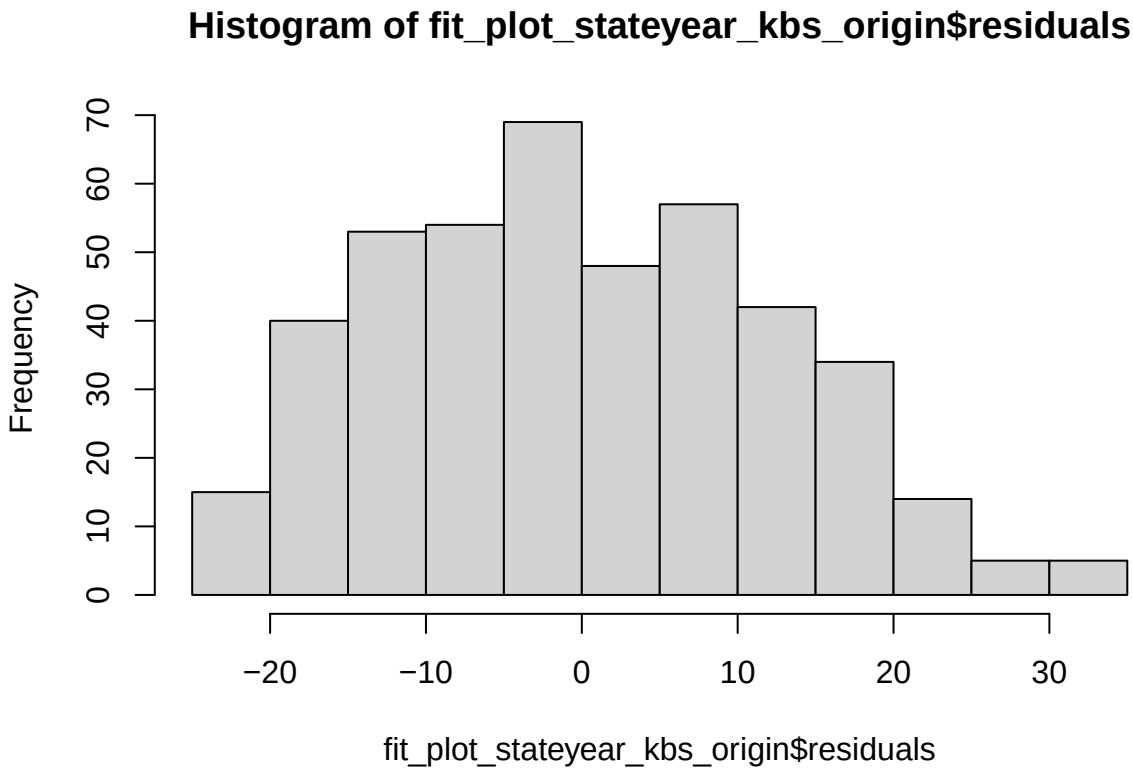
```
## No Studentized residuals with Bonferroni p < 0.05
## Largest |rstudent|:
##     rstudent unadjusted p-value Bonferroni p
## 130 2.715213          0.0068888           NA
```

```
qqPlot(fit_plot_stateyear_kbs_origin, main = "QQ Plot")
```

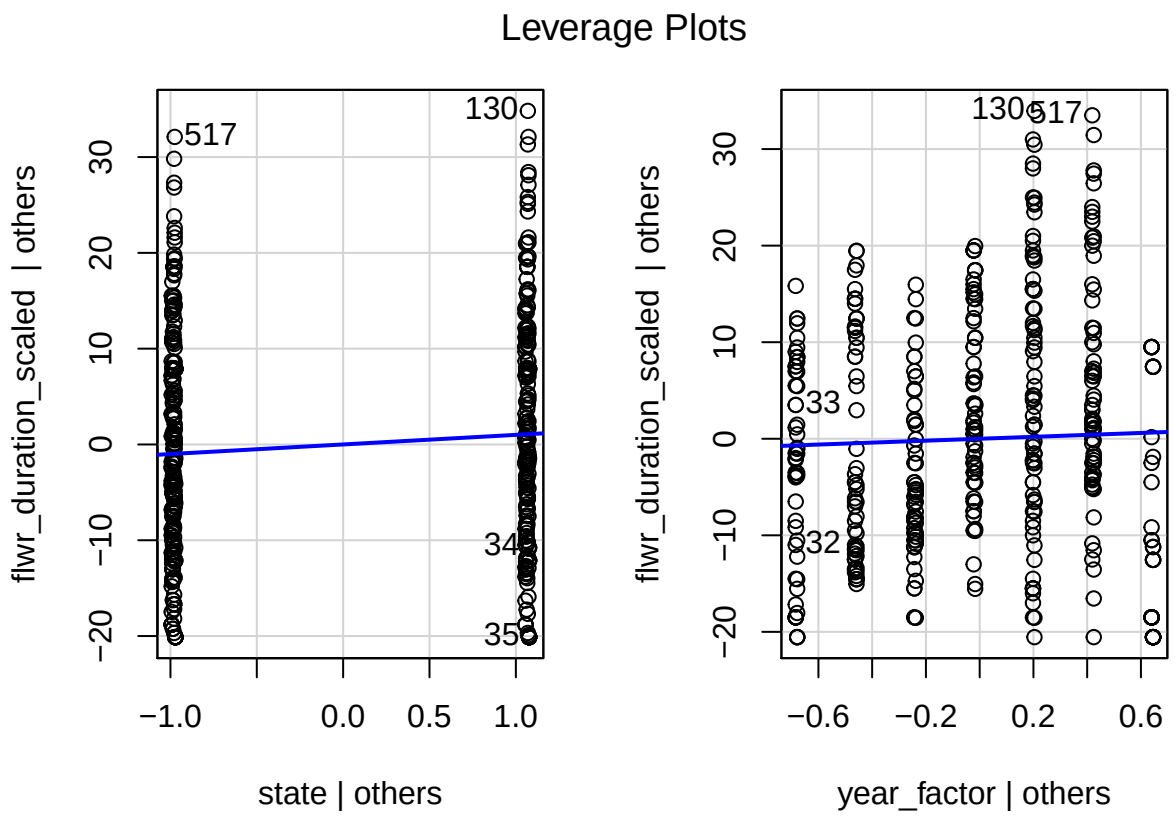



```
## 130 517
##  83 335
```

```
hist(fit_plot_stateyear_kbs_origin$residuals)
```




```
leveragePlots(fit_plot_stateyear_kbs_origin)
```

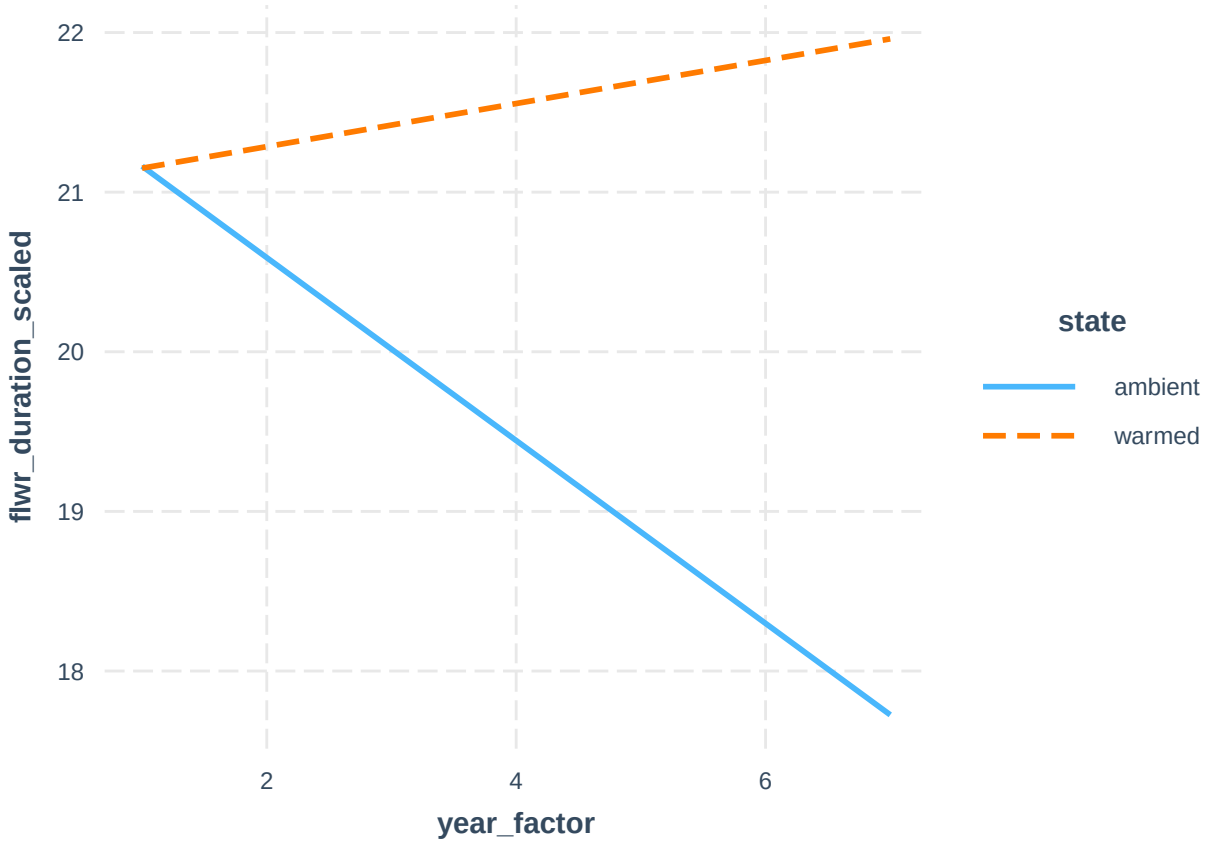


```
ols_test_normality(fit_plot_stateyear_kbs_origin)  # a couple tests say not normal
```

```
## Warning in ks.test(y, "pnorm", mean(y), sd(y)): ties should not be present for
## the Kolmogorov-Smirnov test
```

```
## -----------------------------------------------
##        Test             Statistic       pvalue
## -----------------------------------------------
## Shapiro-Wilk              0.9795         0.0000
## Kolmogorov-Smirnov        0.0486         0.2540
## Cramer-von Mises         35.2889         0.0000
## Anderson-Darling          1.7582          2e-04
## -----------------------------------------------
```

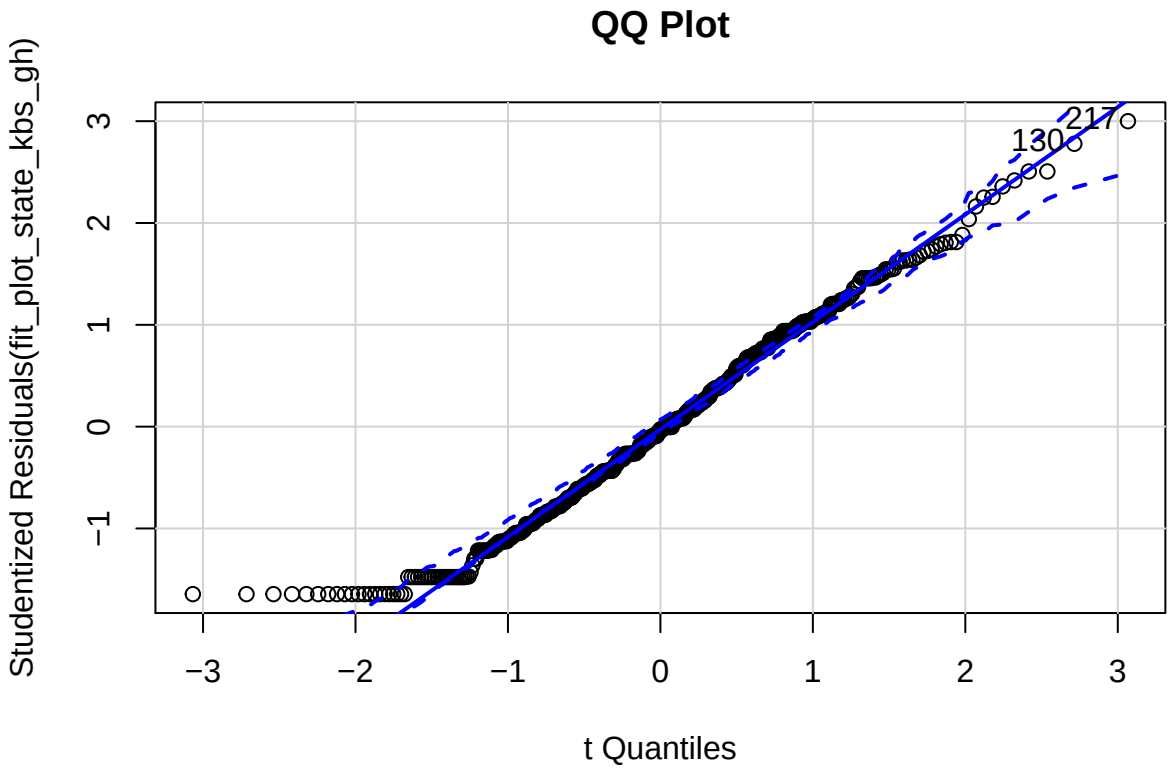
```
# Interaction plot (ignore for now the repeated measures with species); see:
# https://cran.r-project.org/web/packages/interactions/vignettes/interactions.html
# and: https://interactions.jacob-long.com/

fit3 <- lm(flwr_duration_scaled ~ state * year_factor, data = kbs_flwr_plot_origin)
interact_plot(fit3, pred = year_factor, modx = state)  # this looks very strange to me
```




```
# Plot level GROWTH HABIT data KBS State-only model
fit_plot_state_kbs_gh <- lm(flwr_duration_scaled ~ state, data = kbs_flwr_plot_growthhabit)
outlierTest(fit_plot_state_kbs_gh)  # no outliers
```

```
## No Studentized residuals with Bonferroni p < 0.05
## Largest |rstudent|:
##     rstudent unadjusted p-value Bonferroni p
## 217 2.999702          0.0028587           NA
```

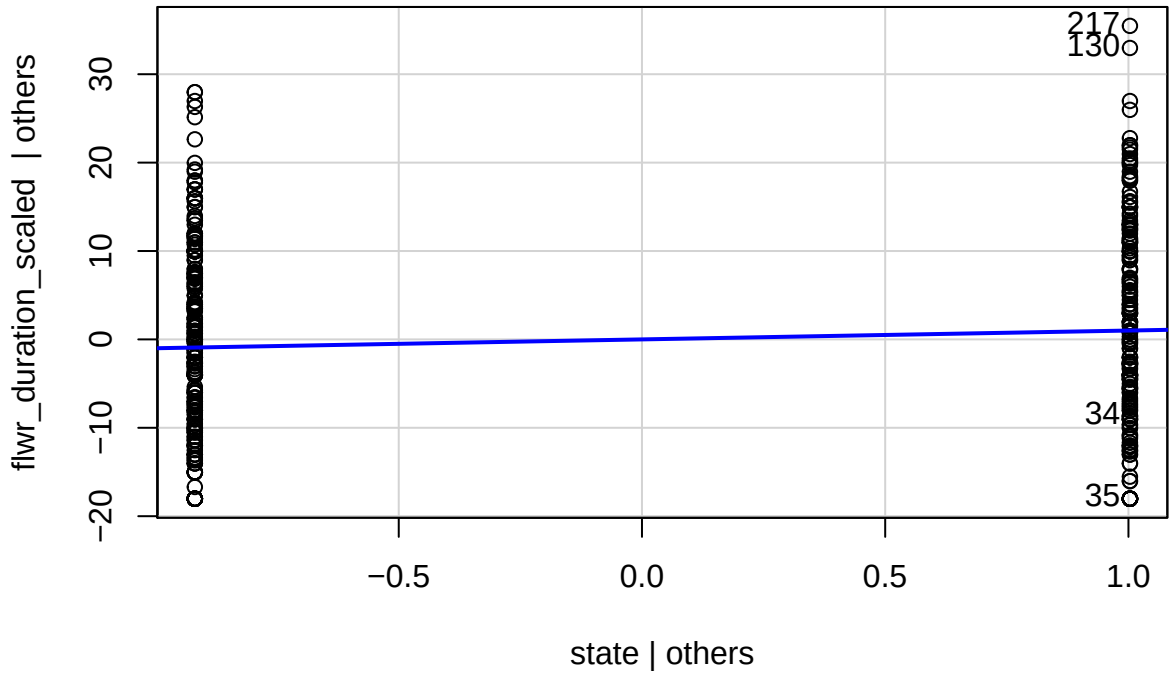
```
qqPlot(fit_plot_state_kbs_gh, main = "QQ Plot")
```




```
## 130 217
##  81 136
```

```
hist(fit_plot_state_kbs_gh$residuals)
```


```
leveragePlots(fit_plot_state_kbs_gh)
```




```
ols_test_normality(fit_plot_state_kbs_gh)  # looks ok besides Kolmogorov-Smirnov test
```

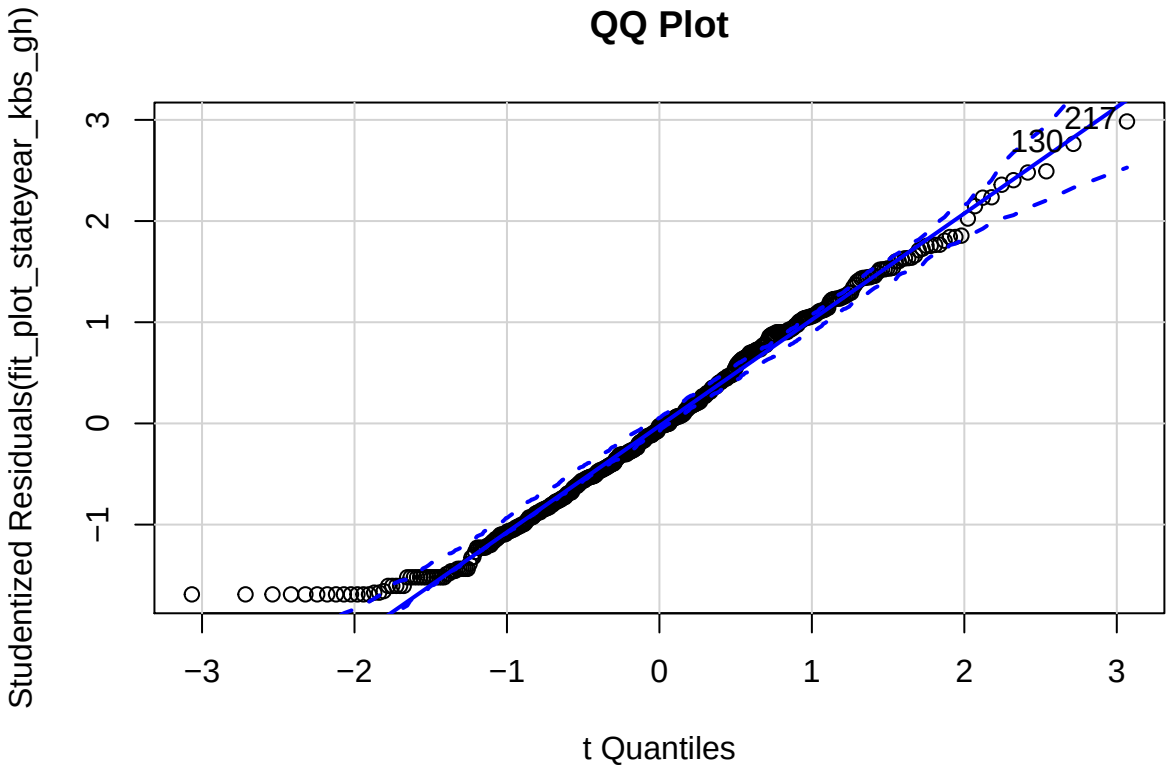
```
## Warning in ks.test(y, "pnorm", mean(y), sd(y)): ties should not be present for
## the Kolmogorov-Smirnov test
```

```
## ------------------------------------------------
##        Test             Statistic       pvalue
## ------------------------------------------------
## Shapiro-Wilk              0.9779         0.0000
## Kolmogorov-Smirnov        0.0506         0.2158
## Cramer-von Mises         35.1778         0.0000
## Anderson-Darling          1.815           1e-04
## ------------------------------------------------
```

```
# KBS State and year model
fit_plot_stateyear_kbs_gh <- lm(flwr_duration_scaled ~ state + year_factor, data = kbs_flwr_plot_growthl
outlierTest(fit_plot_stateyear_kbs_gh)  # no outliers
```

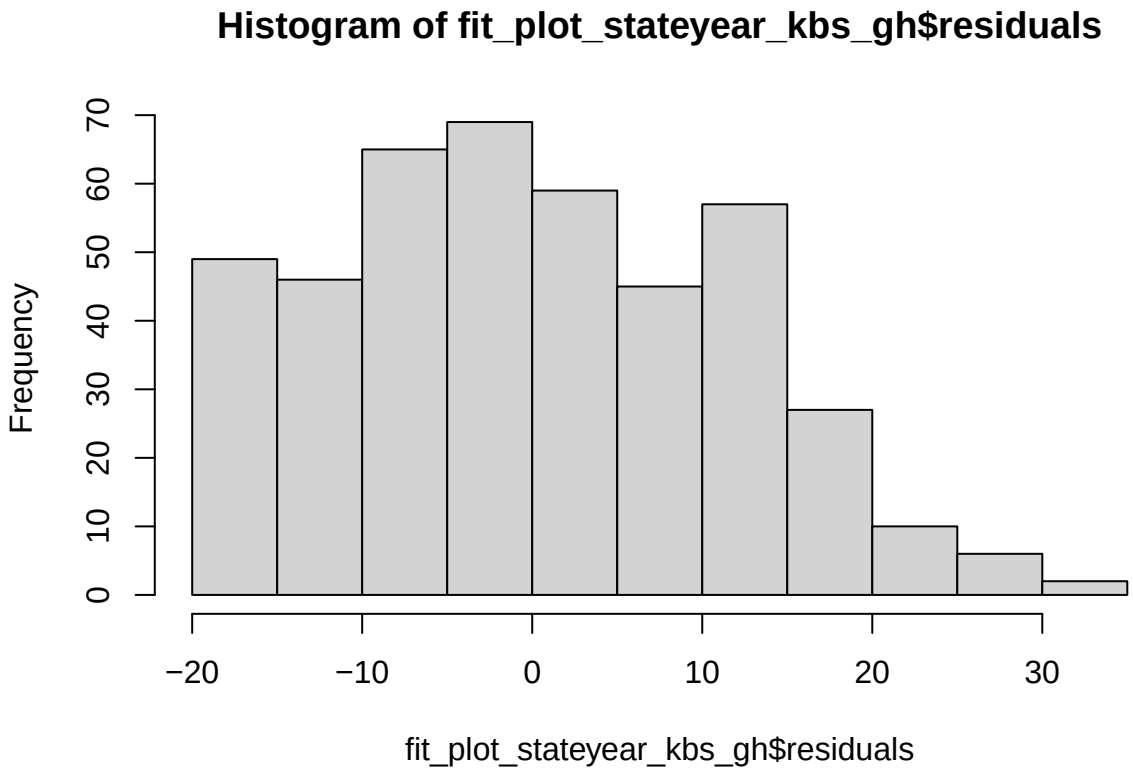
```
## No Studentized residuals with Bonferroni p < 0.05
## Largest |rstudent|:
##     rstudent unadjusted p-value Bonferroni p
## 217 2.984411          0.0030029           NA
```

```
qqPlot(fit_plot_stateyear_kbs_gh, main = "QQ Plot")
```

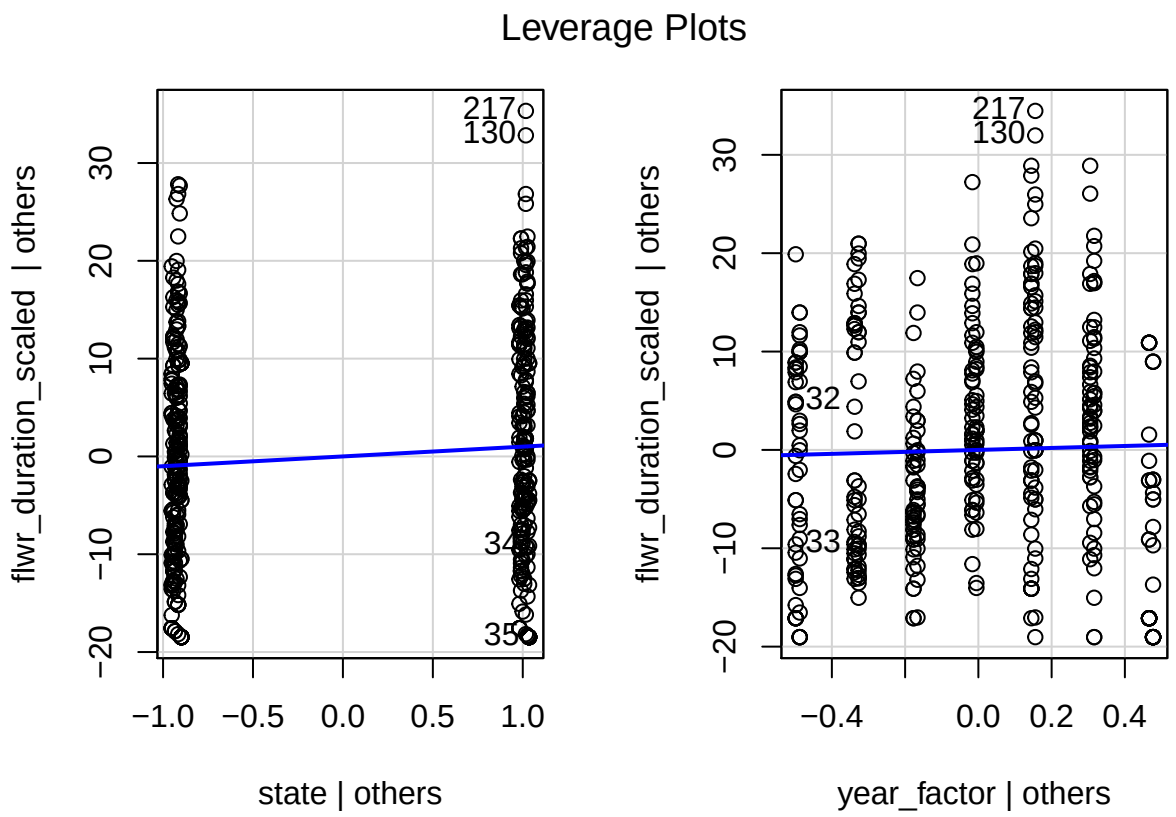



```
## 130 217
##  81 136
```

```
hist(fit_plot_stateyear_kbs_gh$residuals)
```




```
leveragePlots(fit_plot_stateyear_kbs_gh)
```

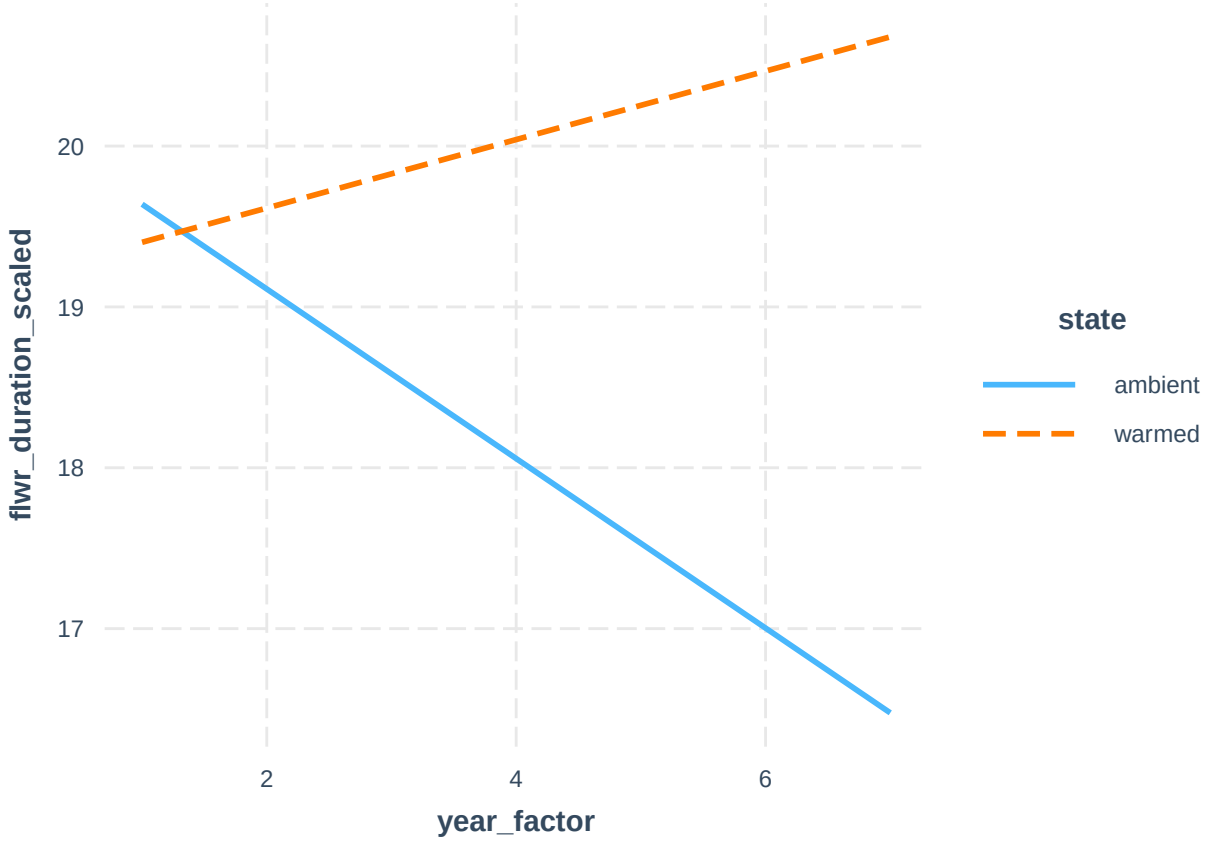


```
ols_test_normality(fit_plot_stateyear_kbs_gh)  # a couple tests say not normal
```

```
## Warning in ks.test(y, "pnorm", mean(y), sd(y)): ties should not be present for
## the Kolmogorov-Smirnov test
```

```
## -----------------------------------------------
##        Test             Statistic       pvalue
## -----------------------------------------------
## Shapiro-Wilk              0.9801         0.0000
## Kolmogorov-Smirnov        0.0464         0.3067
## Cramer-von Mises         34.3948         0.0000
## Anderson-Darling          1.6239          4e-04
## -----------------------------------------------
```

```
# Interaction plot (ignore for now the repeated measures with species); see:
# https://cran.r-project.org/web/packages/interactions/vignettes/interactions.html
# and: https://interactions.jacob-long.com/

fit3 <- lm(flwr_duration_scaled ~ state * year_factor, data = kbs_flwr_plot_growthhabit)
interact_plot(fit3, pred = year_factor, modx = state)  # this looks very strange to me
```

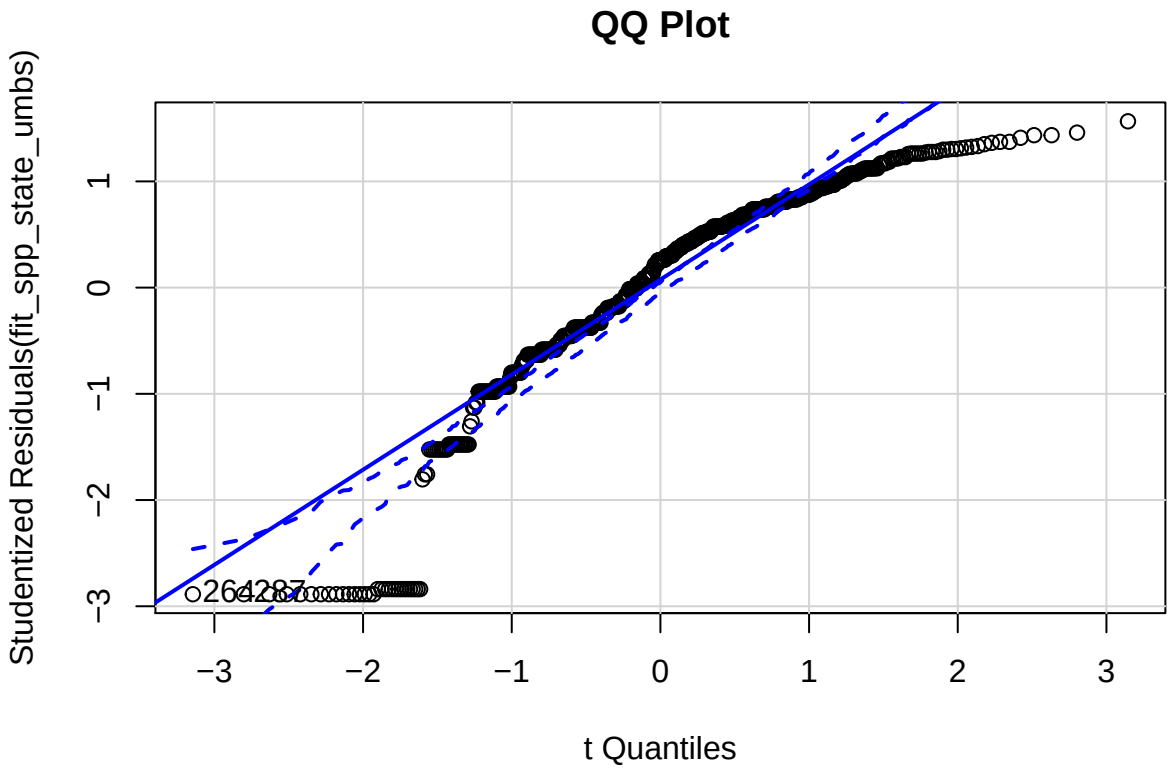


UMBS

```
# log transformation wont work because we have zeros in the data so I'm going to
# square root the response variable since the data is skewed to the right.
# species level data UMBS State-only model
fit_spp_state_umbs <- lm(log(flwr_duration_scaled) ~ state, data = umbs_flwr_spp)
outlierTest(fit_spp_state_umbs)  # no outliers
```

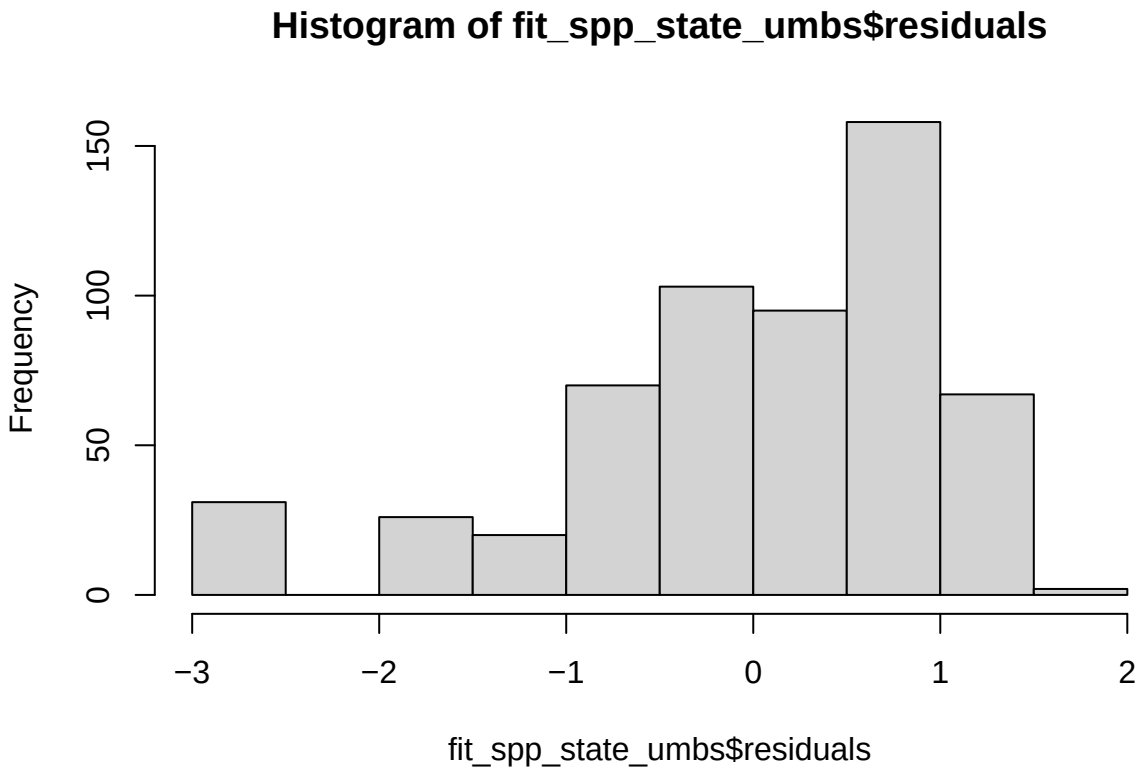
```
## No Studentized residuals with Bonferroni p < 0.05
## Largest |rstudent|:
##      rstudent unadjusted p-value Bonferroni p
## 264 -2.886724          0.0040406           NA
```

```
qqPlot(fit_spp_state_umbs, main = "QQ Plot")
```

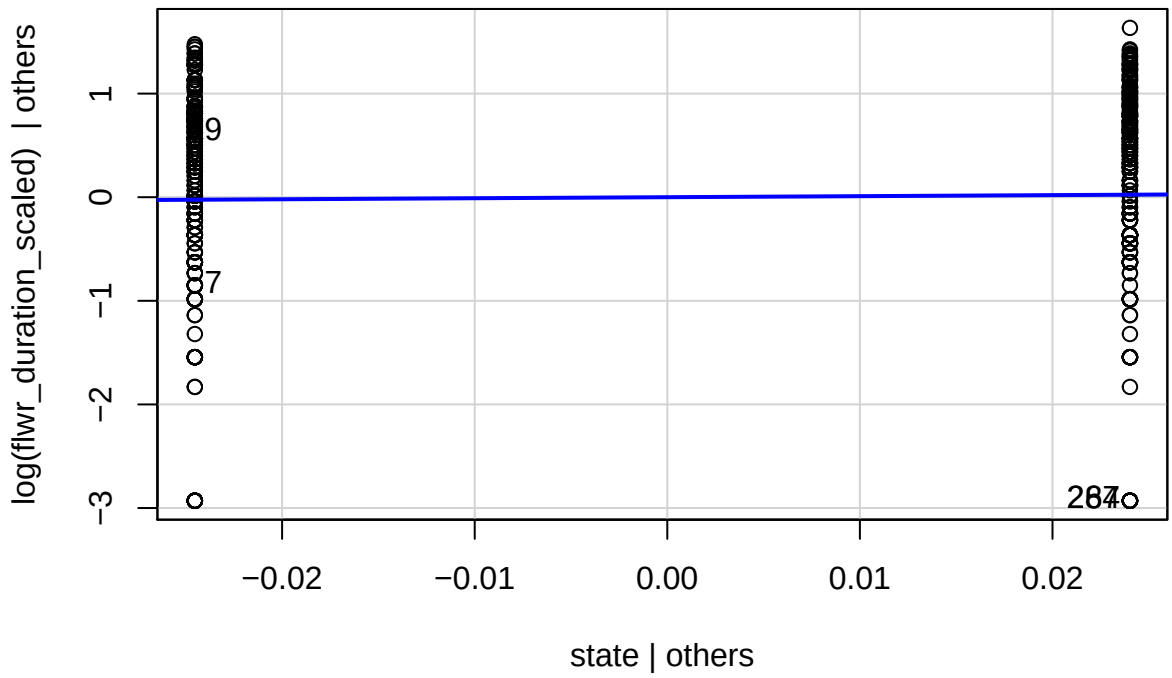



```
## 264 287
##  87  96
```

```
hist(fit_spp_state_umbs$residuals)
```




```
leveragePlots(fit_spp_state_umbs)
```




```
ols_test_normality(fit_spp_state_umbs)  # ok except Kol-Smir test
```

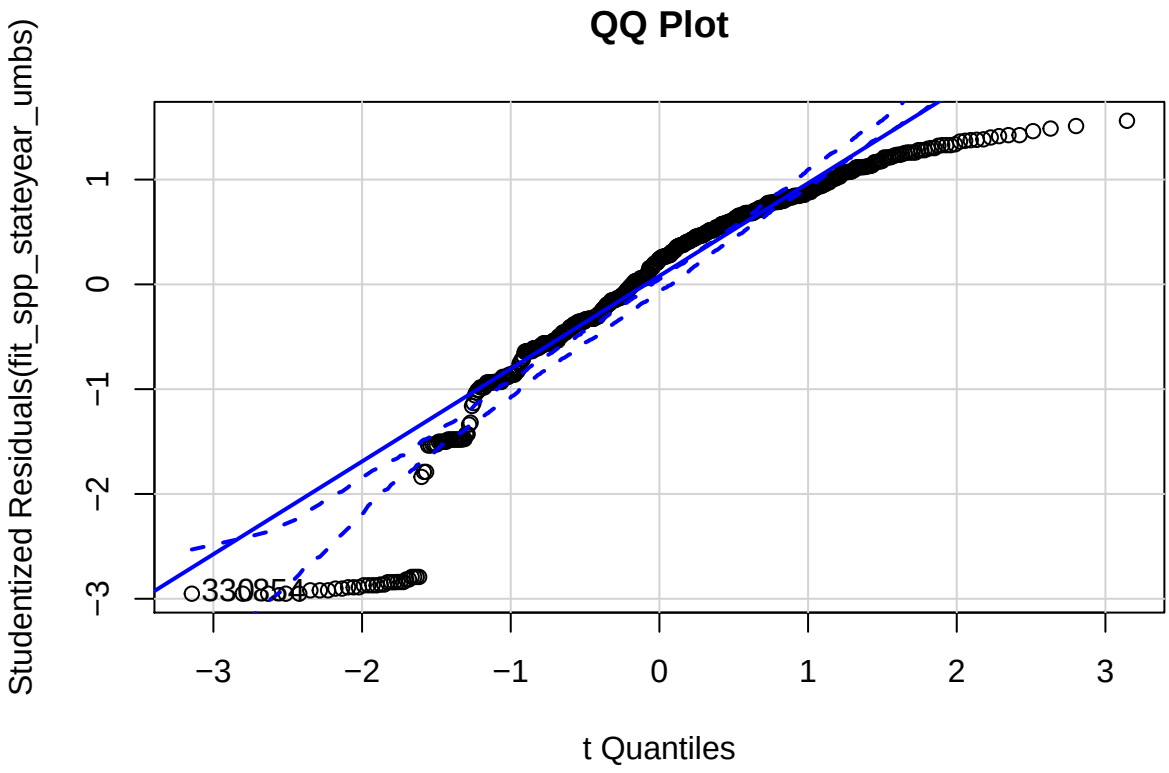
```
## Warning in ks.test(y, "pnorm", mean(y), sd(y)): ties should not be present for
## the Kolmogorov-Smirnov test
```

```
## ------------------------------------------------
##        Test             Statistic       pvalue
## ------------------------------------------------
## Shapiro-Wilk              0.8993         0.0000
## Kolmogorov-Smirnov        0.1084         0.0000
## Cramer-von Mises         22.9348         0.0000
## Anderson-Darling         13.7067         0.0000
## ------------------------------------------------
```

```
# UMBS State and year model
fit_spp_stateyear_umbs <- lm(log(flwr_duration_scaled) ~ state + year_factor, data = umbs_flwr_spp)
outlierTest(fit_spp_stateyear_umbs)  # no outliers
```

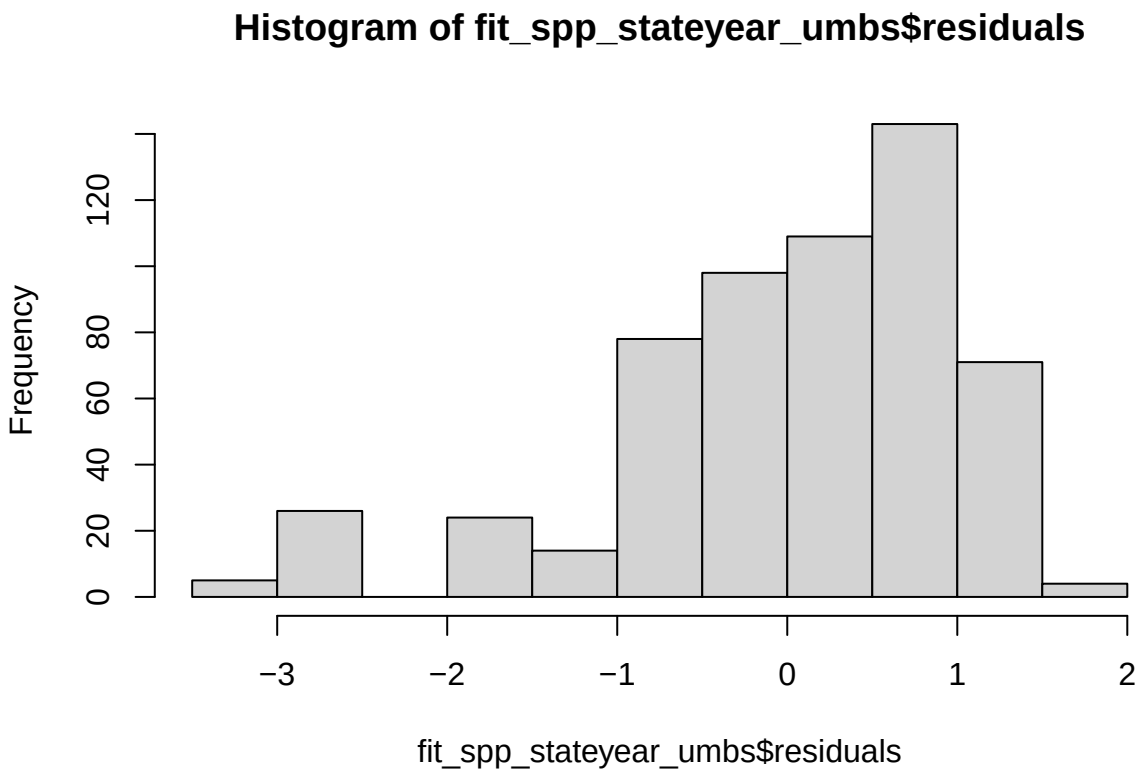
```
## No Studentized residuals with Bonferroni p < 0.05
## Largest |rstudent|:
##      rstudent unadjusted p-value Bonferroni p
## 330 -2.951658          0.0032912           NA
```

```
qqPlot(fit_spp_stateyear_umbs, main = "QQ Plot")
```

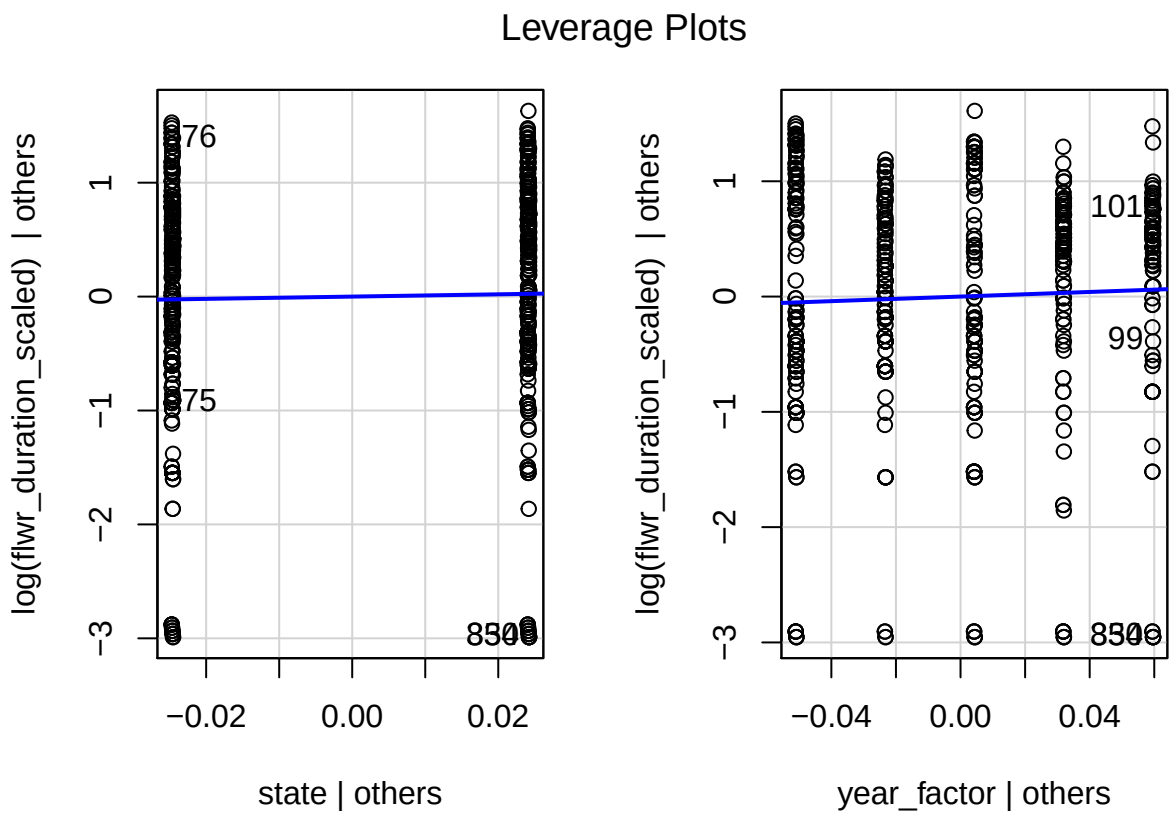



```
## 330 854
## 114 301
```

```
hist(fit_spp_stateyear_umbs$residuals)
```




```
leveragePlots(fit_spp_stateyear_umbs)
```



```
ols_test_normality(fit_spp_stateyear_umbs)  # ok except Kol-Smir test
```

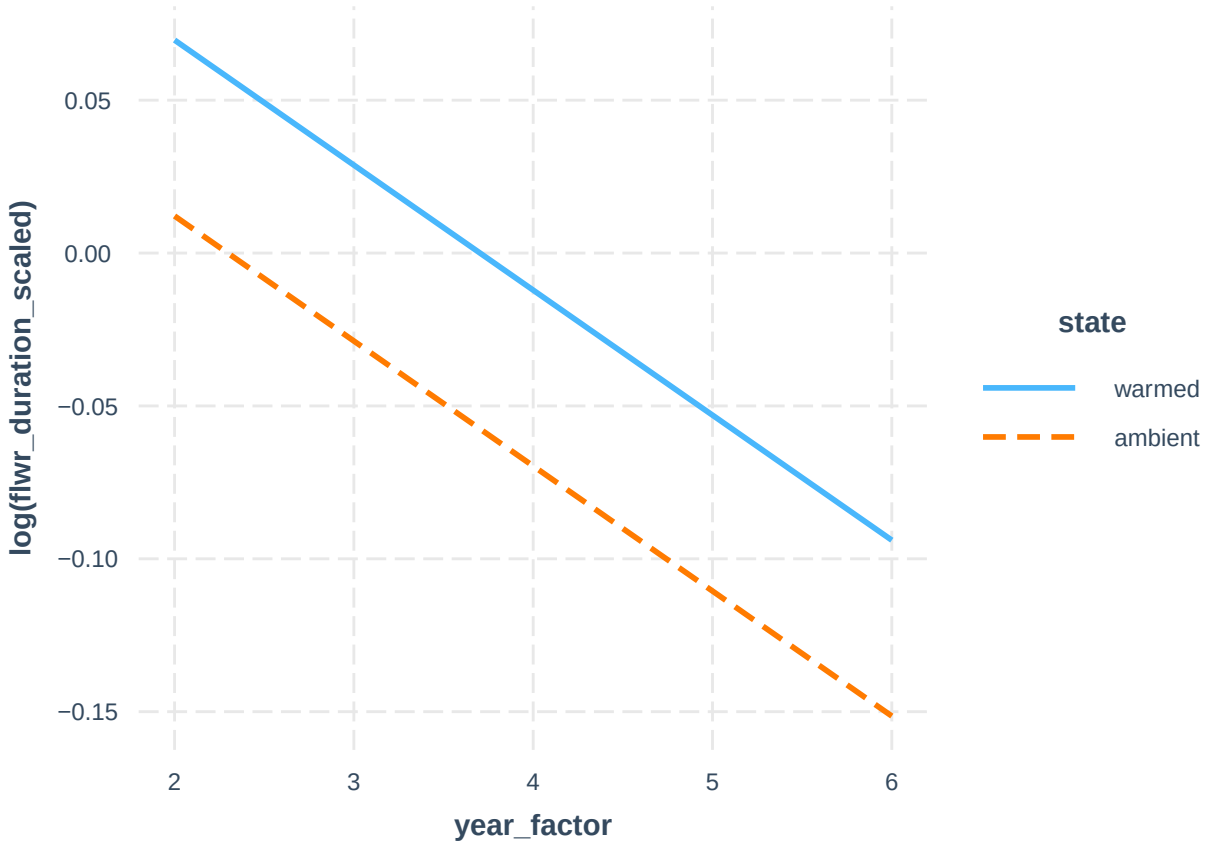
```
## Warning in ks.test(y, "pnorm", mean(y), sd(y)): ties should not be present for
## the Kolmogorov-Smirnov test
```

```
## -----------------------------------------------
##        Test             Statistic       pvalue
## -----------------------------------------------
## Shapiro-Wilk              0.9031         0.0000
## Kolmogorov-Smirnov        0.0976         0.0000
## Cramer-von Mises         23.7024         0.0000
## Anderson-Darling         12.9455         0.0000
## -----------------------------------------------
```

```
# Interaction plot (ignore for now the repeated measures with species); see:
# https://cran.r-project.org/web/packages/interactions/vignettes/interactions.html
# and: https://interactions.jacob-long.com/

fit3 <- lm(log(flwr_duration_scaled) ~ state + year_factor + species, data = umbs_flwr_spp)
interact_plot(fit3, pred = year_factor, modx = state)
```

```
## Using data umbs_flwr_spp from global environment. This could cause
## incorrect results if umbs_flwr_spp has been altered since the model was
## fit. You can manually provide the data to the "data =" argument.
```

```
## Warning: year_factor and state are not included in an interaction with one another
## in the model.
```



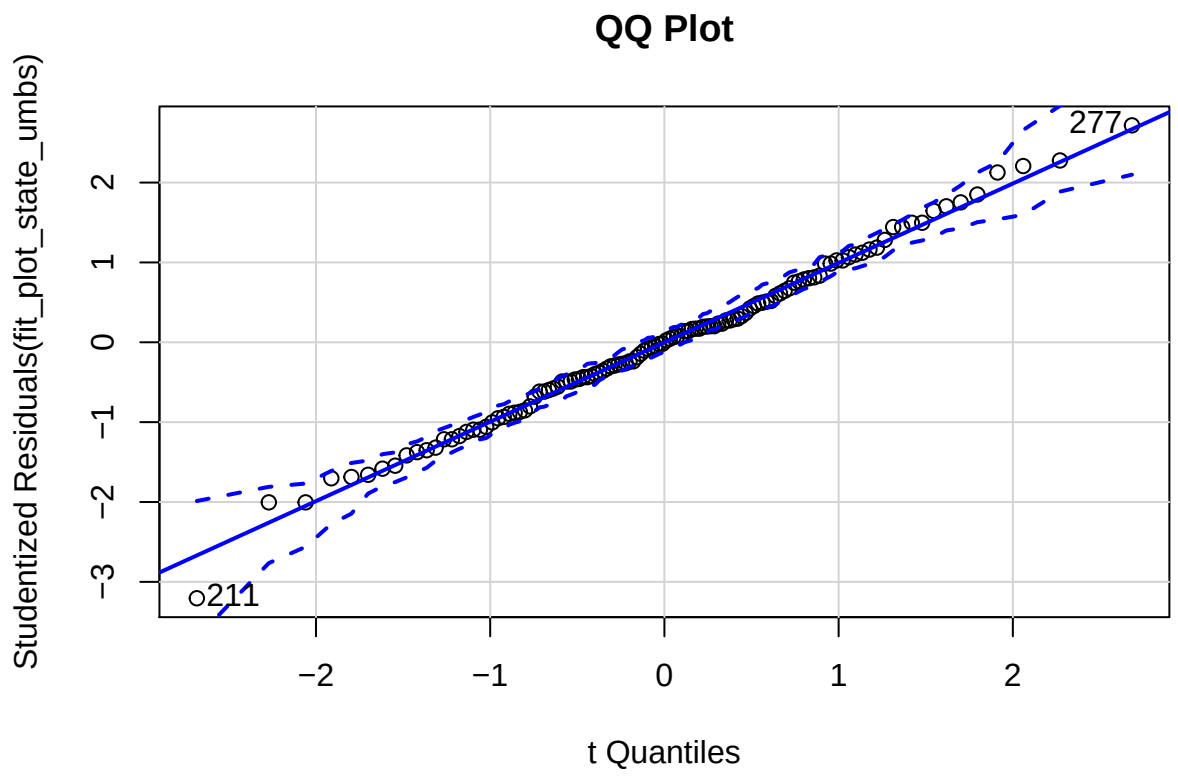

```
fit4 <- lm(log(flwr_duration_scaled) ~ state * year_factor + species, data = umbs_flwr_spp)
interact_plot(fit4, pred = year_factor, modx = state, mod2 = species)
```

```
## Using data umbs_flwr_spp from global environment. This could cause
## incorrect results if umbs_flwr_spp has been altered since the model was
## fit. You can manually provide the data to the "data =" argument.

## Warning: year_factor and state and species are not included in an interaction with
## one another in the model.
```


```
# Plot level data UMBS State-only model
fit_plot_state_umbs <- lm(flwr_duration_scaled ~ state, data = umbs_flwr_plot)
outlierTest(fit_plot_state_umbs)  # no outliers
```

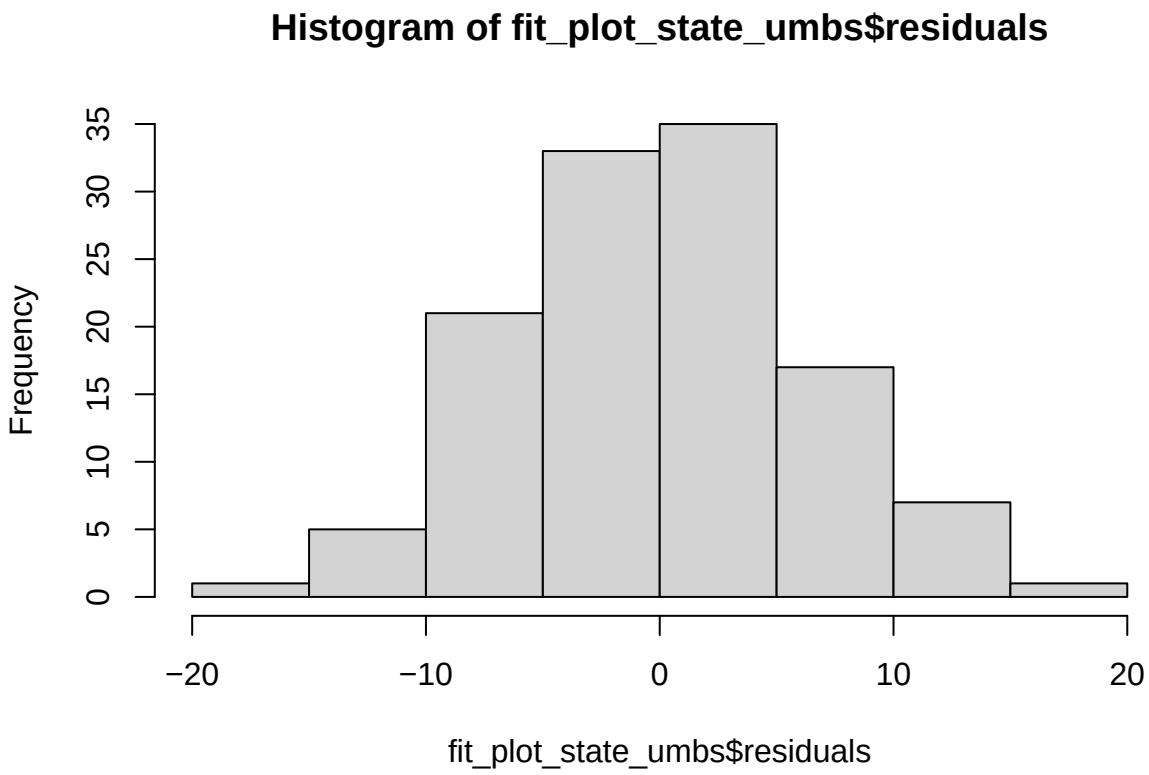
```
## No Studentized residuals with Bonferroni p < 0.05
## Largest |rstudent|:
##     rstudent unadjusted p-value Bonferroni p
## 211 -3.20522          0.0017399      0.20879
```

```
qqPlot(fit_plot_state_umbs, main = "QQ Plot")
```

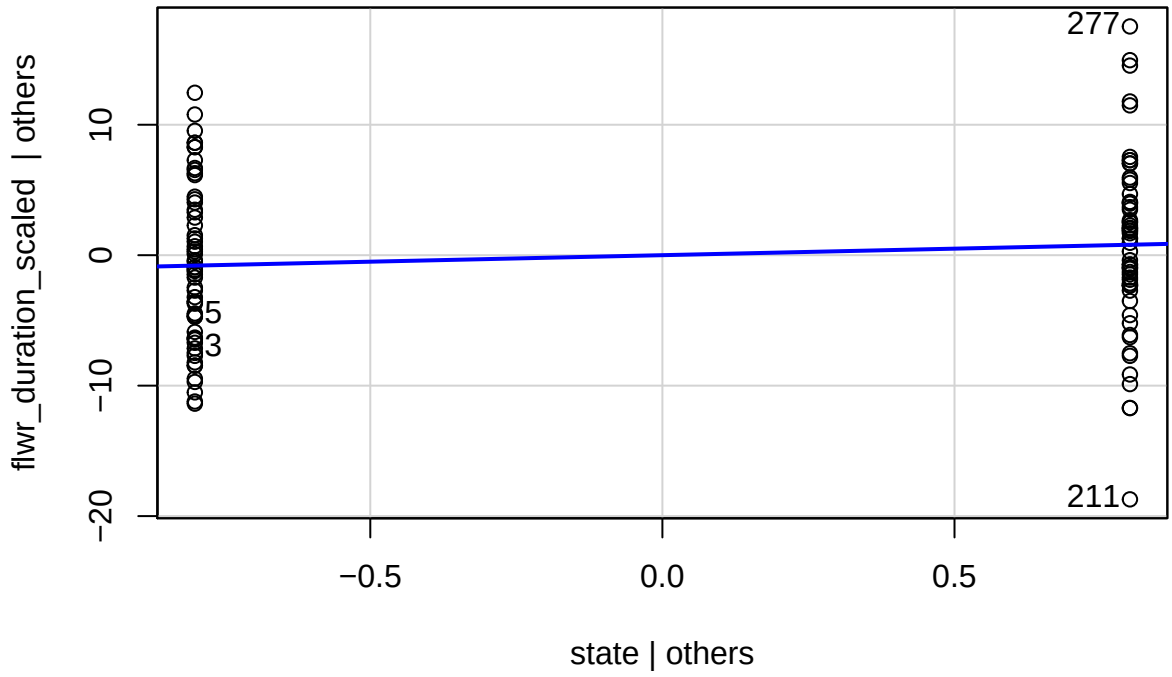



```
## 211 277
##  88 116
```

```
hist(fit_plot_state_umbs$residuals)
```



```
leveragePlots(fit_plot_state_umbs)
```




```
ols_test_normality(fit_plot_state_umbs)  # these don't look great...
```

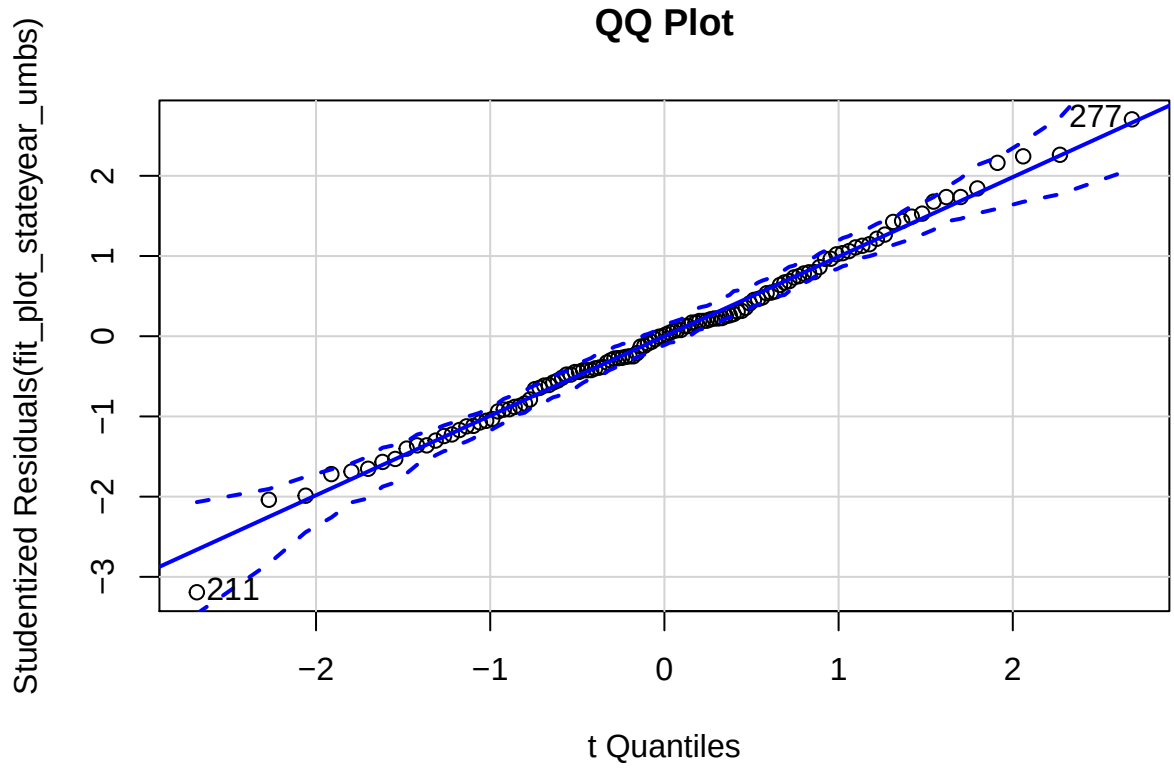
```
## Warning in ks.test(y, "pnorm", mean(y), sd(y)): ties should not be present for
## the Kolmogorov-Smirnov test
```

```
## -----------------------------------------------
##        Test             Statistic       pvalue
## -----------------------------------------------
## Shapiro-Wilk              0.9952         0.9596
## Kolmogorov-Smirnov        0.0501         0.9242
## Cramer-von Mises          8.8624         0.0000
## Anderson-Darling          0.1803         0.9137
## -----------------------------------------------
```

```
# UMBS State and year model
fit_plot_stateyear_umbs <- lm(flwr_duration_scaled ~ state + year_factor, data = umbs_flwr_plot)
outlierTest(fit_plot_stateyear_umbs)  # no outliers
```

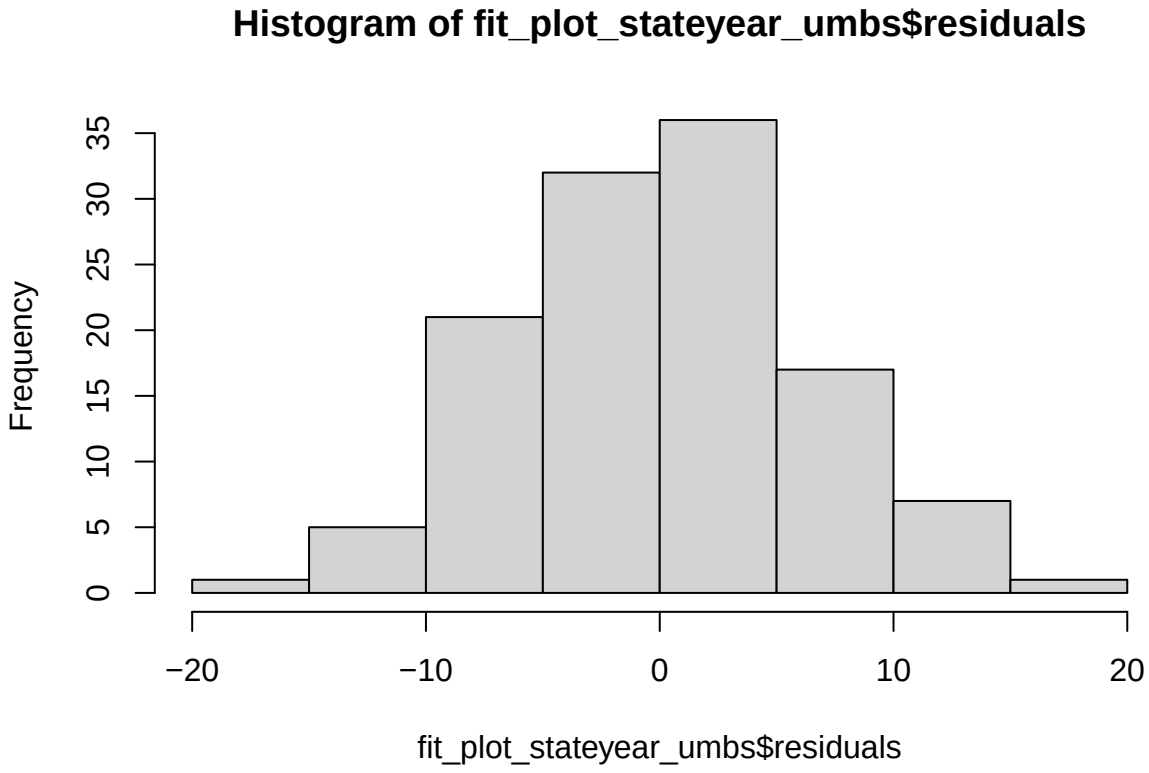
```
## No Studentized residuals with Bonferroni p < 0.05
## Largest |rstudent|:
##      rstudent unadjusted p-value Bonferroni p
## 211 -3.191987          0.0018186      0.21823
```

```
qqPlot(fit_plot_stateyear_umbs, main = "QQ Plot")
```

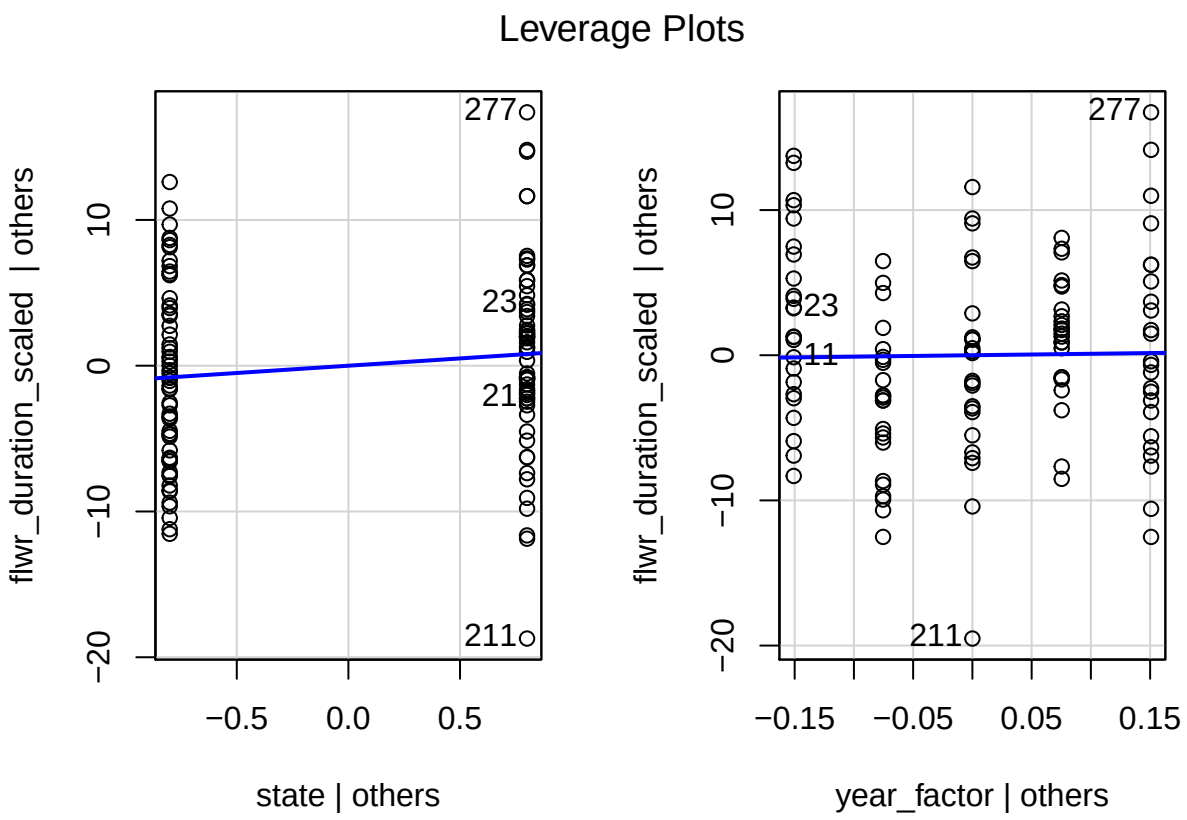



```
## 211 277
##  88 116
```

```
hist(fit_plot_stateyear_umbs$residuals)
```



```r
leveragePlots(fit_plot_stateyear_umbs)
```

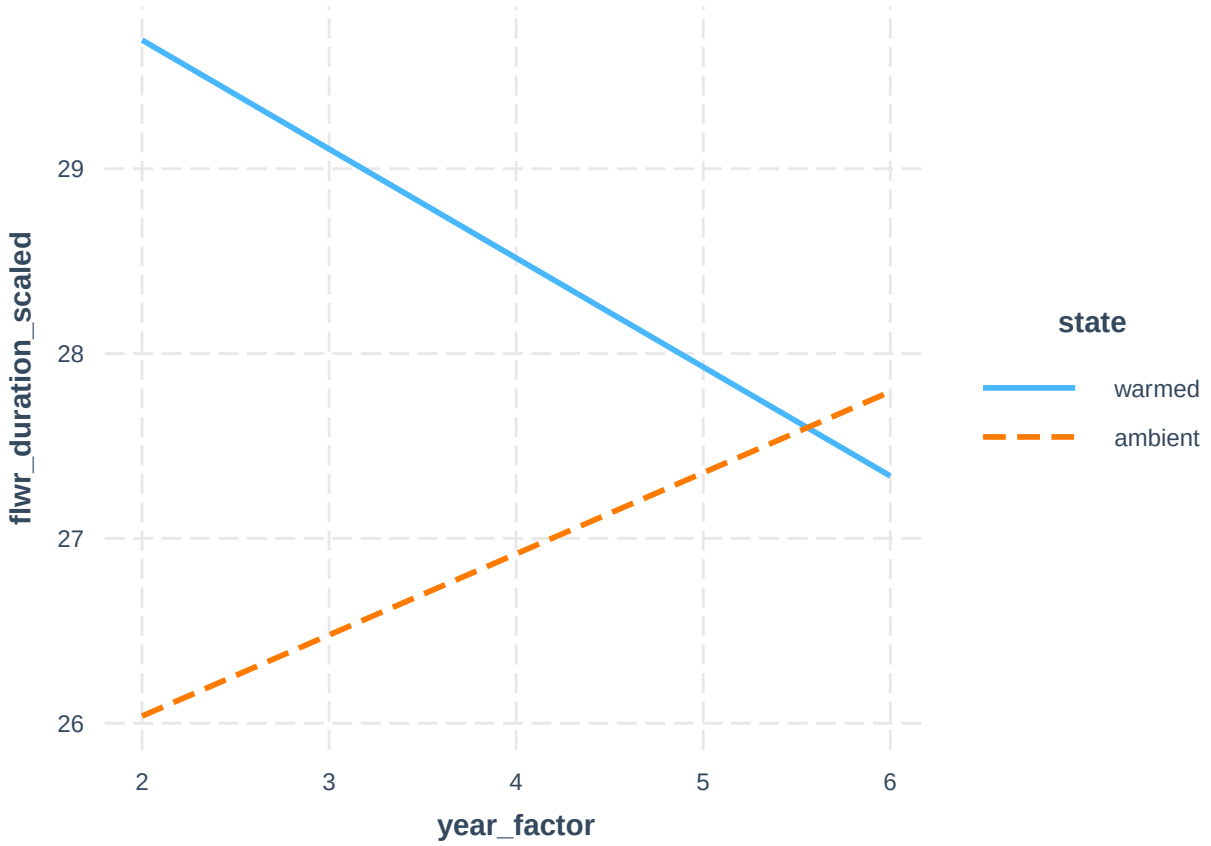



```r
ols_test_normality(fit_plot_stateyear_umbs)  # these don't look great either
```

```
## Warning in ks.test(y, "pnorm", mean(y), sd(y)): ties should not be present for
## the Kolmogorov-Smirnov test
```

```
## -----------------------------------------------
##        Test             Statistic       pvalue
## -----------------------------------------------
## Shapiro-Wilk              0.995          0.9484
## Kolmogorov-Smirnov        0.0509         0.9152
## Cramer-von Mises          8.7622         0.0000
## Anderson-Darling          0.1904         0.8968
## -----------------------------------------------
```

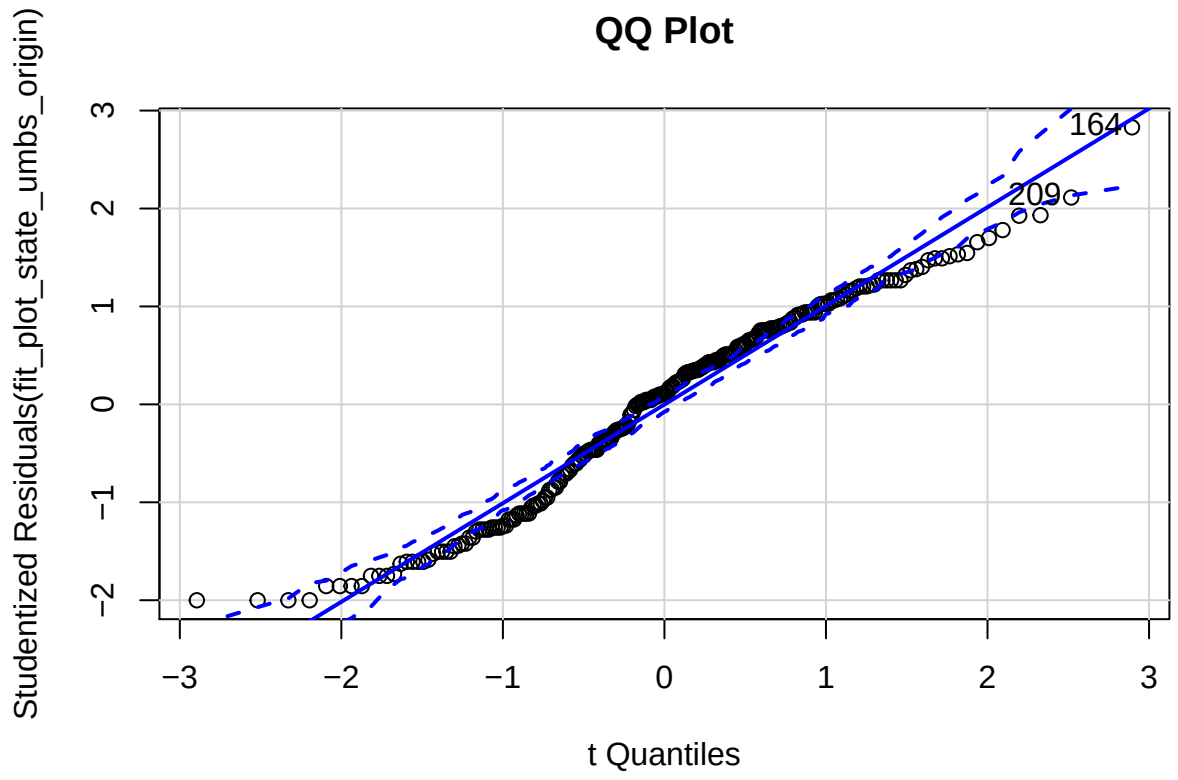
```r
# Interaction plot (ignore for now the repeated measures with species); see:
# https://cran.r-project.org/web/packages/interactions/vignettes/interactions.html
# and: https://interactions.jacob-long.com/

fit3 <- lm(flwr_duration_scaled ~ state * year_factor, data = umbs_flwr_plot)
interact_plot(fit3, pred = year_factor, modx = state)
```




```
# Plot level ORIGIN data UMBS State-only model
fit_plot_state_umbs_origin <- lm(flwr_duration_scaled ~ state, data = umbs_flwr_plot_origin)
outlierTest(fit_plot_state_umbs_origin)  # no outliers
```

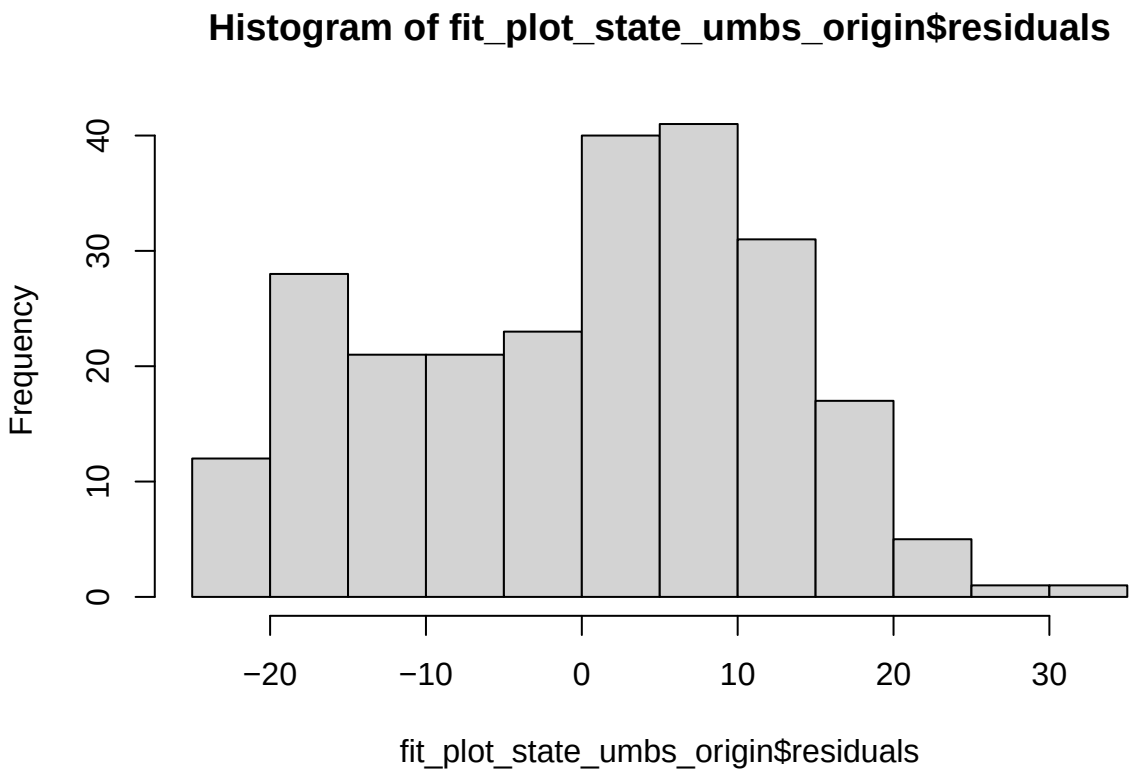
```
## No Studentized residuals with Bonferroni p < 0.05
## Largest |rstudent|:
##     rstudent unadjusted p-value Bonferroni p
## 164 2.828726          0.0050718           NA
```

```
qqPlot(fit_plot_state_umbs_origin, main = "QQ Plot")
```

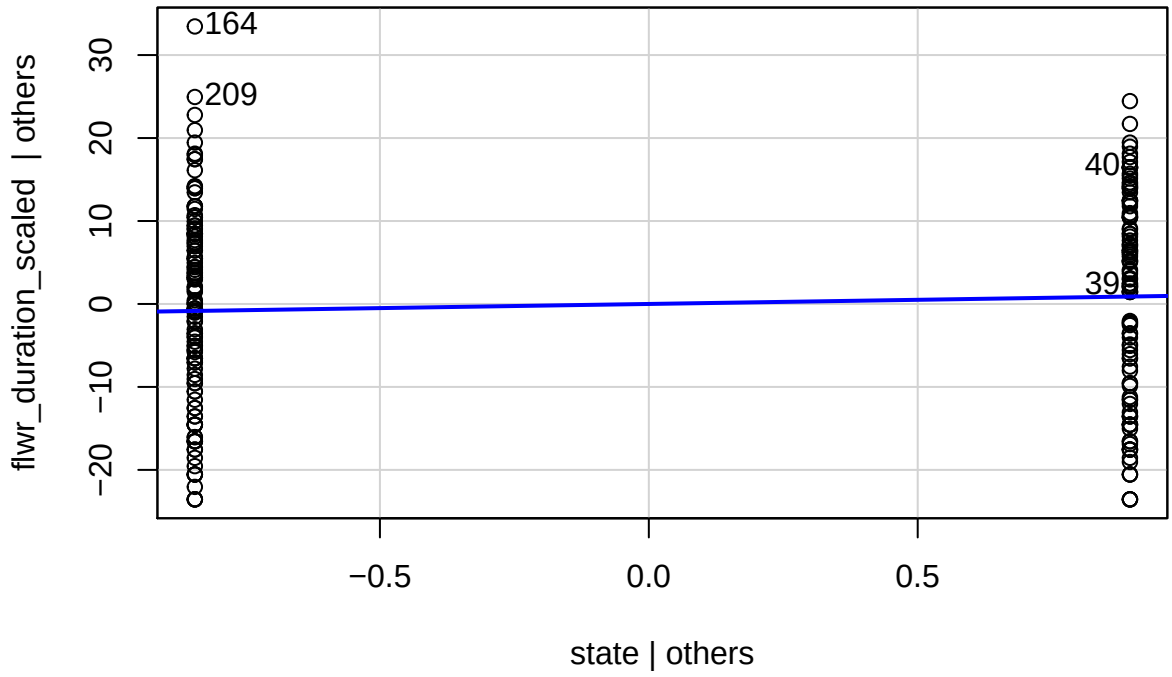



```
## 164 209
##  62  80
```

```
hist(fit_plot_state_umbs_origin$residuals)
```



```
leveragePlots(fit_plot_state_umbs_origin)
```




```
ols_test_normality(fit_plot_state_umbs_origin)  # these don't look great...
```

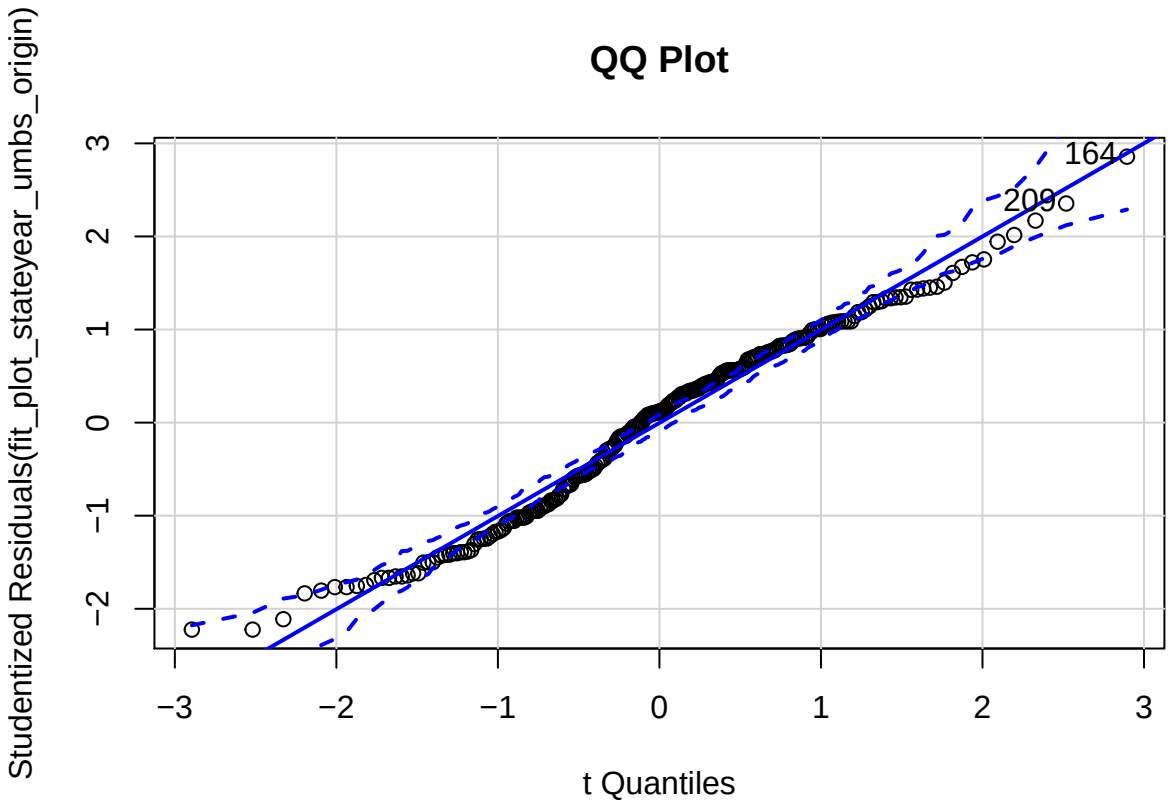
```
## Warning in ks.test(y, "pnorm", mean(y), sd(y)): ties should not be present for
## the Kolmogorov-Smirnov test
```

```
## -----------------------------------------------
##        Test             Statistic       pvalue
## -----------------------------------------------
## Shapiro-Wilk              0.9738          2e-04
## Kolmogorov-Smirnov        0.0742         0.1412
## Cramer-von Mises         18.6842         0.0000
## Anderson-Darling          2.1055         0.0000
## -----------------------------------------------
```

```
# UMBS State and year model
fit_plot_stateyear_umbs_origin <- lm(flwr_duration_scaled ~ state + year_factor,
    data = umbs_flwr_plot_origin)
outlierTest(fit_plot_stateyear_umbs_origin)  # no outliers
```

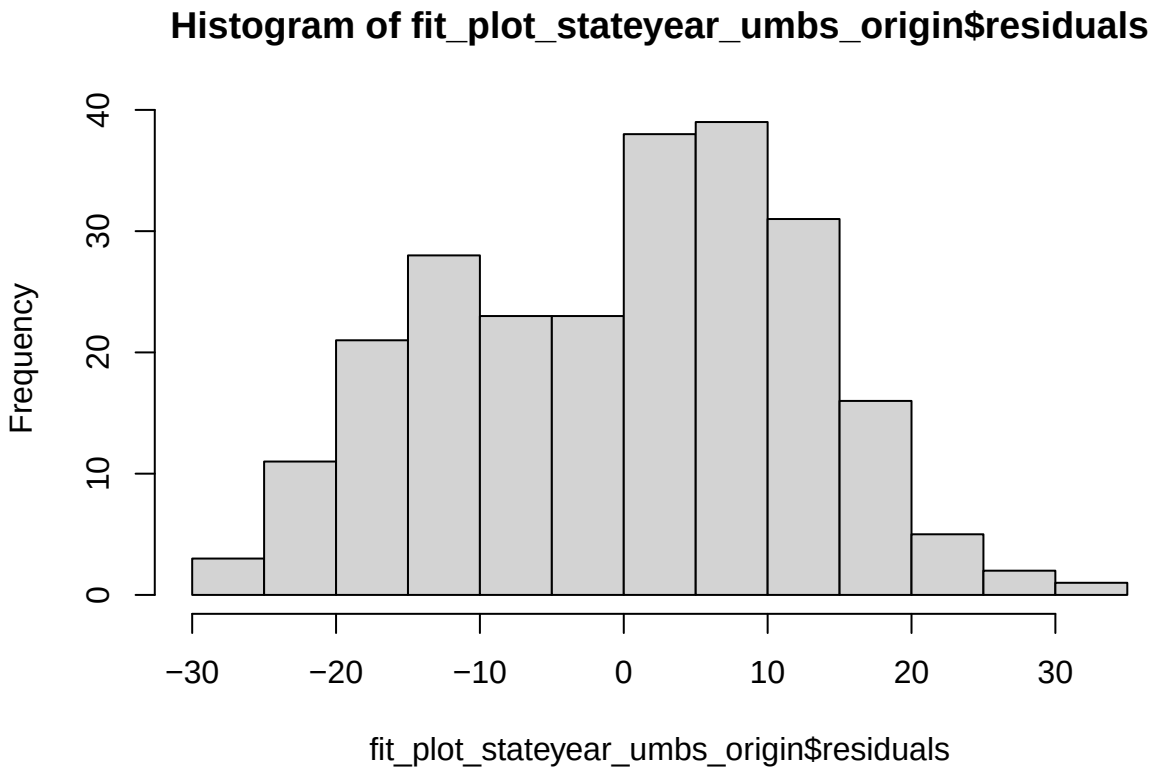
```
## No Studentized residuals with Bonferroni p < 0.05
## Largest |rstudent|:
##     rstudent unadjusted p-value Bonferroni p
## 164  2.85699          0.0046568           NA
```

```
qqPlot(fit_plot_stateyear_umbs_origin, main = "QQ Plot")
```

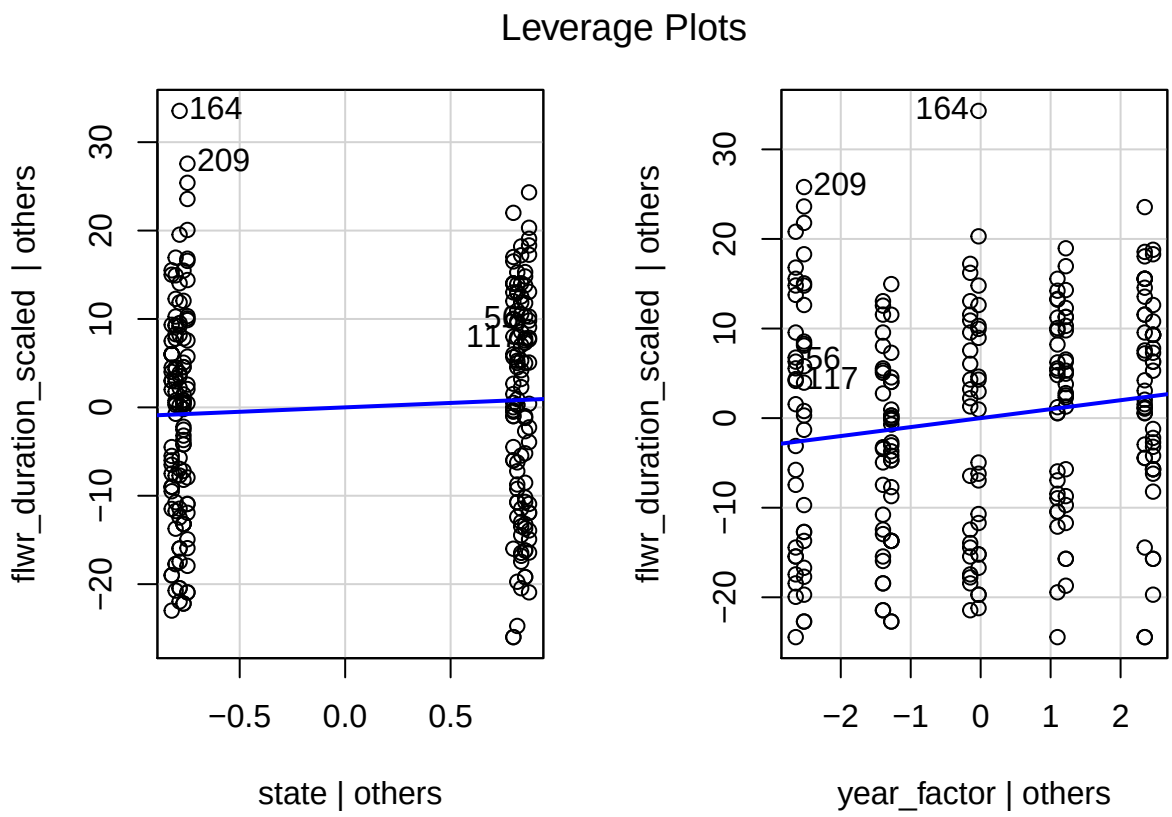



```
## 164 209
##  62  80
```

```
hist(fit_plot_stateyear_umbs_origin$residuals)
```




```
leveragePlots(fit_plot_stateyear_umbs_origin)
```

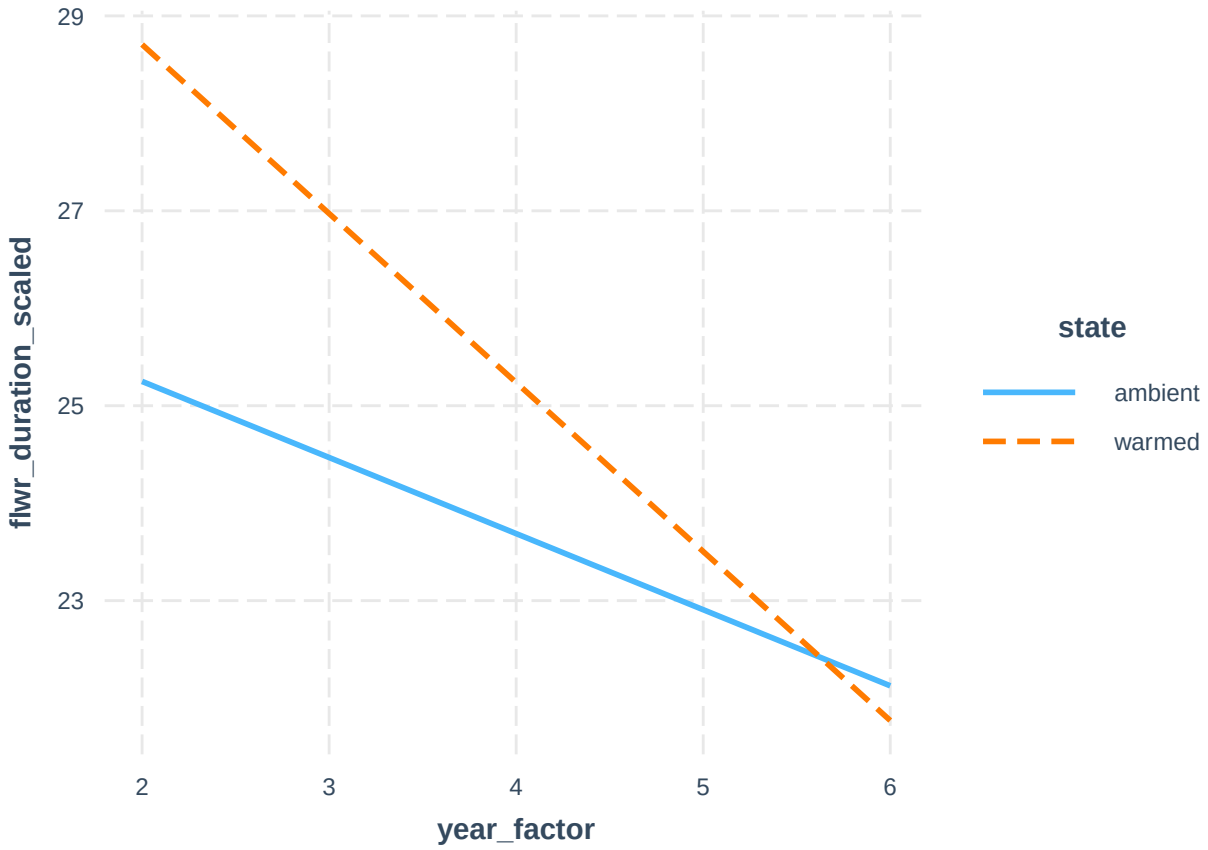


```
ols_test_normality(fit_plot_stateyear_umbs_origin)  # these don't look great either
```

```
## Warning in ks.test(y, "pnorm", mean(y), sd(y)): ties should not be present for
## the Kolmogorov-Smirnov test
```

```
## -----------------------------------------------
##        Test             Statistic       pvalue
## -----------------------------------------------
## Shapiro-Wilk              0.981          0.0026
## Kolmogorov-Smirnov        0.0676         0.2211
## Cramer-von Mises         19.7838         0.0000
## Anderson-Darling          1.6723          3e-04
## -----------------------------------------------
```

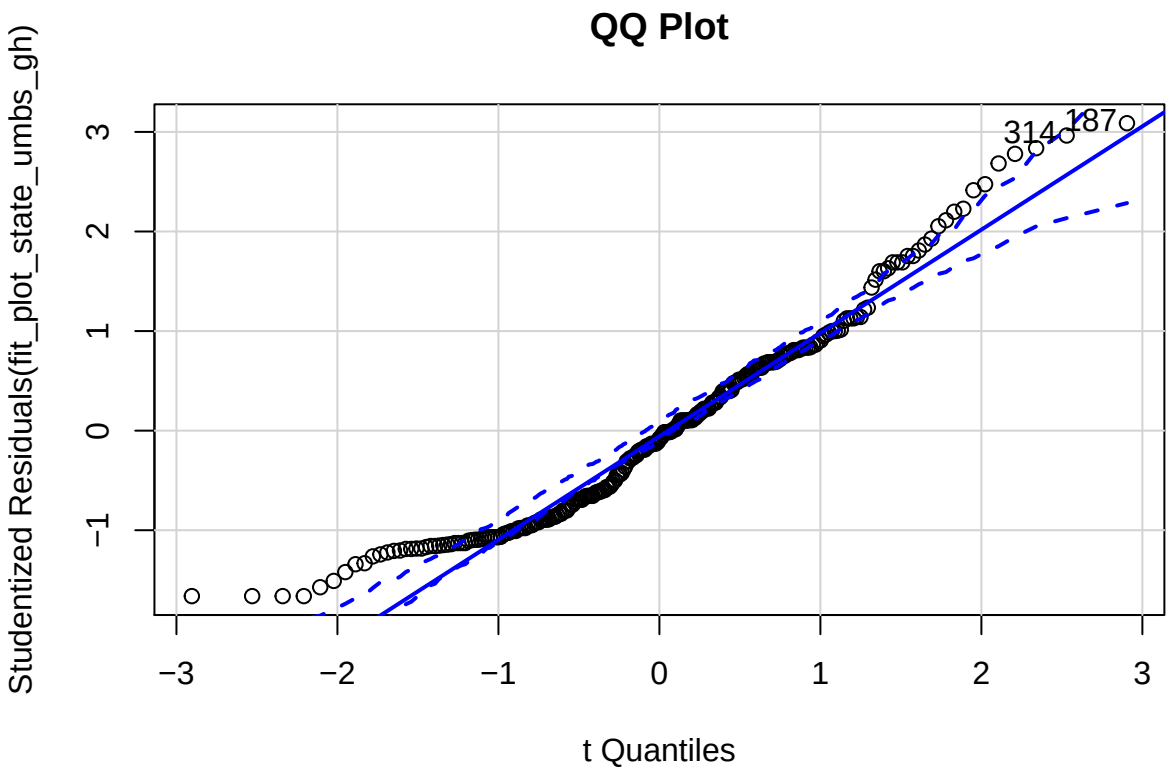
```
# Interaction plot (ignore for now the repeated measures with species); see:
# https://cran.r-project.org/web/packages/interactions/vignettes/interactions.html
# and: https://interactions.jacob-long.com/

fit3 <- lm(flwr_duration_scaled ~ state * year_factor, data = umbs_flwr_plot_origin)
interact_plot(fit3, pred = year_factor, modx = state)
```




```
# Plot level GROWTH HABIT data UMBS State-only model
fit_plot_state_umbs_gh <- lm(flwr_duration_scaled ~ state, data = umbs_flwr_plot_growthhabit)
outlierTest(fit_plot_state_umbs_gh)  # no outliers
```

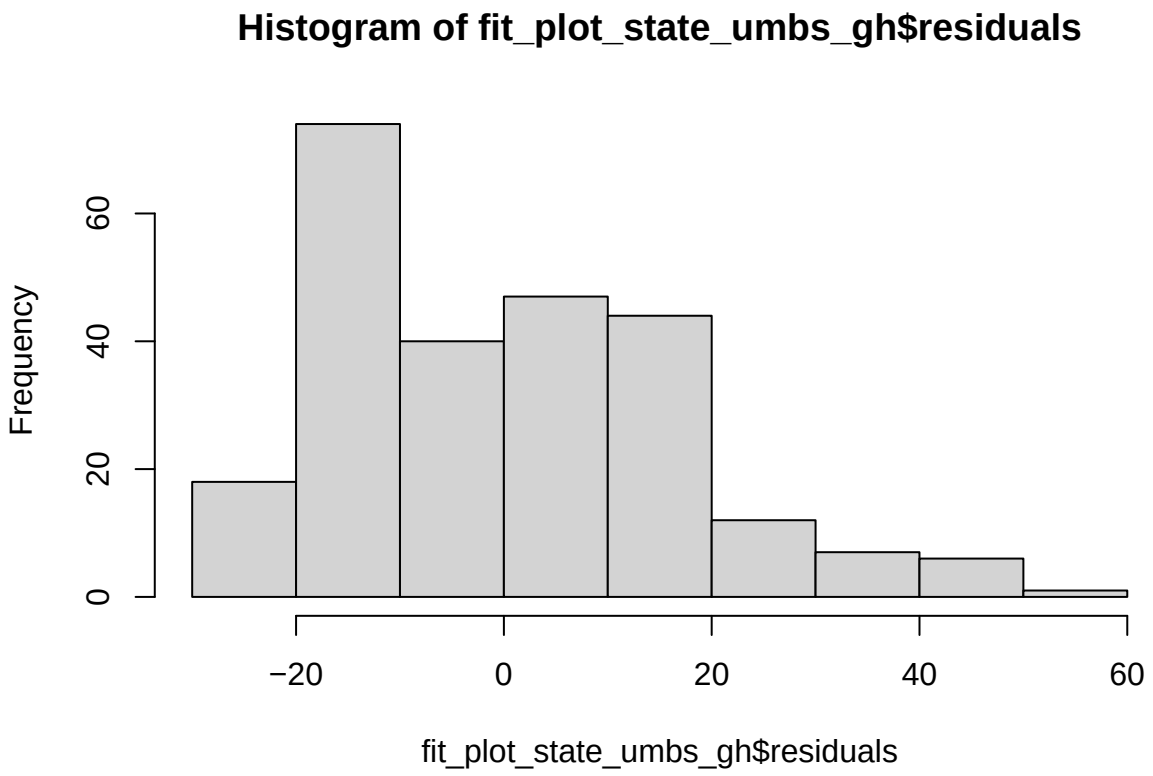
```
## No Studentized residuals with Bonferroni p < 0.05
## Largest |rstudent|:
##     rstudent unadjusted p-value Bonferroni p
## 187 3.087383          0.0022507      0.56042
```

```
qqPlot(fit_plot_state_umbs_gh, main = "QQ Plot")
```

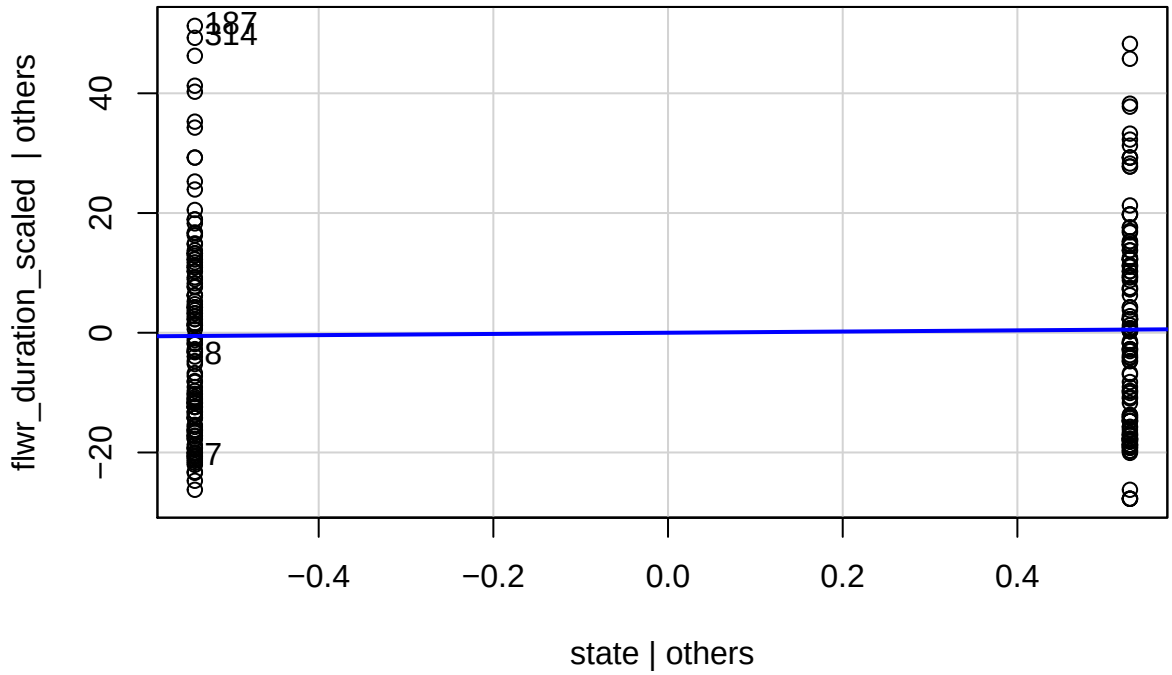



```
## 187 314
##  71 118
```

```
hist(fit_plot_state_umbs_gh$residuals)
```




```
leveragePlots(fit_plot_state_umbs_gh)
```




```
ols_test_normality(fit_plot_state_umbs_gh)  # these don't look great...
```

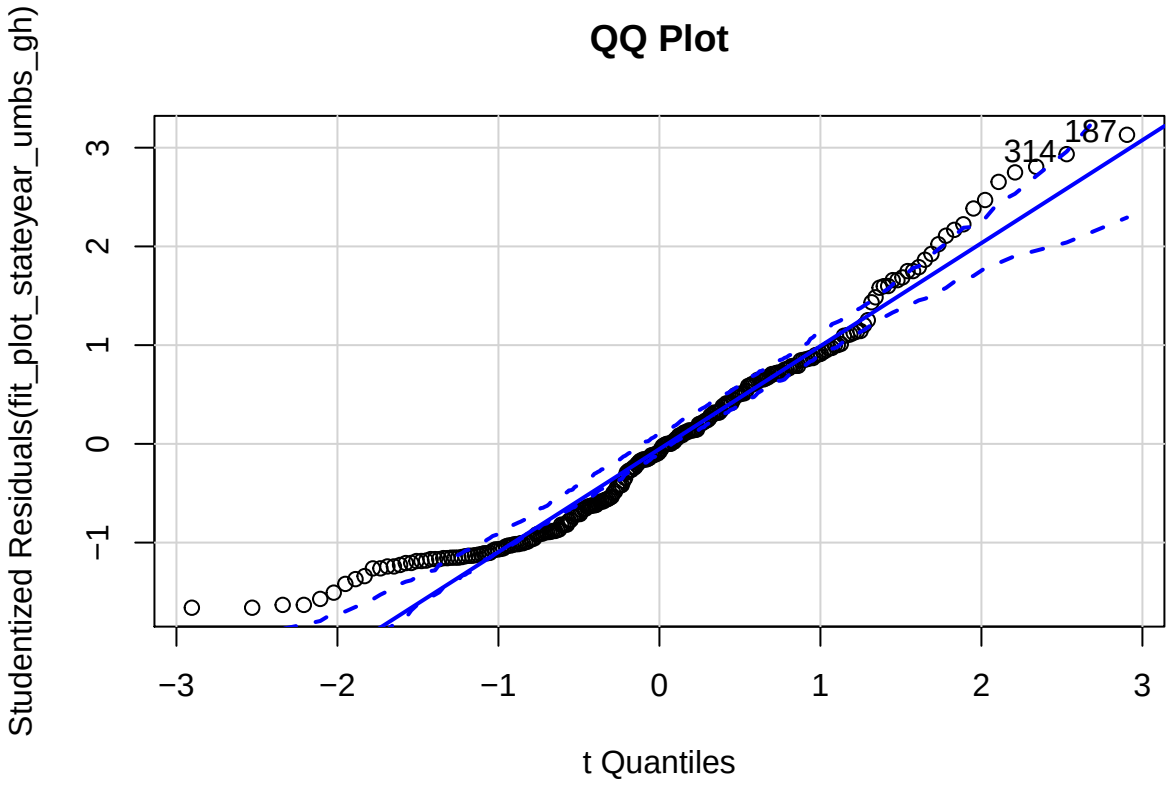
```
## Warning in ks.test(y, "pnorm", mean(y), sd(y)): ties should not be present for
## the Kolmogorov-Smirnov test
```

```
## ------------------------------------------------
##        Test             Statistic       pvalue
## ------------------------------------------------
## Shapiro-Wilk              0.9527         0.0000
## Kolmogorov-Smirnov        0.0941         0.0242
## Cramer-von Mises         20.5537         0.0000
## Anderson-Darling          2.9721         0.0000
## ------------------------------------------------
```

```
# UMBS State and year model
fit_plot_stateyear_umbs_gh <- lm(flwr_duration_scaled ~ state + year_factor, data = umbs_flwr_plot_grow
outlierTest(fit_plot_stateyear_umbs_gh)  # no outliers
```

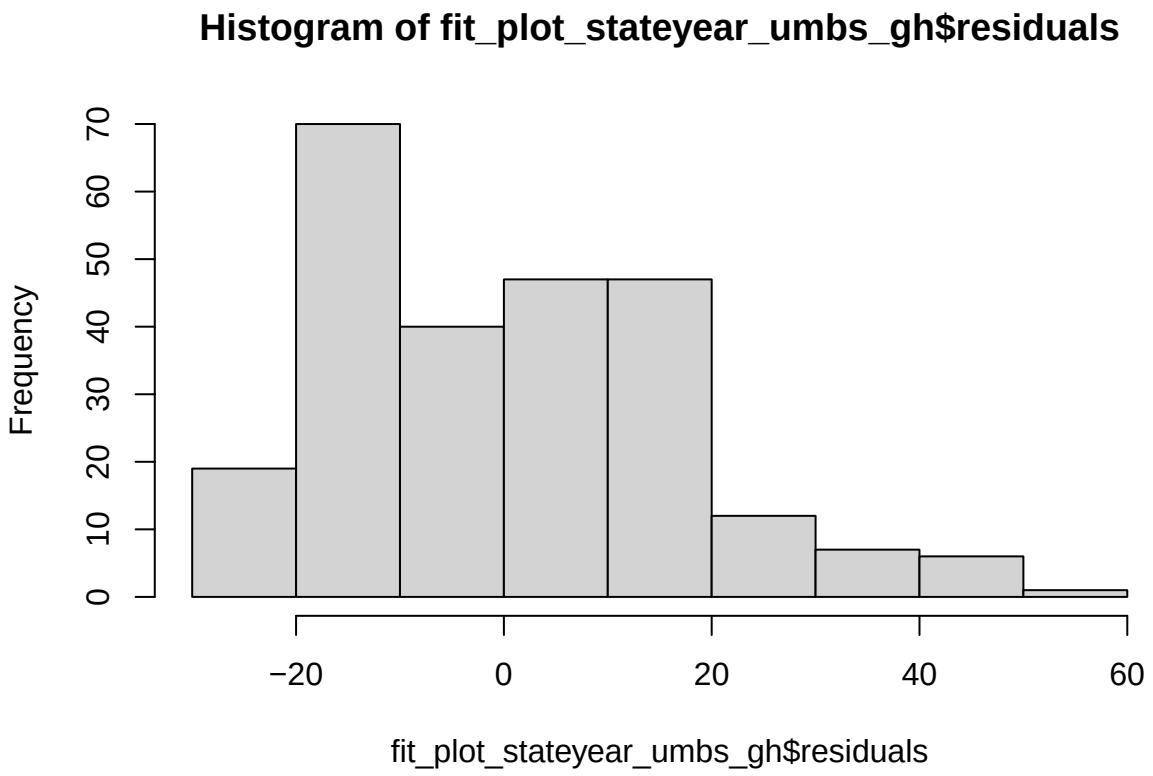
```
## No Studentized residuals with Bonferroni p < 0.05
## Largest |rstudent|:
##     rstudent unadjusted p-value Bonferroni p
## 187 3.130744          0.0019553      0.48687
```

```
qqPlot(fit_plot_stateyear_umbs_gh, main = "QQ Plot")
```

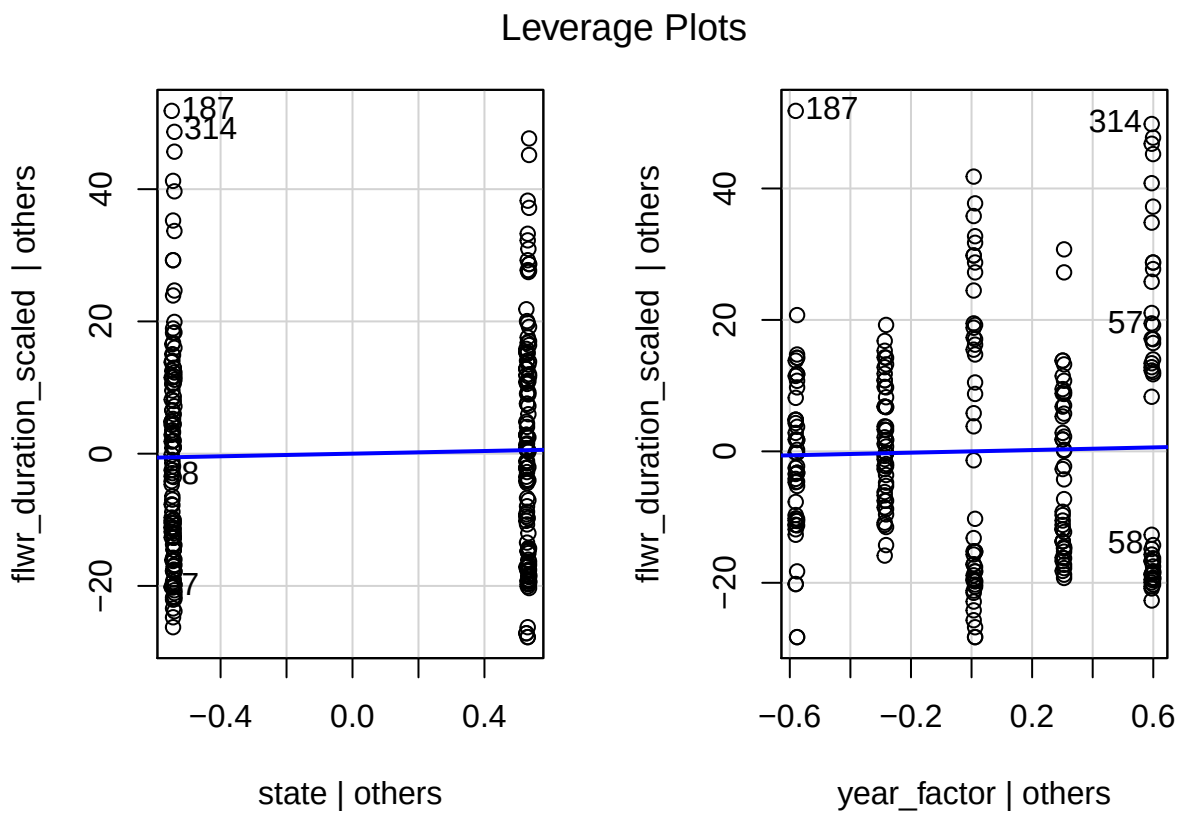



```
## 187 314
##  71 118
```

```
hist(fit_plot_stateyear_umbs_gh$residuals)
```




```
leveragePlots(fit_plot_stateyear_umbs_gh)
```

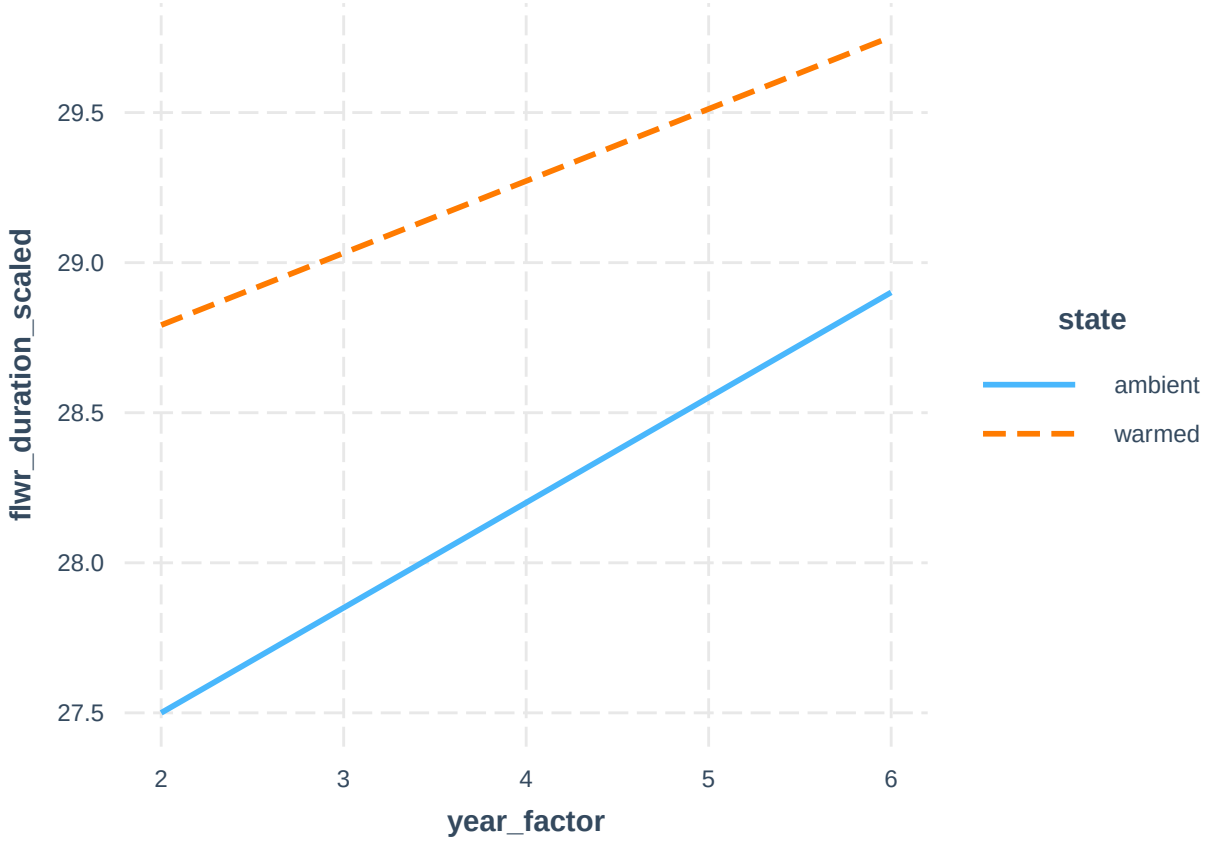


```
ols_test_normality(fit_plot_stateyear_umbs_gh)  # these don't look great either
```

```
## Warning in ks.test(y, "pnorm", mean(y), sd(y)): ties should not be present for
## the Kolmogorov-Smirnov test
```

```
## -----------------------------------------------
##        Test             Statistic       pvalue
## -----------------------------------------------
## Shapiro-Wilk              0.9548         0.0000
## Kolmogorov-Smirnov        0.0886         0.0403
## Cramer-von Mises         20.4142         0.0000
## Anderson-Darling          2.7947         0.0000
## -----------------------------------------------
```

```
# Interaction plot (ignore for now the repeated measures with species); see:
# https://cran.r-project.org/web/packages/interactions/vignettes/interactions.html
# and: https://interactions.jacob-long.com/

fit3 <- lm(flwr_duration_scaled ~ state * year_factor, data = umbs_flwr_plot_growthhabit)
interact_plot(fit3, pred = year_factor, modx = state)
```



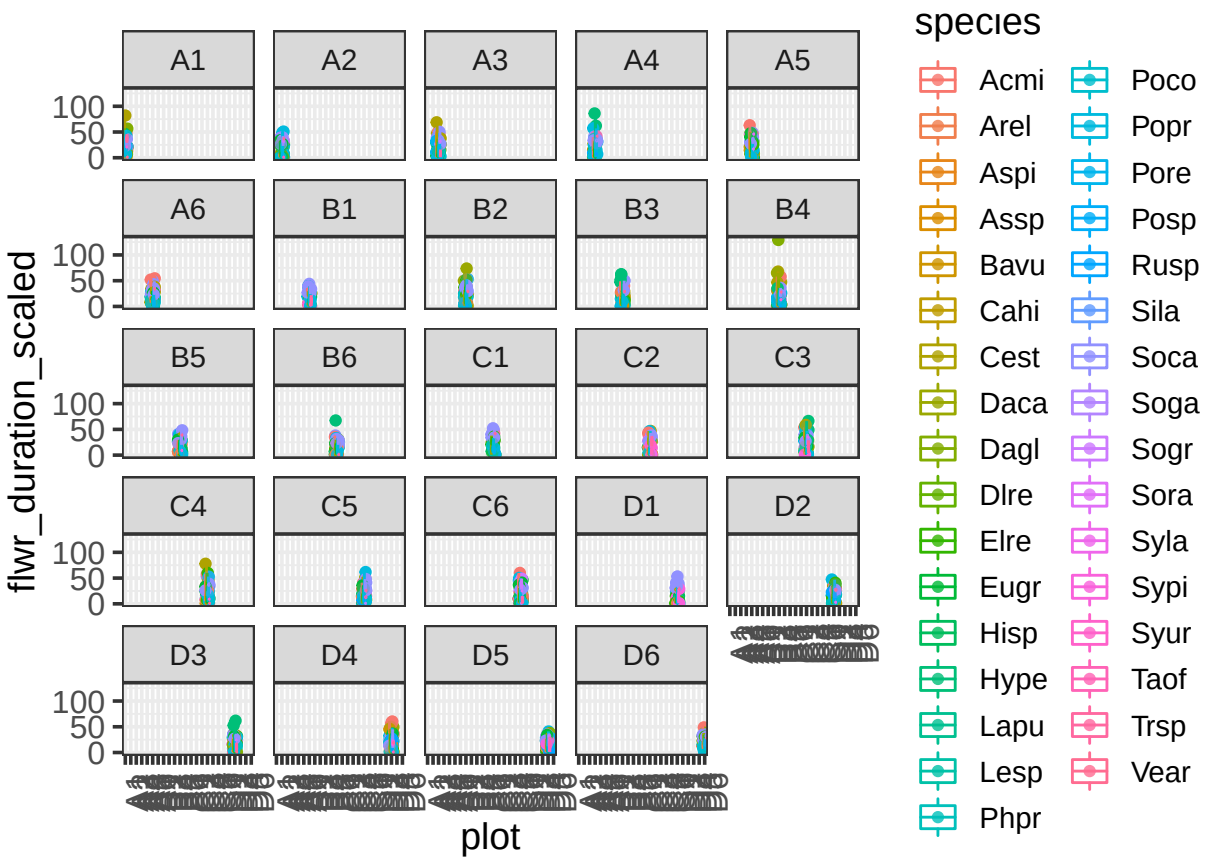
MIXED EFFECT MODELS

KBS

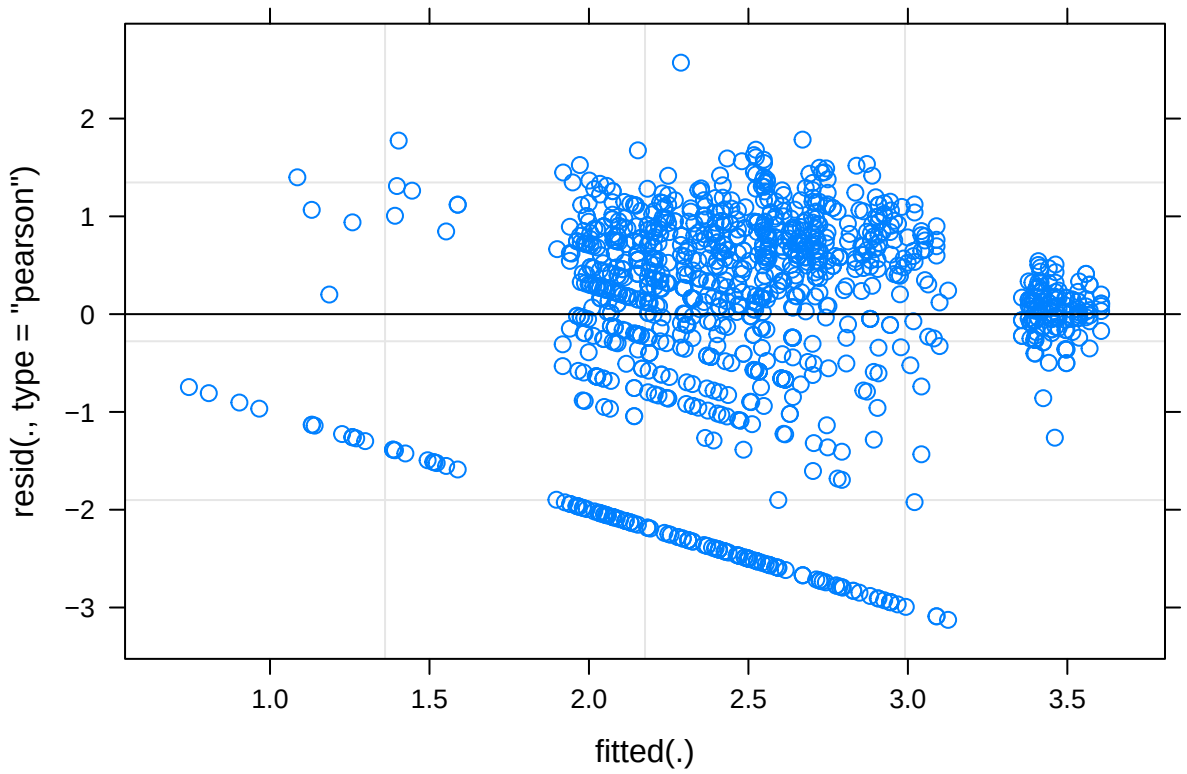
```
# KBS SPECIES LEVEL - Looking at DURATION of flowering
mod1 <- lmer(log(flwr_duration_scaled) ~ state * year_factor + insecticide * year_factor +
    (1 | species) + (1 | plot), kbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
ggplot(kbs_flwr_spp, aes(x = plot, y = flwr_duration_scaled, col = species)) + geom_jitter() +
    geom_boxplot(alpha = 0.2) + facet_wrap(~plot)
```




```
# Check Assumptions: (1) Linearity: if covariates are not categorical (year
# isn't) (2) Homogeneity: Need to Check by plotting residuals vs predicted
# values.
par(mfrow = c(1, 2))
plot(mod1)  # the ones in the data are making this look weird - idk this doesn't look great
```




```
# Homogeneity of variance looks weird here Check for homogeneity of variances
# (true if p>0.05). If the result is not significant, the assumption of equal
# variances (homoscedasticity) is met (no significant difference between the
# group variances).  *****Levene's Test - tests whether or not the variance among
# two or more groups is equal - If the p-value is less than our chosen
# significance level, we can reject the null hypothesis and conclude that we have
# enough evidence to state that the variance among the groups is not equal (which
# we want).

leveneTest(residuals(mod1) ~ kbs_flwr_spp$state)
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##         Df F value Pr(>F)
## group    1  0.5122 0.4744
##       1149
```

```
# Assumption not met
leveneTest(residuals(mod1) ~ kbs_flwr_spp$species)
```

```
## Warning in leveneTest.default(y = y, group = group, ...): group coerced to
## factor.
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##         Df F value    Pr(>F)
## group   32  3.5061 3.174e-10 ***
##       1118
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
# Assumption met
leveneTest(residuals(mod1) ~ kbs_flwr_spp$insecticide)
```

```
## Warning in leveneTest.default(y = y, group = group, ...): group coerced to
## factor.
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##         Df F value Pr(>F)
## group    1  0.5721 0.4496
##       1149
```

```r
# Assumption not met - this seems weird
leveneTest(residuals(mod1) ~ kbs_flwr_spp$plot)
```

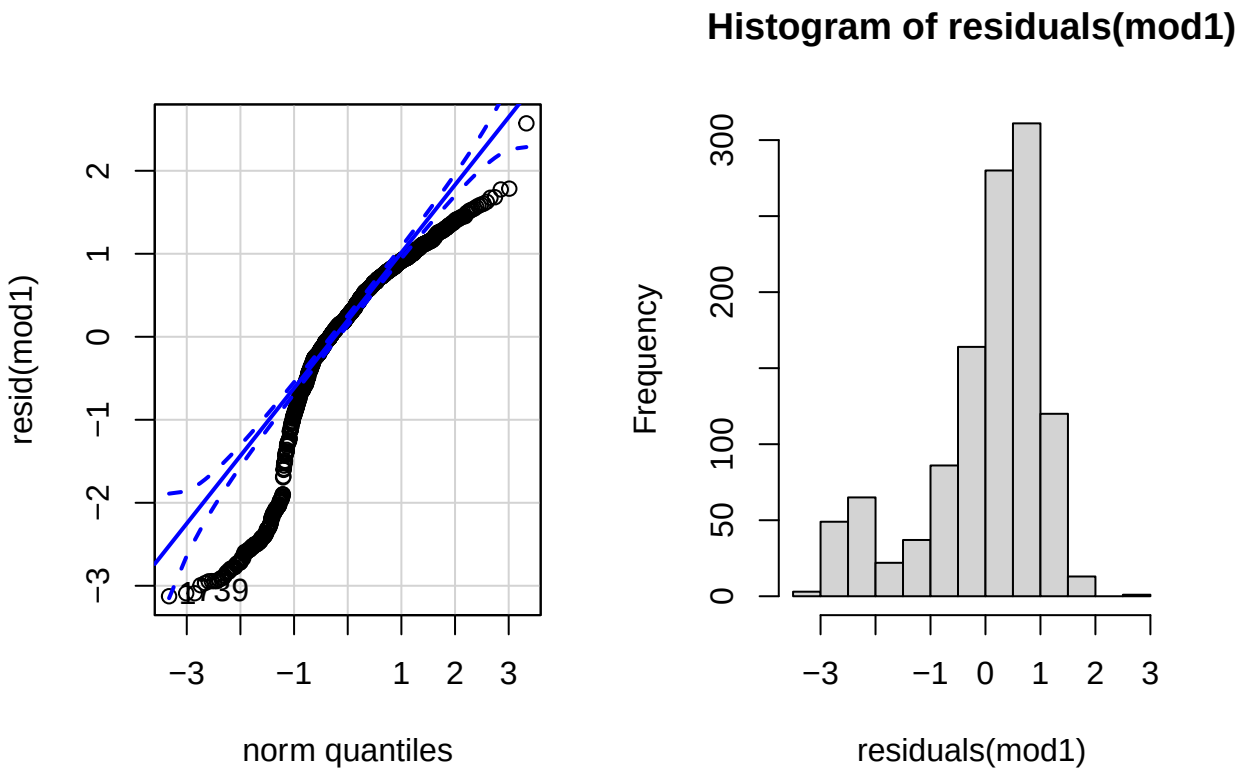
```
## Warning in leveneTest.default(y = y, group = group, ...): group coerced to
## factor.
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##         Df F value Pr(>F)
## group   23   0.901 0.5979
##       1127
```

```r
# Assumption not met

# (3) Normality of error term: need to check by histogram, QQplot of residuals,
# could do Kolmogorov-Smirnov test.  Check for normal residuals
qqPlot(resid(mod1))
```

```
##   1 739
##   1 478
```

```r
hist(residuals(mod1))
```




```
shapiro.test(resid(mod1))  # not normally distributed resids bc p<0.05
```

```
##
##  Shapiro-Wilk normality test
##
## data:  resid(mod1)
## W = 0.88491, p-value < 2.2e-16
```

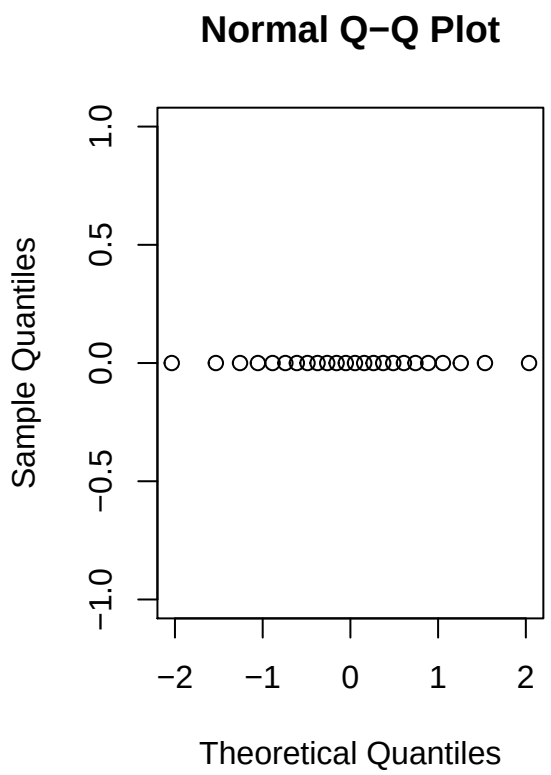
```
outlierTest(mod1)  # no outliers
```

```
## No Studentized residuals with Bonferroni p < 0.05
## Largest |rstudent|:
##    rstudent unadjusted p-value Bonferroni p
## 1 -2.927841           0.003481           NA
```

```
# (4) Normality of random effect: Get the estimate of random effect (e.g., random
# intercepts), and check them as you would check the residual.
require(lme4)
r_int <- ranef(mod1)$plot$`(Intercept)`
qqnorm(r_int)
# qqline(r_int) doesn't work
shapiro.test(r_int)
```

```
## Error in shapiro.test(r_int): all 'x' values are identical
```

```
# Not normally distributed random effect - p-value = 0.0015
```




```
# Do we need to include plot as a random effect with the KBS models?
mod1 <- lmer(log(flwr_duration_scaled) ~ state * year_factor + insecticide * year_factor +
    (1 | species) + (1 | plot), kbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod2 <- lmer(log(flwr_duration_scaled) ~ state * year_factor + insecticide * year_factor +
    (1 | species), kbs_flwr_spp, REML = FALSE)
# Run analysis of variance on each model (see this for more explanation on how
# anova on a linear mixed effects model is similar to an anove on a regular
# linear model: https://m-clark.github.io/docs/mixedModels/anovamixed.html)
anova(mod1)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##                           Sum Sq Mean Sq NumDF  DenDF F value Pr(>F)
## state                    0.28814 0.28814     1 1115.4  0.2466 0.6195
## year_factor              1.36080 1.36080     1 1147.9  1.1648 0.2807
## insecticide              1.46275 1.46275     1 1112.9  1.2521 0.2634
## state:year_factor        0.20099 0.20099     1 1115.2  0.1720 0.6784
## year_factor:insecticide 0.21197 0.21197     1 1114.0  0.1814 0.6702
```

```
anova(mod2)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
```

```
##                            Sum Sq Mean Sq NumDF  DenDF F value Pr(>F)
## state                     0.28814 0.28814     1 1115.4  0.2466 0.6195
## year_factor               1.36080 1.36080     1 1147.9  1.1648 0.2807
## insecticide               1.46275 1.46275     1 1112.9  1.2521 0.2634
## state:year_factor         0.20099 0.20099     1 1115.2  0.1720 0.6784
## year_factor:insecticide 0.21197 0.21197     1 1114.0  0.1814 0.6702
```

```
anova(mod1, mod2)  # Go with model 2 since pvalue >0.05, aka more complex model does not have something
```

```
## Data: kbs_flwr_spp
## Models:
## mod2: log(flwr_duration_scaled) ~ state * year_factor + insecticide *
## mod2:     year_factor + (1 | species)
## mod1: log(flwr_duration_scaled) ~ state * year_factor + insecticide *
## mod1:     year_factor + (1 | species) + (1 | plot)
##      npar    AIC    BIC  logLik deviance Chisq Df Pr(>Chisq)
## mod2    8 3530.2 3570.6 -1757.1   3514.2
## mod1    9 3532.2 3577.7 -1757.1   3514.2     0  1          1
```

```
summ(mod1)
```

Observations	1151
Dependent variable	log(flwr_duration_scaled)
Type	Mixed effects linear regression

AIC	3532.23
BIC	3577.66
Pseudo-R^2 (fixed effects)	0.00
Pseudo-R^2 (total)	0.29

Fixed Effects

	Est.	S.E.	t val.	d.f.	p
(Intercept)	2.15	0.19	11.20	69.97	0.00
stateambient	0.08	0.16	0.50	1115.38	0.62
year_factor	-0.01	0.03	-0.20	1129.68	0.84
insecticideno_insects	0.17	0.16	1.12	1112.89	0.26
stateambient:year_factor	-0.01	0.04	-0.41	1115.24	0.68
year_factor:insecticideno_insects	-0.02	0.04	-0.43	1114.01	0.67

p values calculated using Satterthwaite d.f.

Random Effects

Group	Parameter	Std. Dev.
species	(Intercept)	0.69
plot	(Intercept)	0.00
Residual		1.08

Grouping Variables		
Group	# groups	ICC
species	33	0.29
plot	24	0.00

```
summ(mod2)
```

Observations	1151
Dependent variable	log(flwr_duration_scaled)
Type	Mixed effects linear regression

AIC	3530.23
BIC	3570.61
Pseudo-R^2 (fixed effects)	0.00
Pseudo-R^2 (total)	0.29

Fixed Effects					
	Est.	S.E.	t val.	d.f.	p
(Intercept)	2.15	0.19	11.20	69.97	0.00
stateambient	0.08	0.16	0.50	1115.38	0.62
year_factor	-0.01	0.03	-0.20	1129.68	0.84
insecticideno_insects	0.17	0.16	1.12	1112.89	0.26
stateambient:year_factor	-0.01	0.04	-0.41	1115.24	0.68
year_factor:insecticideno_insects	-0.02	0.04	-0.43	1114.01	0.67

p values calculated using Satterthwaite d.f.

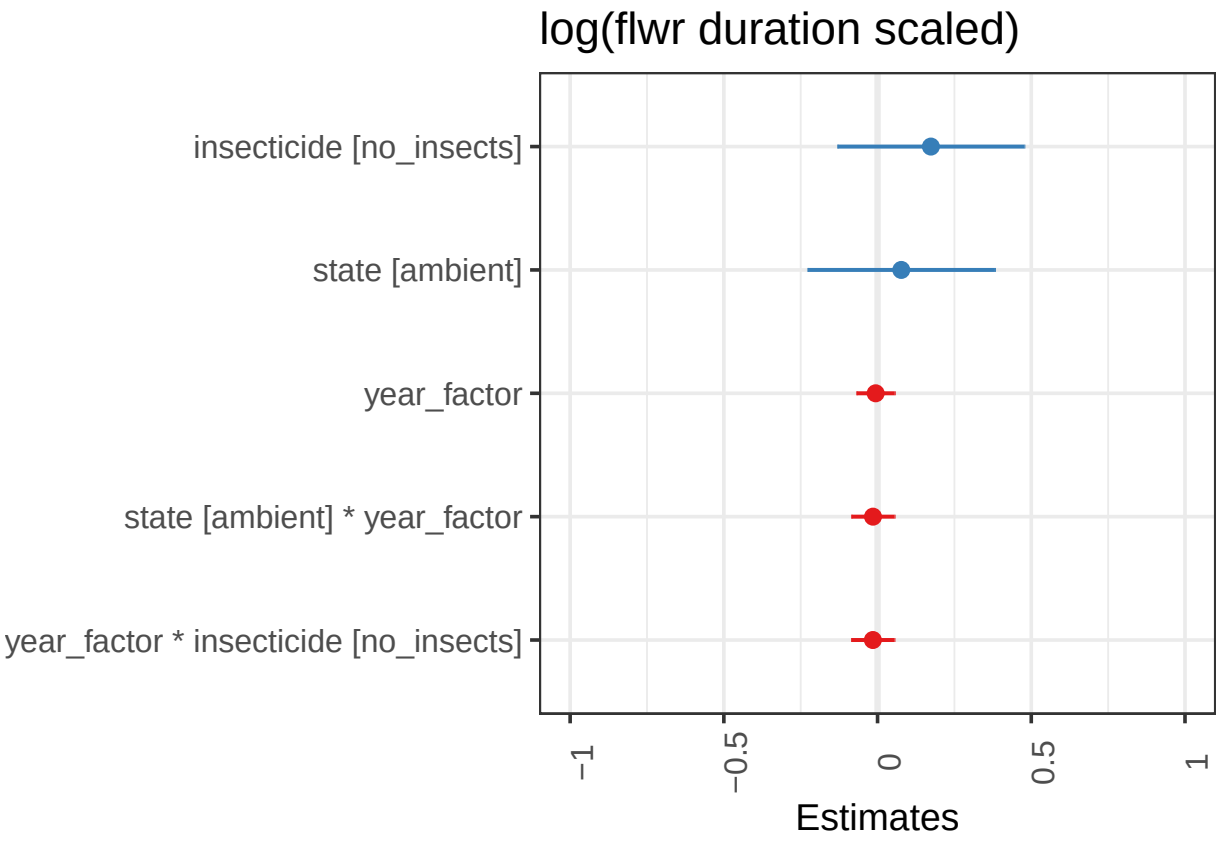
Random Effects		
Group	Parameter	Std. Dev.
species	(Intercept)	0.69
Residual		1.08

Grouping Variables		
Group	# groups	ICC
species	33	0.29

```
AICctab(mod1, mod2, weights = T)
```

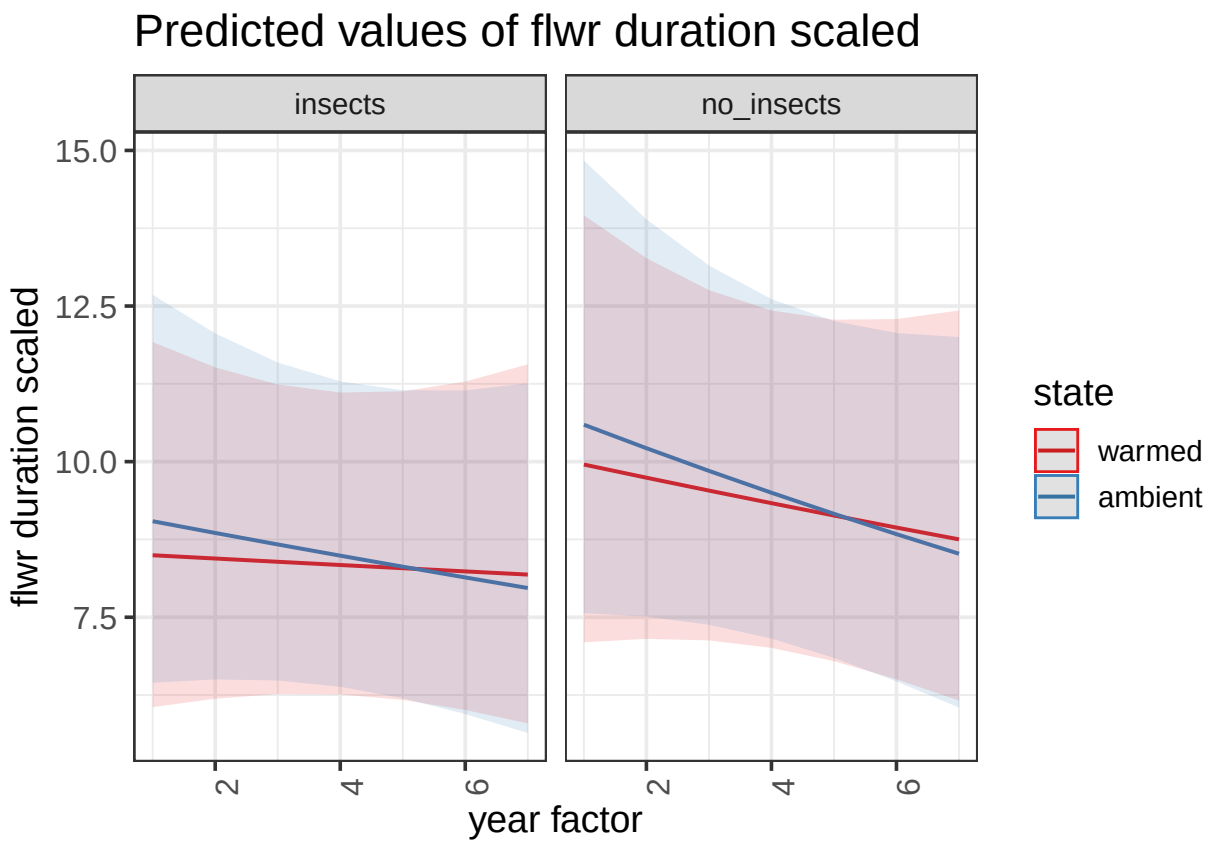
```
##      dAICc df weight
## mod2 0.0   8  0.73
## mod1 2.0   9  0.27
```

```
# Plot the fixed effects estimates for different models these are the fixed
# effects estimates from summary(mod1)
plot_model(mod2, sort.est = TRUE)
```

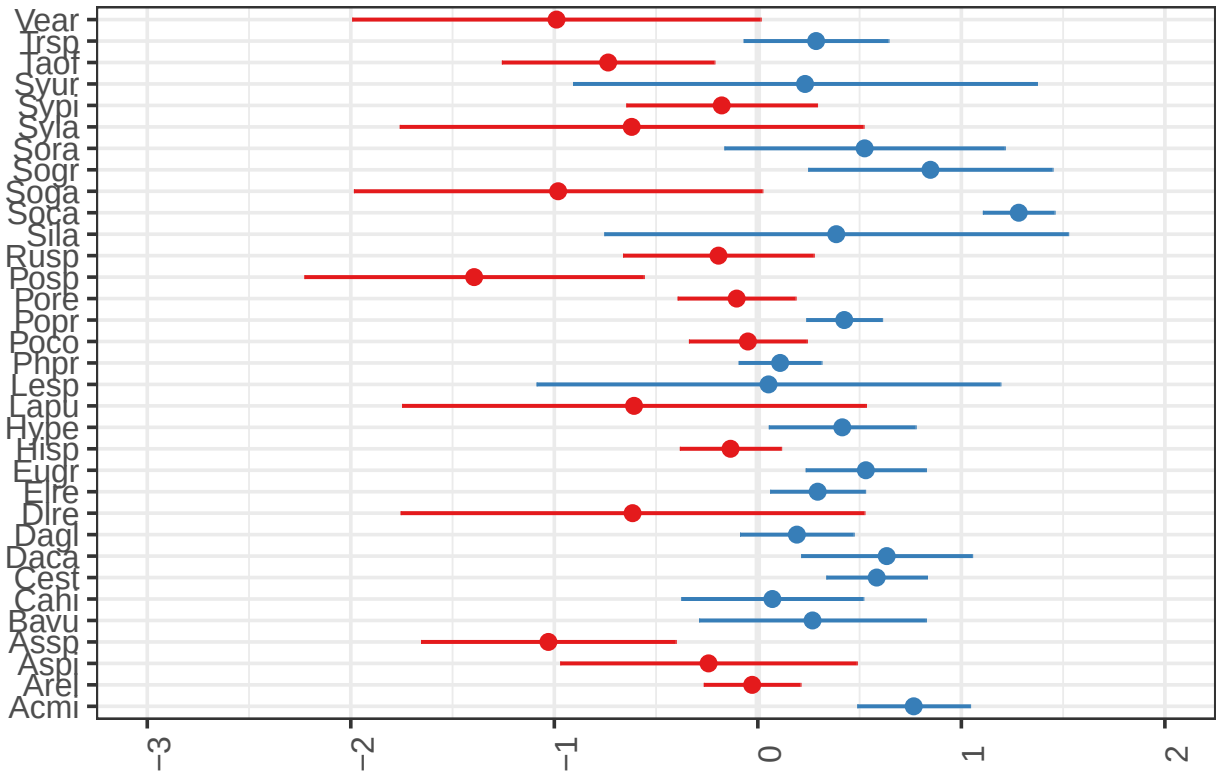



```
# these are the fixed predicted values:
plot_model(mod2, type = "pred", terms = c("year_factor", "state", "insecticide"))
```

```
## Model has log-transformed response. Back-transforming predictions to original response scale. Standa
```




```
# these are the random effects estimates
plot_model(mod2, type = "re", terms = c("species"))
```




```
# Do we need to include insecticide? (dropping insecticide from the model) mod2
# <- lmer(log(relabun) ~ state*year_factor + insecticide*year_factor +
# (1|species), comp_kbs_spp, REML=FALSE)
mod3 <- lmer(log(flwr_duration_scaled) ~ state * year_factor + (1 | species), kbs_flwr_spp,
    REML = FALSE)
anova(mod2, mod3)
```

```
## Data: kbs_flwr_spp
## Models:
## mod3: log(flwr_duration_scaled) ~ state * year_factor + (1 | species)
## mod2: log(flwr_duration_scaled) ~ state * year_factor + insecticide *
## mod2:     year_factor + (1 | species)
##      npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## mod3    6 3529.5 3559.8 -1758.7   3517.5
## mod2    8 3530.2 3570.6 -1757.1   3514.2 3.2452  2     0.1974
```

```
AICctab(mod2, mod3, weights = T)
```

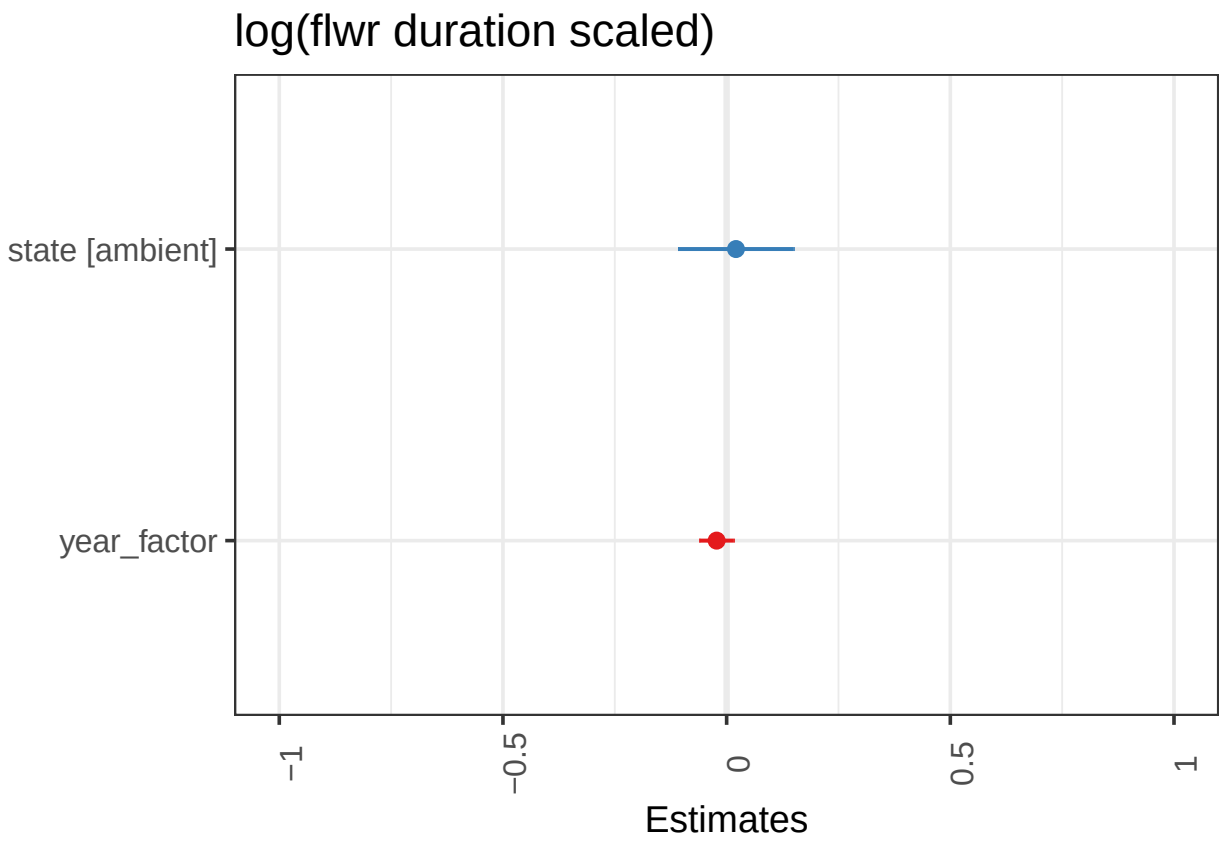
```
##      dAICc df weight
## mod3 0.0   6  0.6
## mod2 0.8   8  0.4
```

```
# Looks like no, pvalue > 0.05, so insecticide does not improve model fit so we
# will go with mod 3
```

```r
# Does year need to be interactive with insecticide? - already removed
# insecticide mod4 <- lmer(log(julian_median) ~ state*year_factor + insecticide +
# (1|species) + (1|plot), umbs_flwr_spp, REML=FALSE)

# Does year need to be interactive with state?
mod5 <- lmer(log(flwr_duration_scaled) ~ state + year_factor + (1 | species), kbs_flwr_spp,
    REML = FALSE)
anova(mod3, mod5)
```

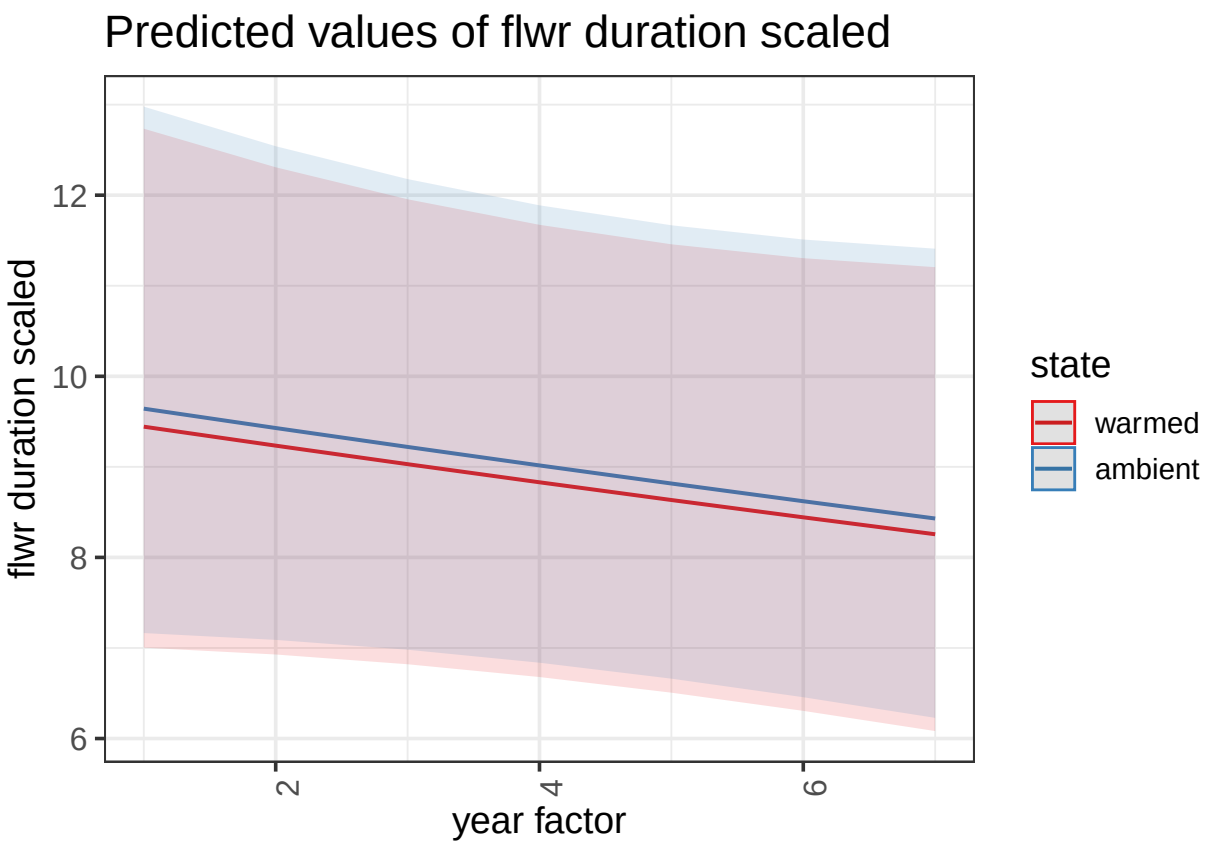
```
## Data: kbs_flwr_spp
## Models:
## mod5: log(flwr_duration_scaled) ~ state + year_factor + (1 | species)
## mod3: log(flwr_duration_scaled) ~ state * year_factor + (1 | species)
##      npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## mod5    5 3527.6 3552.9 -1758.8   3517.6
## mod3    6 3529.5 3559.8 -1758.7   3517.5 0.1538  1     0.6949
```

```r
# No, P>0.05 so state*year_factor doesn't strongly improve model fit so we will
# shift to mod5, but AIC values are super close!!

# Plot the fixed effects estimates for different models these are the fixed
# effects estimates from summary(mod5)
plot_model(mod5, sort.est = TRUE)
```

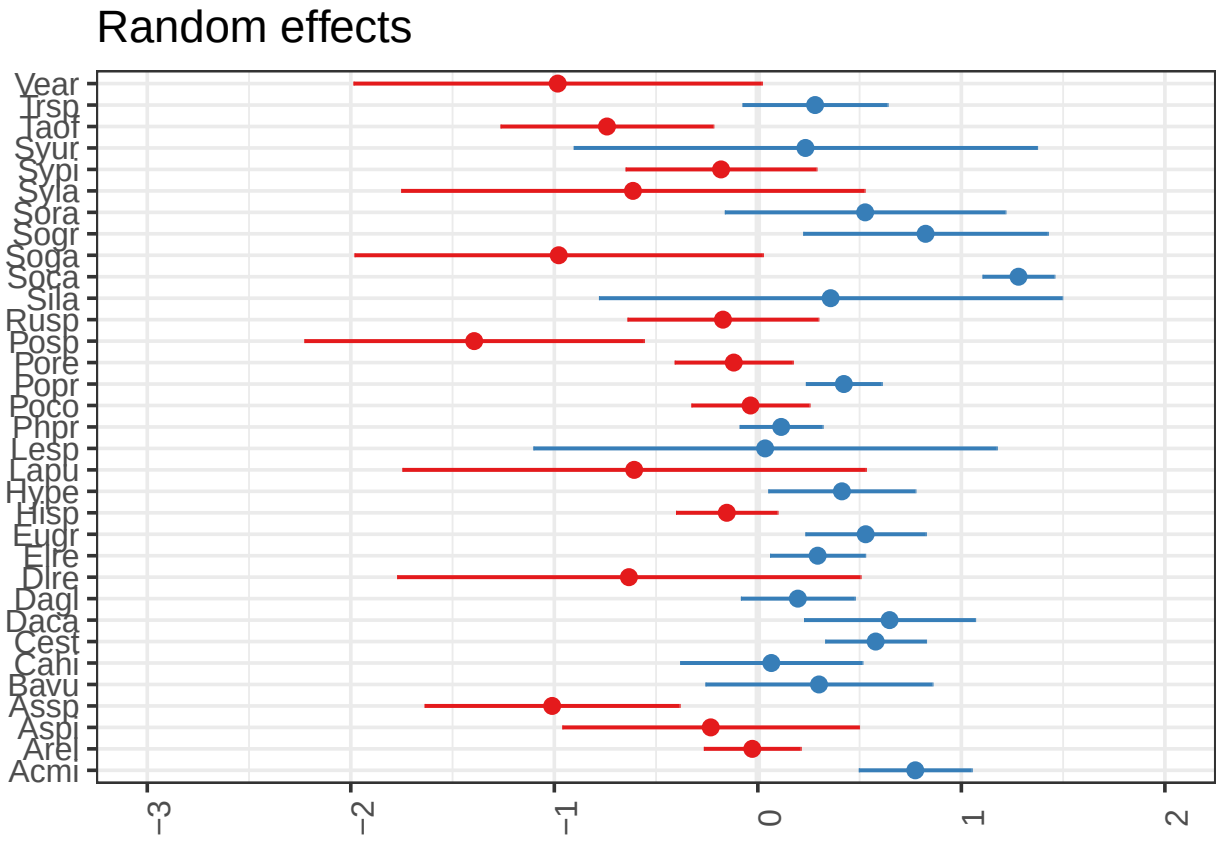


```r
# these are the fixed predicted values:
plot_model(mod5, type = "pred", terms = c("year_factor", "state"))
```

```
## Model has log-transformed response. Back-transforming predictions to original response scale. Standa
```




```r
# these are the random effects estimates
plot_model(mod5, type = "re", terms = c("species"))
```




```
# If we wanted to include plots nested within year it would look like this:
mod6 <- lmer(log(flwr_duration_scaled) ~ state + year_factor + (1 | species) + (1 +
    year_factor | plot), kbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
anova(mod5, mod6)
```

```
## Data: kbs_flwr_spp
## Models:
## mod5: log(flwr_duration_scaled) ~ state + year_factor + (1 | species)
## mod6: log(flwr_duration_scaled) ~ state + year_factor + (1 | species) +
## mod6:     (1 + year_factor | plot)
##      npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## mod5    5 3527.6 3552.9 -1758.8   3517.6
## mod6    8 3530.6 3571.0 -1757.3   3514.6 3.0431  3      0.385
```

```
AICctab(mod5, mod6, weights = T)
```

```
##      dAICc df weight
## mod5 0.0   5  0.82
## mod6 3.0   8  0.18
```

```
anova(mod5)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##              Sum Sq Mean Sq NumDF  DenDF F value Pr(>F)
## state       0.11699 0.11699     1 1128.7  0.0998 0.7521
## year_factor 1.51470 1.51470     1 1147.8  1.2925 0.2558
```

```
# We can consider an alternative model that's simpler to understand and also one
# that provides more insight about the species. That would be something like
# this:
mod7 <- lmer(log(flwr_duration_scaled) ~ state + species + (1 + factor(year_factor) |
    plot), kbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod7a <- lmer(log(flwr_duration_scaled) ~ state + species + factor(year_factor) +
    (1 | plot), kbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod7b <- lmer(log(flwr_duration_scaled) ~ state * factor(year_factor) + species +
    (1 | plot), kbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod7c <- lmer(log(flwr_duration_scaled) ~ state + species + factor(year_factor) +
    insecticide + (1 | plot), kbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
anova(mod5, mod7)  # model 7 is a better fit to data
```

```
## Data: kbs_flwr_spp
## Models:
## mod5: log(flwr_duration_scaled) ~ state + year_factor + (1 | species)
## mod7: log(flwr_duration_scaled) ~ state + species + (1 + factor(year_factor) |
## mod7:     plot)
##      npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## mod5    5 3527.6 3552.9 -1758.8   3517.6
## mod7   63 3290.5 3608.6 -1582.2   3164.5 353.12 58  < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
anova(mod7, mod7a)  #mod 7a
```

```
## Data: kbs_flwr_spp
## Models:
## mod7a: log(flwr_duration_scaled) ~ state + species + factor(year_factor) +
```

```
## mod7a:     (1 | plot)
## mod7: log(flwr_duration_scaled) ~ state + species + (1 + factor(year_factor) |
## mod7:     plot)
##       npar    AIC    BIC  logLik deviance Chisq Df Pr(>Chisq)
## mod7a   42 3199.6 3411.6 -1557.8   3115.6
## mod7    63 3290.5 3608.6 -1582.2   3164.5     0 21          1
```

```
anova(mod7a, mod7b)  #mod 7a - interaction between state and year does not improve model go with simple
```

```
## Data: kbs_flwr_spp
## Models:
## mod7a: log(flwr_duration_scaled) ~ state + species + factor(year_factor) +
## mod7a:     (1 | plot)
## mod7b: log(flwr_duration_scaled) ~ state * factor(year_factor) + species +
## mod7b:     (1 | plot)
##       npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## mod7a   42 3199.6 3411.6 -1557.8   3115.6
## mod7b   48 3209.3 3451.6 -1556.7   3113.3 2.2869  6     0.8915
```

```
anova(mod7a, mod7c)  #models are not different than one another, go with simpler model = mod7a
```

```
## Data: kbs_flwr_spp
## Models:
## mod7a: log(flwr_duration_scaled) ~ state + species + factor(year_factor) +
## mod7a:     (1 | plot)
## mod7c: log(flwr_duration_scaled) ~ state + species + factor(year_factor) +
## mod7c:     insecticide + (1 | plot)
##       npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## mod7a   42 3199.6 3411.6 -1557.8   3115.6
## mod7c   43 3200.4 3417.5 -1557.2   3114.4 1.2371  1      0.266
```

```
summary(mod7a)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: log(flwr_duration_scaled) ~ state + species + factor(year_factor) +
##     (1 | plot)
##    Data: kbs_flwr_spp
##
##      AIC      BIC   logLik deviance df.resid
##   3199.6   3411.6  -1557.8   3115.6     1109
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.6381 -0.3669  0.1663  0.5936  2.8919
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  plot     (Intercept) 0.0000   0.0000
##  Residual             0.8772   0.9366
## Number of obs: 1151, groups:  plot, 24
##
```

```
## Fixed effects:
##                         Estimate Std. Error         df t value Pr(>|t|)
## (Intercept)              1.37159    0.16646 1151.00000   8.240 4.65e-16 ***
## stateambient            -0.02860    0.05754 1151.00000  -0.497 0.619258
## speciesArel             -0.92604    0.16877 1151.00000  -5.487 5.03e-08 ***
## speciesAspi             -1.37385    0.40594 1151.00000  -3.384 0.000737 ***
## speciesAssp             -2.39186    0.33958 1151.00000  -7.044 3.22e-12 ***
## speciesBavu             -0.56878    0.30029 1151.00000  -1.894 0.058463 .
## speciesCahi             -1.11291    0.24634 1151.00000  -4.518 6.89e-06 ***
## speciesCest              0.11516    0.16872 1151.00000   0.683 0.495036
## speciesDaca             -0.14226    0.23258 1151.00000  -0.612 0.540895
## speciesDagl             -0.81921    0.17977 1151.00000  -4.557 5.74e-06 ***
## speciesDlre             -3.43605    0.94731 1151.00000  -3.627 0.000299 ***
## speciesElre             -0.58567    0.16696 1151.00000  -3.508 0.000469 ***
## speciesEugr              0.02179    0.18744 1151.00000   0.116 0.907472
## speciesHisp             -1.17902    0.16935 1151.00000  -6.962 5.63e-12 ***
## speciesHype             -0.05845    0.20898 1151.00000  -0.280 0.779767
## speciesLapu             -2.51215    0.95033 1151.00000  -2.643 0.008318 **
## speciesLesp             -1.24721    0.94810 1151.00000  -1.315 0.188611
## speciesPhpr             -0.68003    0.15614 1151.00000  -4.355 1.45e-05 ***
## speciesPoco             -0.91746    0.18682 1151.00000  -4.911 1.04e-06 ***
## speciesPopr             -0.52308    0.15310 1151.00000  -3.417 0.000656 ***
## speciesPore             -1.02770    0.18212 1151.00000  -5.643 2.10e-08 ***
## speciesPosp             -1.35729    0.49611 1151.00000  -2.736 0.006317 **
## speciesRusp             -1.12566    0.25520 1151.00000  -4.411 1.13e-05 ***
## speciesSila              0.22187    0.94706 1151.00000   0.234 0.814814
## speciesSoca              0.37146    0.15097 1151.00000   2.461 0.014019 *
## speciesSoga             -3.53550    0.67748 1151.00000  -5.219 2.14e-07 ***
## speciesSogr             -0.27801    0.32506 1151.00000  -0.855 0.392575
## speciesSora             -0.50070    0.37997 1151.00000  -1.318 0.187849
## speciesSyla             -2.48355    0.94999 1151.00000  -2.614 0.009058 **
## speciesSypi             -1.08779    0.25955 1151.00000  -4.191 2.99e-05 ***
## speciesSyur              0.46089    0.94999 1151.00000   0.485 0.627662
## speciesTaof             -2.03824    0.28063 1151.00000  -7.263 6.96e-13 ***
## speciesTrsp              0.11860    0.21049 1151.00000   0.563 0.573252
## speciesVear             -3.47862    0.67519 1151.00000  -5.152 3.03e-07 ***
## factor(year_factor)2     1.87227    0.13083 1151.00000  14.311  < 2e-16 ***
## factor(year_factor)3     2.06446    0.13882 1151.00000  14.872  < 2e-16 ***
## factor(year_factor)4     2.17821    0.13884 1151.00000  15.689  < 2e-16 ***
## factor(year_factor)5     1.59855    0.14194 1151.00000  11.262  < 2e-16 ***
## factor(year_factor)6     1.62751    0.14448 1151.00000  11.265  < 2e-16 ***
## factor(year_factor)7     1.14056    0.15036 1151.00000   7.586 6.79e-14 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 40 > 12.
## Use print(x, correlation=TRUE)  or
##     vcov(x)        if you need it

## optimizer (nloptwrap) convergence code: 0 (OK)
## boundary (singular) fit: see ?isSingular
```

```r
anova(mod7a)  # investigates whether at least one of the levels within each factor is significantly dif
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##                     Sum Sq Mean Sq NumDF DenDF F value Pr(>F)
## state                 0.22   0.217     1  1151   0.247 0.6193
## species             396.26  12.383    32  1151  14.117 <2e-16 ***
## factor(year_factor) 292.34  48.723     6  1151  55.543 <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
# Yes, at least one of the species is different (they do not all have the same
# relative abundances).
emmeans(mod7c, list(pairwise ~ state + year_factor), adjust = "tukey")
```

```
## $`emmeans of state, year_factor`
##  state   year_factor emmean    SE  df lower.CL upper.CL
##  warmed            1  0.342 0.146 891   0.0556    0.628
##  ambient           1  0.312 0.147 930   0.0225    0.601
##  warmed            2  2.210 0.109 605   1.9957    2.424
##  ambient           2  2.180 0.108 607   1.9675    2.392
##  warmed            3  2.402 0.109 569   2.1881    2.616
##  ambient           3  2.372 0.108 592   2.1594    2.585
##  warmed            4  2.516 0.109 582   2.3011    2.731
##  ambient           4  2.486 0.108 572   2.2744    2.698
##  warmed            5  1.941 0.117 639   1.7110    2.171
##  ambient           5  1.911 0.116 643   1.6841    2.138
##  warmed            6  1.966 0.120 694   1.7308    2.202
##  ambient           6  1.937 0.120 701   1.7012    2.172
##  warmed            7  1.484 0.121 670   1.2463    1.722
##  ambient           7  1.454 0.121 679   1.2166    1.692
##
## Results are averaged over the levels of: species, insecticide
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
## $`pairwise differences of state, year_factor`
##  1                     estimate     SE     df t.ratio p.value
##  warmed 1 - ambient 1   0.02984 0.0602   26.3   0.496 1.0000
##  warmed 1 - warmed 2   -1.86800 0.1333 1189.9 -14.010 <.0001
##  warmed 1 - ambient 2  -1.83817 0.1440  541.7 -12.768 <.0001
##  warmed 1 - warmed 3   -2.06031 0.1415 1189.7 -14.564 <.0001
##  warmed 1 - ambient 3  -2.03048 0.1517  618.5 -13.383 <.0001
##  warmed 1 - warmed 4   -2.17442 0.1415 1192.0 -15.365 <.0001
##  warmed 1 - ambient 4  -2.14458 0.1510  589.8 -14.201 <.0001
##  warmed 1 - warmed 5   -1.59929 0.1446 1191.8 -11.057 <.0001
##  warmed 1 - ambient 5  -1.56946 0.1540  622.1 -10.194 <.0001
##  warmed 1 - warmed 6   -1.62468 0.1473 1192.8 -11.030 <.0001
##  warmed 1 - ambient 6  -1.59485 0.1574  636.8 -10.129 <.0001
##  warmed 1 - warmed 7   -1.14257 0.1533 1193.4  -7.453 <.0001
##  warmed 1 - ambient 7  -1.11274 0.1631  673.2  -6.821 <.0001
##  ambient 1 - warmed 2  -1.89784 0.1486  613.0 -12.772 <.0001
```

```
##  ambient 1 - ambient 2 -1.86800 0.1333 1189.9 -14.010 <.0001
##  ambient 1 - warmed 3  -2.09015 0.1557  663.3 -13.421 <.0001
##  ambient 1 - ambient 3 -2.06031 0.1415 1189.7 -14.564 <.0001
##  ambient 1 - warmed 4  -2.20425 0.1565  669.0 -14.083 <.0001
##  ambient 1 - ambient 4 -2.17442 0.1415 1192.0 -15.365 <.0001
##  ambient 1 - warmed 5  -1.62913 0.1593  685.2 -10.224 <.0001
##  ambient 1 - ambient 5 -1.59929 0.1446 1191.8 -11.057 <.0001
##  ambient 1 - warmed 6  -1.65452 0.1608  695.3 -10.290 <.0001
##  ambient 1 - ambient 6 -1.62468 0.1473 1192.8 -11.030 <.0001
##  ambient 1 - warmed 7  -1.17241 0.1663  726.1  -7.051 <.0001
##  ambient 1 - ambient 7 -1.14257 0.1533 1193.4  -7.453 <.0001
##  warmed 2 - ambient 2   0.02984 0.0602   26.3   0.496 1.0000
##  warmed 2 - warmed 3   -0.19231 0.0976 1183.6  -1.971 0.7855
##  warmed 2 - ambient 3  -0.16248 0.1149  316.9  -1.414 0.9797
##  warmed 2 - warmed 4   -0.30642 0.0958 1182.5  -3.199 0.0811
##  warmed 2 - ambient 4  -0.27658 0.1124  287.9  -2.461 0.4390
##  warmed 2 - warmed 5    0.26871 0.1010 1189.2   2.660 0.3040
##  warmed 2 - ambient 5   0.29855 0.1169  323.9   2.554 0.3749
##  warmed 2 - warmed 6    0.24332 0.1038 1191.7   2.344 0.5221
##  warmed 2 - ambient 6   0.27316 0.1206  344.6   2.265 0.5820
##  warmed 2 - warmed 7    0.72543 0.1131 1193.1   6.416 <.0001
##  warmed 2 - ambient 7   0.75526 0.1287  409.3   5.868 <.0001
##  ambient 2 - warmed 3  -0.22215 0.1144  297.3  -1.942 0.8015
##  ambient 2 - ambient 3 -0.19231 0.0976 1183.6  -1.971 0.7855
##  ambient 2 - warmed 4  -0.33625 0.1139  302.6  -2.953 0.1618
##  ambient 2 - ambient 4 -0.30642 0.0958 1182.5  -3.199 0.0811
##  ambient 2 - warmed 5   0.23888 0.1183  326.8   2.019 0.7548
##  ambient 2 - ambient 5  0.26871 0.1010 1189.2   2.660 0.3040
##  ambient 2 - warmed 6   0.21349 0.1194  336.0   1.788 0.8801
##  ambient 2 - ambient 6  0.24332 0.1038 1191.7   2.344 0.5221
##  ambient 2 - warmed 7   0.69559 0.1275  398.4   5.457 <.0001
##  ambient 2 - ambient 7  0.72543 0.1131 1193.1   6.416 <.0001
##  warmed 3 - ambient 3   0.02984 0.0602   26.3   0.496 1.0000
##  warmed 3 - warmed 4   -0.11410 0.0998 1179.9  -1.143 0.9973
##  warmed 3 - ambient 4  -0.08427 0.1156  309.7  -0.729 1.0000
##  warmed 3 - warmed 5    0.46102 0.1058 1189.0   4.358 0.0012
##  warmed 3 - ambient 5   0.49086 0.1208  349.5   4.063 0.0046
##  warmed 3 - warmed 6    0.43563 0.1090 1193.6   3.998 0.0052
##  warmed 3 - ambient 6   0.46547 0.1248  362.6   3.729 0.0157
##  warmed 3 - warmed 7    0.91774 0.1175 1193.1   7.812 <.0001
##  warmed 3 - ambient 7   0.94757 0.1324  418.1   7.157 <.0001
##  ambient 3 - warmed 4  -0.14394 0.1175  345.0  -1.225 0.9945
##  ambient 3 - ambient 4 -0.11410 0.0998 1179.9  -1.143 0.9973
##  ambient 3 - warmed 5   0.43119 0.1226  372.6   3.516 0.0322
##  ambient 3 - ambient 5  0.46102 0.1058 1189.0   4.358 0.0012
##  ambient 3 - warmed 6   0.40580 0.1241  374.6   3.269 0.0688
##  ambient 3 - ambient 6  0.43563 0.1090 1193.6   3.998 0.0052
##  ambient 3 - warmed 7   0.88790 0.1316  428.6   6.745 <.0001
##  ambient 3 - ambient 7  0.91774 0.1175 1193.1   7.812 <.0001
##  warmed 4 - ambient 4   0.02984 0.0602   26.3   0.496 1.0000
##  warmed 4 - warmed 5    0.57513 0.1018 1182.5   5.648 <.0001
##  warmed 4 - ambient 5   0.60496 0.1183  345.9   5.114 <.0001
##  warmed 4 - warmed 6    0.54974 0.1051 1189.9   5.233 <.0001
##  warmed 4 - ambient 6   0.57957 0.1224  365.4   4.736 0.0003
```

```
##  warmed 4 - warmed 7    1.03184 0.1139 1192.4   9.058 <.0001
##  warmed 4 - ambient 7   1.06168 0.1301  426.6   8.160 <.0001
##  ambient 4 - warmed 5   0.54529 0.1183  333.7   4.610 0.0005
##  ambient 4 - ambient 5  0.57513 0.1018 1182.5   5.648 <.0001
##  ambient 4 - warmed 6   0.51990 0.1198  342.1   4.340 0.0015
##  ambient 4 - ambient 6  0.54974 0.1051 1189.9   5.233 <.0001
##  ambient 4 - warmed 7   1.00201 0.1276  401.2   7.855 <.0001
##  ambient 4 - ambient 7  1.03184 0.1139 1192.4   9.058 <.0001
##  warmed 5 - ambient 5   0.02984 0.0602   26.3   0.496 1.0000
##  warmed 5 - warmed 6   -0.02539 0.1077 1180.0  -0.236 1.0000
##  warmed 5 - ambient 6   0.00445 0.1247  394.1   0.036 1.0000
##  warmed 5 - warmed 7    0.45672 0.1155 1183.6   3.955 0.0062
##  warmed 5 - ambient 7   0.48655 0.1315  453.0   3.701 0.0170
##  ambient 5 - warmed 6  -0.05522 0.1221  383.6  -0.452 1.0000
##  ambient 5 - ambient 6 -0.02539 0.1077 1180.0  -0.236 1.0000
##  ambient 5 - warmed 7   0.42688 0.1290  441.1   3.310 0.0605
##  ambient 5 - ambient 7  0.45672 0.1155 1183.6   3.955 0.0062
##  warmed 6 - ambient 6   0.02984 0.0602   26.3   0.496 1.0000
##  warmed 6 - warmed 7    0.48211 0.1179 1176.6   4.088 0.0037
##  warmed 6 - ambient 7   0.51194 0.1325  480.2   3.864 0.0094
##  ambient 6 - warmed 7   0.45227 0.1324  477.2   3.417 0.0434
##  ambient 6 - ambient 7  0.48211 0.1179 1176.6   4.088 0.0037
##  warmed 7 - ambient 7   0.02984 0.0602   26.3   0.496 1.0000
##
## Results are averaged over the levels of: species, insecticide
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## P value adjustment: tukey method for comparing a family of 14 estimates
```

```
emmeans(mod7c, list(pairwise ~ year_factor), adjust = "tukey")
```

```
## $`emmeans of year_factor`
##  year_factor emmean    SE   df lower.CL upper.CL
##            1  0.327 0.144 1094   0.0452    0.608
##            2  2.195 0.104  930   1.9901    2.400
##            3  2.387 0.104  893   2.1823    2.592
##            4  2.501 0.104  888   2.2963    2.706
##            5  1.926 0.112  927   1.7054    2.147
##            6  1.952 0.116  978   1.7236    2.179
##            7  1.469 0.117  945   1.2391    1.700
##
## Results are averaged over the levels of: state, species, insecticide
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
## $`pairwise differences of year_factor`
##  1     estimate     SE   df t.ratio p.value
##  1 - 2  -1.8680 0.1333 1190 -14.010 <.0001
##  1 - 3  -2.0603 0.1415 1190 -14.564 <.0001
##  1 - 4  -2.1744 0.1415 1192 -15.365 <.0001
##  1 - 5  -1.5993 0.1446 1192 -11.057 <.0001
##  1 - 6  -1.6247 0.1473 1193 -11.030 <.0001
##  1 - 7  -1.1426 0.1533 1193  -7.453 <.0001
```

```
##  2 - 3  -0.1923 0.0976 1184  -1.971 0.4336
##  2 - 4  -0.3064 0.0958 1182  -3.199 0.0238
##  2 - 5   0.2687 0.1010 1189   2.660 0.1097
##  2 - 6   0.2433 0.1038 1192   2.344 0.2239
##  2 - 7   0.7254 0.1131 1193   6.416 <.0001
##  3 - 4  -0.1141 0.0998 1180  -1.143 0.9145
##  3 - 5   0.4610 0.1058 1189   4.358 0.0003
##  3 - 6   0.4356 0.1090 1194   3.998 0.0013
##  3 - 7   0.9177 0.1175 1193   7.812 <.0001
##  4 - 5   0.5751 0.1018 1183   5.648 <.0001
##  4 - 6   0.5497 0.1051 1190   5.233 <.0001
##  4 - 7   1.0318 0.1139 1192   9.058 <.0001
##  5 - 6  -0.0254 0.1077 1180  -0.236 1.0000
##  5 - 7   0.4567 0.1155 1184   3.955 0.0016
##  6 - 7   0.4821 0.1179 1177   4.088 0.0009
##
## Results are averaged over the levels of: state, species, insecticide
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## P value adjustment: tukey method for comparing a family of 7 estimates
```

```
emmeans(mod7c, list(pairwise ~ species), adjust = "tukey")
```

```
## $`emmeans of species`
##  species emmean     SE   df lower.CL upper.CL
##  Acmi     2.849 0.1301 1079    2.594    3.105
##  Arel     1.927 0.1115  998    1.708    2.145
##  Aspi     1.472 0.3952 1194    0.697    2.248
##  Assp     0.454 0.3234 1194   -0.180    1.088
##  Bavu     2.265 0.2791 1067    1.717    2.812
##  Cahi     1.744 0.2175 1167    1.317    2.170
##  Cest     2.972 0.1170 1009    2.742    3.202
##  Daca     2.704 0.2011 1155    2.309    3.098
##  Dagl     2.034 0.1309 1030    1.777    2.291
##  Dlre    -0.548 0.9586 1194   -2.429    1.332
##  Elre     2.270 0.1086 1002    2.057    2.483
##  Eugr     2.874 0.1384 1026    2.602    3.145
##  Hisp     1.688 0.1170 1062    1.458    1.917
##  Hype     2.796 0.1701  993    2.462    3.130
##  Lapu     0.369 0.9592 1193   -1.512    2.251
##  Lesp     1.640 0.9582 1194   -0.240    3.520
##  Phpr     2.172 0.0935  855    1.988    2.355
##  Poco     1.927 0.1370 1060    1.659    2.196
##  Popr     2.332 0.0867  854    2.162    2.502
##  Pore     1.835 0.1358 1097    1.569    2.101
##  Posp     1.496 0.4896 1193    0.535    2.456
##  Rusp     1.713 0.2279 1070    1.265    2.160
##  Sila     3.110 0.9581 1194    1.230    4.990
##  Soca     3.226 0.0822  798    3.065    3.387
##  Soga    -0.679 0.6785 1194   -2.010    0.652
##  Sogr     2.591 0.3063 1192    1.990    3.192
##  Sora     2.352 0.3676 1193    1.631    3.073
##  Syla     0.337 0.9595 1194   -1.546    2.219
##  Sypi     1.763 0.2296 1181    1.313    2.213
```

```
##  Syur     3.281 0.9595 1194    1.399    5.164
##  Taof     0.823 0.2583 1158    0.317    1.330
##  Trsp     2.975 0.1741 1184    2.633    3.316
##  Vear    -0.622 0.6770 1194   -1.950    0.707
##
## Results are averaged over the levels of: state, year_factor, insecticide
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
## $`pairwise differences of species`
##  1            estimate    SE   df t.ratio p.value
##  Acmi - Arel  0.922714 0.172 1194   5.362 <.0001
##  Acmi - Aspi  1.377102 0.414 1190   3.329 0.2071
##  Acmi - Assp  2.395452 0.346 1185   6.927 <.0001
##  Acmi - Bavu  0.584788 0.307 1175   1.904 0.9935
##  Acmi - Cahi  1.105737 0.251 1191   4.404 0.0050
##  Acmi - Cest -0.122448 0.172 1189  -0.712 1.0000
##  Acmi - Daca  0.145489 0.237 1193   0.614 1.0000
##  Acmi - Dagl  0.815543 0.183 1193   4.447 0.0042
##  Acmi - Dlre  3.397677 0.966 1193   3.516 0.1246
##  Acmi - Elre  0.579685 0.170 1193   3.403 0.1708
##  Acmi - Eugr -0.024093 0.191 1193  -0.126 1.0000
##  Acmi - Hisp  1.161615 0.173 1187   6.707 <.0001
##  Acmi - Hype  0.053373 0.214 1171   0.250 1.0000
##  Acmi - Lapu  2.479937 0.969 1194   2.558 0.7818
##  Acmi - Lesp  1.209195 0.967 1193   1.250 1.0000
##  Acmi - Phpr  0.677783 0.159 1192   4.259 0.0091
##  Acmi - Poco  0.922020 0.191 1193   4.838 0.0007
##  Acmi - Popr  0.517168 0.156 1192   3.313 0.2160
##  Acmi - Pore  1.014417 0.186 1191   5.455 <.0001
##  Acmi - Posp  1.353821 0.506 1194   2.676 0.6947
##  Acmi - Rusp  1.136923 0.261 1160   4.352 0.0063
##  Acmi - Sila -0.260372 0.966 1193  -0.269 1.0000
##  Acmi - Soca -0.376550 0.154 1192  -2.447 0.8514
##  Acmi - Soga  3.528239 0.691 1193   5.108 0.0002
##  Acmi - Sogr  0.258100 0.332 1193   0.778 1.0000
##  Acmi - Sora  0.497661 0.387 1190   1.285 1.0000
##  Acmi - Syla  2.512855 0.969 1193   2.593 0.7569
##  Acmi - Sypi  1.086480 0.265 1193   4.105 0.0168
##  Acmi - Syur -0.431584 0.969 1193  -0.445 1.0000
##  Acmi - Taof  2.026020 0.287 1187   7.066 <.0001
##  Acmi - Trsp -0.125382 0.214 1185  -0.585 1.0000
##  Acmi - Vear  3.471187 0.688 1193   5.042 0.0003
##  Arel - Aspi  0.454388 0.411 1193   1.104 1.0000
##  Arel - Assp  1.472737 0.343 1190   4.300 0.0077
##  Arel - Bavu -0.337926 0.300 1108  -1.126 1.0000
##  Arel - Cahi  0.183023 0.244 1193   0.751 1.0000
##  Arel - Cest -1.045162 0.164 1192  -6.378 <.0001
##  Arel - Daca -0.777225 0.229 1192  -3.387 0.1782
##  Arel - Dagl -0.107171 0.170 1193  -0.631 1.0000
##  Arel - Dlre  2.474962 0.966 1193   2.563 0.7786
##  Arel - Elre -0.343030 0.154 1194  -2.230 0.9436
##  Arel - Eugr -0.946807 0.177 1188  -5.364 <.0001
```

```
##  Arel - Hisp  0.238901 0.160 1192   1.494 0.9999
##  Arel - Hype -0.869341 0.204 1170  -4.256 0.0093
##  Arel - Lapu  1.557222 0.966 1193   1.613 0.9997
##  Arel - Lesp  0.286481 0.964 1193   0.297 1.0000
##  Arel - Phpr -0.244931 0.144 1193  -1.695 0.9991
##  Arel - Poco -0.000694 0.174 1192  -0.004 1.0000
##  Arel - Popr -0.405546 0.139 1190  -2.923 0.4907
##  Arel - Pore  0.091703 0.175 1193   0.524 1.0000
##  Arel - Posp  0.431106 0.506 1193   0.852 1.0000
##  Arel - Rusp  0.214209 0.252 1137   0.850 1.0000
##  Arel - Sila -1.183086 0.964 1193  -1.227 1.0000
##  Arel - Soca -1.299264 0.136 1190  -9.561 <.0001
##  Arel - Soga  2.605525 0.687 1193   3.794 0.0519
##  Arel - Sogr -0.664614 0.325 1193  -2.042 0.9818
##  Arel - Sora -0.425054 0.386 1193  -1.102 1.0000
##  Arel - Syla  1.590140 0.966 1194   1.647 0.9995
##  Arel - Sypi  0.163766 0.252 1193   0.649 1.0000
##  Arel - Syur -1.354299 0.966 1194  -1.403 1.0000
##  Arel - Taof  1.103306 0.281 1190   3.928 0.0326
##  Arel - Trsp -1.048096 0.209 1187  -5.009 0.0003
##  Arel - Vear  2.548473 0.686 1194   3.714 0.0676
##  Aspi - Assp  1.018350 0.503 1183   2.024 0.9840
##  Aspi - Bavu -0.792314 0.482 1193  -1.643 0.9995
##  Aspi - Cahi -0.271365 0.451 1191  -0.602 1.0000
##  Aspi - Cest -1.499550 0.412 1193  -3.638 0.0861
##  Aspi - Daca -1.231613 0.441 1191  -2.795 0.5975
##  Aspi - Dagl -0.561559 0.416 1193  -1.351 1.0000
##  Aspi - Dlre  2.020575 1.034 1193   1.954 0.9904
##  Aspi - Elre -0.797417 0.410 1193  -1.943 0.9912
##  Aspi - Eugr -1.401194 0.420 1193  -3.335 0.2043
##  Aspi - Hisp -0.215486 0.410 1191  -0.526 1.0000
##  Aspi - Hype -1.323729 0.430 1191  -3.077 0.3687
##  Aspi - Lapu  1.102835 1.038 1193   1.062 1.0000
##  Aspi - Lesp -0.167907 1.038 1193  -0.162 1.0000
##  Aspi - Phpr -0.699318 0.406 1193  -1.723 0.9988
##  Aspi - Poco -0.455082 0.418 1193  -1.088 1.0000
##  Aspi - Popr -0.859934 0.404 1192  -2.130 0.9678
##  Aspi - Pore -0.362685 0.416 1193  -0.872 1.0000
##  Aspi - Posp -0.023281 0.632 1193  -0.037 1.0000
##  Aspi - Rusp -0.240179 0.454 1193  -0.529 1.0000
##  Aspi - Sila -1.637474 1.038 1192  -1.578 0.9998
##  Aspi - Soca -1.753651 0.403 1192  -4.353 0.0062
##  Aspi - Soga  2.151137 0.786 1194   2.736 0.6463
##  Aspi - Sogr -1.119002 0.499 1193  -2.245 0.9391
##  Aspi - Sora -0.879441 0.532 1189  -1.652 0.9994
##  Aspi - Syla  1.135753 1.036 1193   1.096 1.0000
##  Aspi - Sypi -0.290621 0.456 1188  -0.637 1.0000
##  Aspi - Syur -1.808686 1.036 1193  -1.746 0.9985
##  Aspi - Taof  0.648918 0.469 1190   1.384 1.0000
##  Aspi - Trsp -1.502484 0.434 1190  -3.463 0.1448
##  Aspi - Vear  2.094085 0.781 1192   2.680 0.6917
##  Assp - Bavu -1.810663 0.425 1189  -4.256 0.0093
##  Assp - Cahi -1.289715 0.388 1185  -3.321 0.2113
##  Assp - Cest -2.517899 0.344 1191  -7.323 <.0001
```

```
##  Assp - Daca -2.249963 0.377 1186  -5.966 <.0001
##  Assp - Dagl -1.579909 0.348 1189  -4.543 0.0027
##  Assp - Dlre  1.002225 1.008 1190   0.994 1.0000
##  Assp - Elre -1.815767 0.341 1192  -5.322 0.0001
##  Assp - Eugr -2.419544 0.353 1193  -6.846 <.0001
##  Assp - Hisp -1.233836 0.342 1189  -3.612 0.0934
##  Assp - Hype -2.342078 0.365 1193  -6.412 <.0001
##  Assp - Lapu  0.084485 1.014 1193   0.083 1.0000
##  Assp - Lesp -1.186256 1.012 1193  -1.172 1.0000
##  Assp - Phpr -1.717668 0.336 1189  -5.114 0.0002
##  Assp - Poco -1.473432 0.351 1192  -4.196 0.0118
##  Assp - Popr -1.878283 0.334 1191  -5.631 <.0001
##  Assp - Pore -1.381035 0.348 1187  -3.964 0.0286
##  Assp - Posp -1.041631 0.590 1194  -1.766 0.9981
##  Assp - Rusp -1.258529 0.394 1193  -3.198 0.2843
##  Assp - Sila -2.655823 1.012 1190  -2.625 0.7335
##  Assp - Soca -2.772001 0.333 1191  -8.334 <.0001
##  Assp - Soga  1.132788 0.752 1194   1.506 0.9999
##  Assp - Sogr -2.137352 0.444 1193  -4.816 0.0008
##  Assp - Sora -1.897791 0.482 1188  -3.939 0.0313
##  Assp - Syla  0.117403 1.013 1193   0.116 1.0000
##  Assp - Sypi -1.308971 0.395 1190  -3.313 0.2161
##  Assp - Syur -2.827036 1.013 1193  -2.792 0.6006
##  Assp - Taof -0.369432 0.411 1193  -0.899 1.0000
##  Assp - Trsp -2.520833 0.370 1187  -6.821 <.0001
##  Assp - Vear  1.075736 0.748 1191   1.439 1.0000
##  Bavu - Cahi  0.520949 0.352 1172   1.481 0.9999
##  Bavu - Cest -0.707236 0.304 1123  -2.326 0.9099
##  Bavu - Daca -0.439299 0.343 1161  -1.280 1.0000
##  Bavu - Dagl  0.230755 0.307 1122   0.751 1.0000
##  Bavu - Dlre  2.812888 0.998 1193   2.819 0.5777
##  Bavu - Elre -0.005104 0.298 1139  -0.017 1.0000
##  Bavu - Eugr -0.608881 0.311 1142  -1.959 0.9900
##  Bavu - Hisp  0.576827 0.303 1141   1.906 0.9934
##  Bavu - Hype -0.531415 0.327 1138  -1.625 0.9996
##  Bavu - Lapu  1.895149 0.998 1193   1.899 0.9938
##  Bavu - Lesp  0.624407 0.997 1193   0.626 1.0000
##  Bavu - Phpr  0.092995 0.294 1119   0.316 1.0000
##  Bavu - Poco  0.337232 0.309 1113   1.090 1.0000
##  Bavu - Popr -0.067620 0.291 1129  -0.232 1.0000
##  Bavu - Pore  0.429629 0.311 1136   1.382 1.0000
##  Bavu - Posp  0.769033 0.567 1182   1.356 1.0000
##  Bavu - Rusp  0.552135 0.359 1156   1.540 0.9999
##  Bavu - Sila -0.845160 0.998 1193  -0.847 1.0000
##  Bavu - Soca -0.961338 0.290 1130  -3.319 0.2125
##  Bavu - Soga  2.943451 0.733 1190   4.013 0.0238
##  Bavu - Sogr -0.326688 0.414 1186  -0.790 1.0000
##  Bavu - Sora -0.087127 0.459 1194  -0.190 1.0000
##  Bavu - Syla  1.928067 0.998 1192   1.931 0.9920
##  Bavu - Sypi  0.501692 0.361 1157   1.388 1.0000
##  Bavu - Syur -1.016372 0.998 1192  -1.018 1.0000
##  Bavu - Taof  1.441232 0.380 1155   3.797 0.0515
##  Bavu - Trsp -0.710170 0.332 1134  -2.142 0.9655
##  Bavu - Vear  2.886399 0.732 1190   3.944 0.0307
```

```
##  Cahi - Cest -1.228185 0.246 1193  -4.983 0.0003
##  Cahi - Daca -0.960248 0.295 1194  -3.253 0.2500
##  Cahi - Dagl -0.290194 0.251 1194  -1.156 1.0000
##  Cahi - Dlre  2.291940 0.981 1192   2.337 0.9054
##  Cahi - Elre -0.526052 0.241 1194  -2.181 0.9568
##  Cahi - Eugr -1.129830 0.258 1194  -4.371 0.0058
##  Cahi - Hisp  0.055878 0.245 1193   0.228 1.0000
##  Cahi - Hype -1.052364 0.276 1191  -3.807 0.0497
##  Cahi - Lapu  1.374200 0.984 1193   1.396 1.0000
##  Cahi - Lesp  0.103458 0.980 1192   0.106 1.0000
##  Cahi - Phpr -0.427954 0.235 1194  -1.817 0.9970
##  Cahi - Poco -0.183717 0.257 1194  -0.715 1.0000
##  Cahi - Popr -0.588569 0.233 1193  -2.530 0.8005
##  Cahi - Pore -0.091320 0.255 1194  -0.358 1.0000
##  Cahi - Posp  0.248084 0.539 1194   0.460 1.0000
##  Cahi - Rusp  0.031186 0.314 1192   0.099 1.0000
##  Cahi - Sila -1.366109 0.980 1192  -1.394 1.0000
##  Cahi - Soca -1.482286 0.231 1193  -6.414 <.0001
##  Cahi - Soga  2.422502 0.711 1193   3.408 0.1684
##  Cahi - Sogr -0.847637 0.372 1194  -2.277 0.9283
##  Cahi - Sora -0.608076 0.424 1189  -1.433 1.0000
##  Cahi - Syla  1.407118 0.985 1194   1.428 1.0000
##  Cahi - Sypi -0.019257 0.318 1194  -0.061 1.0000
##  Cahi - Syur -1.537321 0.985 1194  -1.560 0.9998
##  Cahi - Taof  0.920283 0.334 1184   2.751 0.6340
##  Cahi - Trsp -1.231119 0.278 1192  -4.422 0.0046
##  Cahi - Vear  2.365450 0.709 1193   3.336 0.2037
##  Cest - Daca  0.267937 0.232 1193   1.157 1.0000
##  Cest - Dagl  0.937991 0.176 1193   5.316 0.0001
##  Cest - Dlre  3.520124 0.966 1193   3.645 0.0842
##  Cest - Elre  0.702132 0.162 1193   4.332 0.0068
##  Cest - Eugr  0.098355 0.183 1181   0.539 1.0000
##  Cest - Hisp  1.284063 0.166 1190   7.748 <.0001
##  Cest - Hype  0.175821 0.205 1157   0.856 1.0000
##  Cest - Lapu  2.602385 0.968 1193   2.689 0.6841
##  Cest - Lesp  1.331643 0.966 1194   1.379 1.0000
##  Cest - Phpr  0.800231 0.149 1191   5.356 0.0001
##  Cest - Poco  1.044468 0.184 1193   5.689 <.0001
##  Cest - Popr  0.639616 0.148 1192   4.330 0.0068
##  Cest - Pore  1.136865 0.178 1192   6.389 <.0001
##  Cest - Posp  1.476269 0.498 1193   2.962 0.4594
##  Cest - Rusp  1.259371 0.257 1114   4.898 0.0005
##  Cest - Sila -0.137924 0.965 1193  -0.143 1.0000
##  Cest - Soca -0.254102 0.145 1192  -1.748 0.9985
##  Cest - Soga  3.650687 0.689 1194   5.301 0.0001
##  Cest - Sogr  0.380548 0.328 1193   1.160 1.0000
##  Cest - Sora  0.620109 0.386 1193   1.607 0.9997
##  Cest - Syla  2.635302 0.968 1193   2.724 0.6566
##  Cest - Sypi  1.208928 0.259 1193   4.663 0.0016
##  Cest - Syur -0.309137 0.968 1193  -0.320 1.0000
##  Cest - Taof  2.148468 0.283 1175   7.596 <.0001
##  Cest - Trsp -0.002934 0.203 1183  -0.014 1.0000
##  Cest - Vear  3.593635 0.687 1193   5.231 0.0001
##  Daca - Dagl  0.670054 0.239 1194   2.807 0.5875
```

```
##  Daca - Dlre  3.252188 0.978 1192   3.324 0.2099
##  Daca - Elre  0.434196 0.229 1192   1.898 0.9939
##  Daca - Eugr -0.169582 0.245 1187  -0.692 1.0000
##  Daca - Hisp  1.016126 0.231 1194   4.398 0.0051
##  Daca - Hype -0.092116 0.263 1182  -0.350 1.0000
##  Daca - Lapu  2.334448 0.982 1194   2.378 0.8869
##  Daca - Lesp  1.063706 0.980 1194   1.086 1.0000
##  Daca - Phpr  0.532295 0.221 1194   2.412 0.8703
##  Daca - Poco  0.776531 0.243 1192   3.190 0.2893
##  Daca - Popr  0.371679 0.218 1193   1.704 0.9990
##  Daca - Pore  0.868928 0.241 1193   3.609 0.0941
##  Daca - Posp  1.208332 0.530 1193   2.280 0.9273
##  Daca - Rusp  0.991434 0.302 1173   3.283 0.2327
##  Daca - Sila -0.405861 0.979 1192  -0.415 1.0000
##  Daca - Soca -0.522038 0.217 1193  -2.410 0.8710
##  Daca - Soga  3.382750 0.708 1194   4.778 0.0009
##  Daca - Sogr  0.112611 0.366 1193   0.308 1.0000
##  Daca - Sora  0.352172 0.416 1191   0.846 1.0000
##  Daca - Syla  2.367366 0.981 1194   2.413 0.8694
##  Daca - Sypi  0.940991 0.304 1192   3.097 0.3543
##  Daca - Syur -0.577073 0.981 1194  -0.588 1.0000
##  Daca - Taof  1.880531 0.326 1185   5.775 <.0001
##  Daca - Trsp -0.270871 0.266 1192  -1.020 1.0000
##  Daca - Vear  3.325698 0.706 1194   4.714 0.0013
##  Dagl - Dlre  2.582134 0.967 1193   2.671 0.6989
##  Dagl - Elre -0.235859 0.168 1194  -1.401 1.0000
##  Dagl - Eugr -0.839636 0.191 1185  -4.405 0.0050
##  Dagl - Hisp  0.346072 0.173 1191   1.999 0.9865
##  Dagl - Hype -0.762170 0.215 1162  -3.541 0.1157
##  Dagl - Lapu  1.664394 0.968 1192   1.719 0.9989
##  Dagl - Lesp  0.393652 0.966 1194   0.407 1.0000
##  Dagl - Phpr -0.137760 0.159 1189  -0.865 1.0000
##  Dagl - Poco  0.106477 0.188 1190   0.567 1.0000
##  Dagl - Popr -0.298375 0.155 1192  -1.927 0.9922
##  Dagl - Pore  0.198874 0.187 1188   1.064 1.0000
##  Dagl - Posp  0.538278 0.510 1193   1.055 1.0000
##  Dagl - Rusp  0.321380 0.261 1161   1.231 1.0000
##  Dagl - Sila -1.075915 0.966 1193  -1.114 1.0000
##  Dagl - Soca -1.192093 0.152 1193  -7.824 <.0001
##  Dagl - Soga  2.712696 0.690 1194   3.930 0.0323
##  Dagl - Sogr -0.557443 0.331 1193  -1.682 0.9992
##  Dagl - Sora -0.317882 0.389 1193  -0.817 1.0000
##  Dagl - Syla  1.697312 0.969 1194   1.752 0.9984
##  Dagl - Sypi  0.270937 0.264 1190   1.027 1.0000
##  Dagl - Syur -1.247127 0.969 1194  -1.287 1.0000
##  Dagl - Taof  1.210477 0.288 1184   4.209 0.0112
##  Dagl - Trsp -0.940925 0.219 1191  -4.290 0.0081
##  Dagl - Vear  2.655644 0.689 1193   3.857 0.0418
##  Dlre - Elre -2.817992 0.964 1193  -2.923 0.4912
##  Dlre - Eugr -3.421769 0.969 1193  -3.531 0.1191
##  Dlre - Hisp -2.236061 0.965 1193  -2.318 0.9131
##  Dlre - Hype -3.344303 0.973 1192  -3.437 0.1555
##  Dlre - Lapu -0.917740 1.356 1193  -0.677 1.0000
##  Dlre - Lesp -2.188481 1.355 1194  -1.616 0.9996
```

```
##  Dlre - Phpr -2.719893 0.963 1193  -2.825 0.5731
##  Dlre - Poco -2.475657 0.969 1194  -2.555 0.7842
##  Dlre - Popr -2.880508 0.962 1193  -2.994 0.4330
##  Dlre - Pore -2.383260 0.967 1193  -2.464 0.8417
##  Dlre - Posp -2.043856 1.078 1194  -1.895 0.9940
##  Dlre - Rusp -2.260754 0.986 1194  -2.294 0.9224
##  Dlre - Sila -3.658048 1.351 1170  -2.708 0.6695
##  Dlre - Soca -3.774226 0.962 1193  -3.925 0.0329
##  Dlre - Soga  0.130563 1.175 1193   0.111 1.0000
##  Dlre - Sogr -3.139576 1.004 1193  -3.126 0.3334
##  Dlre - Sora -2.900016 1.021 1191  -2.840 0.5603
##  Dlre - Syla -0.884822 1.358 1193  -0.651 1.0000
##  Dlre - Sypi -2.311196 0.987 1193  -2.341 0.9034
##  Dlre - Syur -3.829261 1.358 1193  -2.819 0.5777
##  Dlre - Taof -1.371657 0.991 1194  -1.384 1.0000
##  Dlre - Trsp -3.523058 0.975 1193  -3.613 0.0931
##  Dlre - Vear  0.073511 1.170 1181   0.063 1.0000
##  Elre - Eugr -0.603777 0.175 1191  -3.444 0.1526
##  Elre - Hisp  0.581931 0.159 1193   3.668 0.0785
##  Elre - Hype -0.526311 0.202 1154  -2.599 0.7526
##  Elre - Lapu  1.900252 0.965 1193   1.970 0.9892
##  Elre - Lesp  0.629511 0.963 1193   0.653 1.0000
##  Elre - Phpr  0.098099 0.142 1191   0.688 1.0000
##  Elre - Poco  0.342335 0.172 1193   1.985 0.9878
##  Elre - Popr -0.062516 0.137 1187  -0.457 1.0000
##  Elre - Pore  0.434733 0.174 1191   2.499 0.8204
##  Elre - Posp  0.774136 0.505 1194   1.534 0.9999
##  Elre - Rusp  0.557238 0.252 1175   2.213 0.9485
##  Elre - Sila -0.840056 0.964 1193  -0.872 1.0000
##  Elre - Soca -0.956234 0.134 1186  -7.137 <.0001
##  Elre - Soga  2.948555 0.686 1193   4.296 0.0079
##  Elre - Sogr -0.321584 0.324 1192  -0.994 1.0000
##  Elre - Sora -0.082024 0.383 1192  -0.214 1.0000
##  Elre - Syla  1.933170 0.966 1194   2.001 0.9863
##  Elre - Sypi  0.506796 0.253 1193   1.999 0.9865
##  Elre - Syur -1.011269 0.966 1194  -1.047 1.0000
##  Elre - Taof  1.446335 0.280 1187   5.168 0.0001
##  Elre - Trsp -0.705066 0.208 1189  -3.382 0.1807
##  Elre - Vear  2.891503 0.685 1194   4.220 0.0107
##  Eugr - Hisp  1.185708 0.182 1192   6.512 <.0001
##  Eugr - Hype  0.077466 0.219 1150   0.354 1.0000
##  Eugr - Lapu  2.504029 0.968 1193   2.587 0.7615
##  Eugr - Lesp  1.233288 0.969 1194   1.273 1.0000
##  Eugr - Phpr  0.701876 0.167 1185   4.197 0.0117
##  Eugr - Poco  0.946113 0.194 1179   4.880 0.0006
##  Eugr - Popr  0.541261 0.163 1189   3.317 0.2135
##  Eugr - Pore  1.038510 0.195 1189   5.315 0.0001
##  Eugr - Posp  1.377913 0.509 1194   2.705 0.6719
##  Eugr - Rusp  1.161016 0.266 1180   4.367 0.0059
##  Eugr - Sila -0.236279 0.968 1193  -0.244 1.0000
##  Eugr - Soca -0.352457 0.160 1190  -2.197 0.9527
##  Eugr - Soga  3.552332 0.693 1193   5.124 0.0002
##  Eugr - Sogr  0.282193 0.338 1186   0.835 1.0000
##  Eugr - Sora  0.521753 0.394 1186   1.323 1.0000
```

```
##  Eugr - Syla  2.536947 0.969 1194   2.619 0.7381
##  Eugr - Sypi  1.110573 0.268 1190   4.141 0.0146
##  Eugr - Syur -0.407492 0.969 1194  -0.421 1.0000
##  Eugr - Taof  2.050113 0.294 1193   6.968 <.0001
##  Eugr - Trsp -0.101289 0.222 1192  -0.456 1.0000
##  Eugr - Vear  3.495280 0.692 1194   5.050 0.0003
##  Hisp - Hype -1.108242 0.207 1163  -5.355 0.0001
##  Hisp - Lapu  1.318321 0.967 1193   1.364 1.0000
##  Hisp - Lesp  0.047580 0.965 1193   0.049 1.0000
##  Hisp - Phpr -0.483832 0.149 1193  -3.255 0.2487
##  Hisp - Poco -0.239595 0.180 1192  -1.332 1.0000
##  Hisp - Popr -0.644447 0.143 1185  -4.504 0.0033
##  Hisp - Pore -0.147198 0.176 1192  -0.835 1.0000
##  Hisp - Posp  0.192205 0.507 1194   0.379 1.0000
##  Hisp - Rusp -0.024692 0.255 1159  -0.097 1.0000
##  Hisp - Sila -1.421987 0.964 1193  -1.474 0.9999
##  Hisp - Soca -1.538165 0.141 1185 -10.935 <.0001
##  Hisp - Soga  2.366624 0.688 1193   3.441 0.1538
##  Hisp - Sogr -0.903515 0.326 1193  -2.774 0.6156
##  Hisp - Sora -0.663955 0.383 1192  -1.731 0.9987
##  Hisp - Syla  1.351239 0.967 1194   1.397 1.0000
##  Hisp - Sypi -0.075135 0.257 1194  -0.293 1.0000
##  Hisp - Syur -1.593200 0.967 1194  -1.647 0.9995
##  Hisp - Taof  0.864405 0.281 1190   3.079 0.3674
##  Hisp - Trsp -1.286997 0.211 1180  -6.090 <.0001
##  Hisp - Vear  2.309572 0.686 1193   3.367 0.1880
##  Hype - Lapu  2.426564 0.974 1194   2.491 0.8256
##  Hype - Lesp  1.155822 0.973 1191   1.188 1.0000
##  Hype - Phpr  0.624410 0.194 1160   3.216 0.2726
##  Hype - Poco  0.868647 0.219 1149   3.958 0.0292
##  Hype - Popr  0.463795 0.192 1154   2.420 0.8659
##  Hype - Pore  0.961044 0.218 1159   4.410 0.0049
##  Hype - Posp  1.300447 0.516 1194   2.520 0.8069
##  Hype - Rusp  1.083550 0.284 1162   3.810 0.0491
##  Hype - Sila -0.313745 0.973 1193  -0.323 1.0000
##  Hype - Soca -0.429923 0.190 1155  -2.268 0.9316
##  Hype - Soga  3.474866 0.700 1193   4.965 0.0004
##  Hype - Sogr  0.204727 0.351 1194   0.583 1.0000
##  Hype - Sora  0.444287 0.405 1194   1.098 1.0000
##  Hype - Syla  2.459481 0.975 1193   2.524 0.8049
##  Hype - Sypi  1.033107 0.287 1174   3.601 0.0967
##  Hype - Syur -0.484958 0.975 1193  -0.498 1.0000
##  Hype - Taof  1.972647 0.310 1166   6.370 <.0001
##  Hype - Trsp -0.178755 0.242 1186  -0.739 1.0000
##  Hype - Vear  3.417814 0.698 1194   4.896 0.0005
##  Lapu - Lesp -1.270742 1.356 1194  -0.937 1.0000
##  Lapu - Phpr -1.802153 0.964 1193  -1.869 0.9952
##  Lapu - Poco -1.557917 0.968 1193  -1.610 0.9997
##  Lapu - Popr -1.962769 0.963 1193  -2.038 0.9822
##  Lapu - Pore -1.465520 0.970 1193  -1.512 0.9999
##  Lapu - Posp -1.126116 1.080 1194  -1.043 1.0000
##  Lapu - Rusp -1.343014 0.987 1194  -1.361 1.0000
##  Lapu - Sila -2.740309 1.356 1193  -2.021 0.9842
##  Lapu - Soca -2.856486 0.962 1193  -2.969 0.4537
```

```
##  Lapu - Soga  1.048302 1.176 1194   0.892 1.0000
##  Lapu - Sogr -2.221837 1.007 1193  -2.206 0.9504
##  Lapu - Sora -1.982276 1.028 1194  -1.928 0.9922
##  Lapu - Syla  0.032918 1.353 1193   0.024 1.0000
##  Lapu - Sypi -1.393456 0.987 1193  -1.412 1.0000
##  Lapu - Syur -2.911521 1.353 1193  -2.152 0.9633
##  Lapu - Taof -0.453917 0.994 1192  -0.457 1.0000
##  Lapu - Trsp -2.605319 0.977 1193  -2.668 0.7012
##  Lapu - Vear  0.991251 1.175 1194   0.844 1.0000
##  Lesp - Phpr -0.531412 0.963 1193  -0.552 1.0000
##  Lesp - Poco -0.287175 0.967 1194  -0.297 1.0000
##  Lesp - Popr -0.692027 0.962 1193  -0.720 1.0000
##  Lesp - Pore -0.194778 0.967 1194  -0.201 1.0000
##  Lesp - Posp  0.144626 1.078 1194   0.134 1.0000
##  Lesp - Rusp -0.072272 0.986 1194  -0.073 1.0000
##  Lesp - Sila -1.469567 1.354 1194  -1.085 1.0000
##  Lesp - Soca -1.585745 0.961 1193  -1.650 0.9995
##  Lesp - Soga  2.319044 1.170 1194   1.982 0.9881
##  Lesp - Sogr -0.951095 1.003 1194  -0.949 1.0000
##  Lesp - Sora -0.711534 1.027 1194  -0.693 1.0000
##  Lesp - Syla  1.303659 1.358 1193   0.960 1.0000
##  Lesp - Sypi -0.122715 0.985 1193  -0.125 1.0000
##  Lesp - Syur -1.640780 1.358 1193  -1.208 1.0000
##  Lesp - Taof  0.816825 0.992 1194   0.824 1.0000
##  Lesp - Trsp -1.334577 0.975 1194  -1.369 1.0000
##  Lesp - Vear  2.261992 1.172 1194   1.931 0.9920
##  Phpr - Poco  0.244237 0.165 1190   1.480 0.9999
##  Phpr - Popr -0.160615 0.126 1191  -1.270 1.0000
##  Phpr - Pore  0.336634 0.164 1184   2.056 0.9800
##  Phpr - Posp  0.676037 0.499 1194   1.354 1.0000
##  Phpr - Rusp  0.459140 0.245 1154   1.871 0.9951
##  Phpr - Sila -0.938155 0.962 1193  -0.975 1.0000
##  Phpr - Soca -1.054333 0.123 1189  -8.538 <.0001
##  Phpr - Soga  2.850456 0.685 1194   4.163 0.0134
##  Phpr - Sogr -0.419683 0.320 1193  -1.313 1.0000
##  Phpr - Sora -0.180123 0.379 1192  -0.476 1.0000
##  Phpr - Syla  1.835071 0.964 1194   1.903 0.9936
##  Phpr - Sypi  0.408697 0.247 1193   1.652 0.9994
##  Phpr - Syur -1.109368 0.964 1194  -1.150 1.0000
##  Phpr - Taof  1.348237 0.274 1179   4.921 0.0005
##  Phpr - Trsp -0.803165 0.198 1183  -4.065 0.0196
##  Phpr - Vear  2.793404 0.683 1193   4.090 0.0178
##  Poco - Popr -0.404852 0.160 1193  -2.533 0.7984
##  Poco - Pore  0.092397 0.193 1189   0.479 1.0000
##  Poco - Posp  0.431801 0.512 1193   0.843 1.0000
##  Poco - Rusp  0.214903 0.264 1184   0.814 1.0000
##  Poco - Sila -1.182392 0.969 1194  -1.220 1.0000
##  Poco - Soca -1.298569 0.157 1193  -8.258 <.0001
##  Poco - Soga  2.606219 0.691 1194   3.771 0.0560
##  Poco - Sogr -0.663920 0.334 1194  -1.985 0.9878
##  Poco - Sora -0.424359 0.393 1194  -1.079 1.0000
##  Poco - Syla  1.590835 0.968 1194   1.644 0.9995
##  Poco - Sypi  0.164460 0.264 1191   0.622 1.0000
##  Poco - Syur -1.353604 0.968 1194  -1.398 1.0000
```

```
##  Poco - Taof  1.104000 0.293 1189   3.771 0.0561
##  Poco - Trsp -1.047402 0.227 1191  -4.617 0.0020
##  Poco - Vear  2.549167 0.691 1194   3.692 0.0727
##  Popr - Pore  0.497249 0.160 1192   3.111 0.3437
##  Popr - Posp  0.836653 0.501 1193   1.670 0.9993
##  Popr - Rusp  0.619755 0.243 1142   2.555 0.7836
##  Popr - Sila -0.777540 0.962 1193  -0.808 1.0000
##  Popr - Soca -0.893718 0.116 1172  -7.677 <.0001
##  Popr - Soga  3.011071 0.683 1193   4.407 0.0050
##  Popr - Sogr -0.259068 0.317 1193  -0.818 1.0000
##  Popr - Sora -0.019507 0.377 1192  -0.052 1.0000
##  Popr - Syla  1.995686 0.963 1194   2.072 0.9777
##  Popr - Sypi  0.569312 0.244 1193   2.336 0.9058
##  Popr - Syur -0.948753 0.963 1194  -0.985 1.0000
##  Popr - Taof  1.508852 0.271 1184   5.564 <.0001
##  Popr - Trsp -0.642550 0.198 1182  -3.247 0.2535
##  Popr - Vear  2.954019 0.682 1194   4.332 0.0068
##  Pore - Posp  0.339404 0.509 1194   0.666 1.0000
##  Pore - Rusp  0.122506 0.264 1164   0.464 1.0000
##  Pore - Sila -1.274789 0.967 1193  -1.318 1.0000
##  Pore - Soca -1.390967 0.158 1192  -8.817 <.0001
##  Pore - Soga  2.513822 0.691 1194   3.637 0.0863
##  Pore - Sogr -0.756317 0.333 1193  -2.272 0.9301
##  Pore - Sora -0.516756 0.390 1193  -1.324 1.0000
##  Pore - Syla  1.498438 0.970 1194   1.545 0.9999
##  Pore - Sypi  0.072063 0.265 1190   0.272 1.0000
##  Pore - Syur -1.446001 0.970 1194  -1.491 0.9999
##  Pore - Taof  1.011603 0.289 1186   3.496 0.1319
##  Pore - Trsp -1.139799 0.221 1188  -5.163 0.0001
##  Pore - Vear  2.456770 0.689 1193   3.564 0.1080
##  Posp - Rusp -0.216898 0.543 1193  -0.399 1.0000
##  Posp - Sila -1.614193 1.077 1194  -1.498 0.9999
##  Posp - Soca -1.730370 0.500 1193  -3.459 0.1464
##  Posp - Soga  2.174418 0.838 1190   2.594 0.7567
##  Posp - Sogr -1.095721 0.581 1194  -1.886 0.9944
##  Posp - Sora -0.856160 0.615 1193  -1.391 1.0000
##  Posp - Syla  1.159034 1.079 1194   1.074 1.0000
##  Posp - Sypi -0.267340 0.545 1192  -0.491 1.0000
##  Posp - Syur -1.785405 1.079 1194  -1.654 0.9994
##  Posp - Taof  0.672199 0.556 1193   1.208 1.0000
##  Posp - Trsp -1.479203 0.511 1194  -2.893 0.5158
##  Posp - Vear  2.117367 0.838 1193   2.527 0.8027
##  Rusp - Sila -1.397295 0.985 1194  -1.419 1.0000
##  Rusp - Soca -1.513473 0.241 1146  -6.283 <.0001
##  Rusp - Soga  2.391316 0.715 1193   3.343 0.1999
##  Rusp - Sogr -0.878823 0.381 1194  -2.304 0.9186
##  Rusp - Sora -0.639262 0.431 1192  -1.483 0.9999
##  Rusp - Syla  1.375932 0.986 1193   1.396 1.0000
##  Rusp - Sypi -0.050443 0.322 1172  -0.157 1.0000
##  Rusp - Syur -1.568507 0.986 1193  -1.591 0.9997
##  Rusp - Taof  0.889097 0.342 1194   2.598 0.7540
##  Rusp - Trsp -1.262305 0.288 1176  -4.384 0.0055
##  Rusp - Vear  2.334264 0.714 1192   3.268 0.2413
##  Sila - Soca -0.116178 0.961 1193  -0.121 1.0000
```

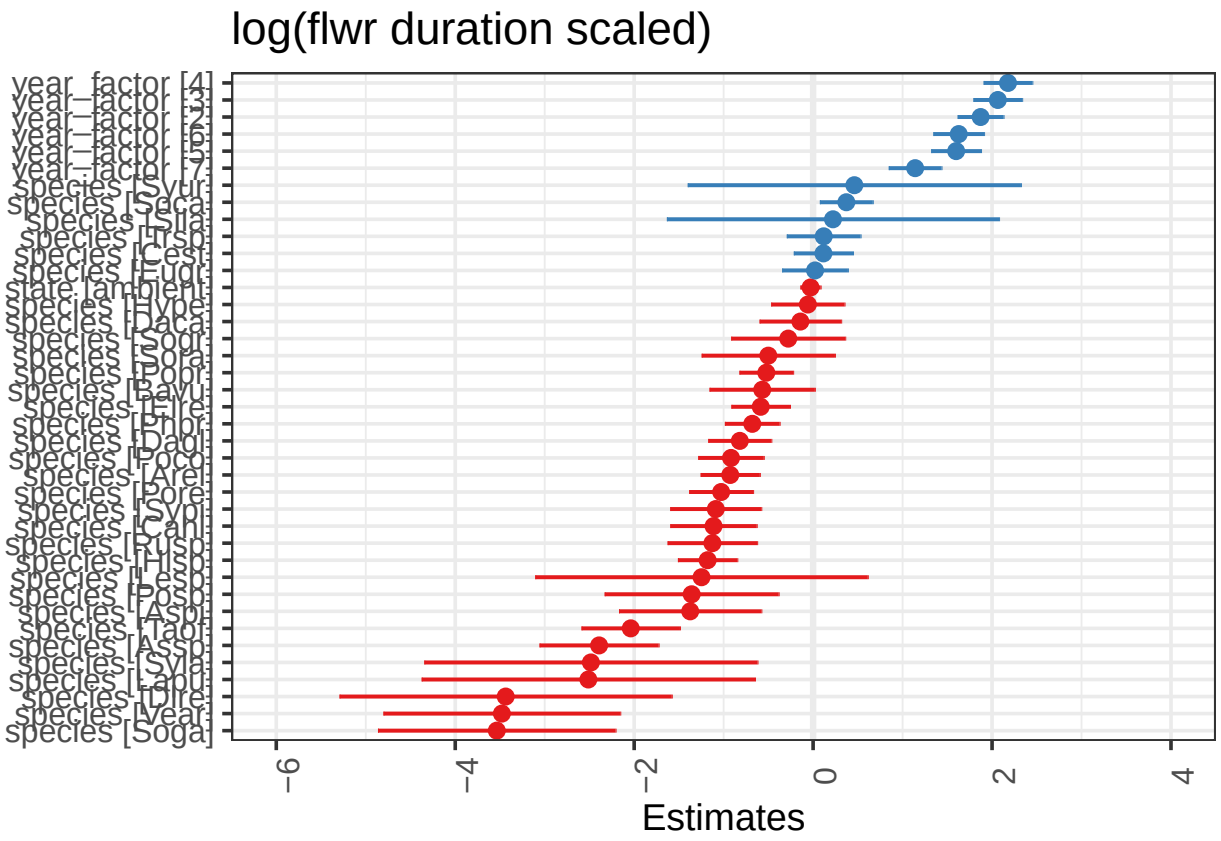
```
##  Sila - Soga  3.788611 1.174 1194   3.226 0.2664
##  Sila - Sogr  0.518472 1.006 1193   0.516 1.0000
##  Sila - Sora  0.758033 1.026 1191   0.739 1.0000
##  Sila - Syla  2.773226 1.358 1193   2.042 0.9817
##  Sila - Sypi  1.346852 0.987 1193   1.365 1.0000
##  Sila - Syur -0.171212 1.358 1193  -0.126 1.0000
##  Sila - Taof  2.286392 0.991 1194   2.307 0.9175
##  Sila - Trsp  0.134990 0.972 1193   0.139 1.0000
##  Sila - Vear  3.731559 1.171 1181   3.186 0.2925
##  Soca - Soga  3.904789 0.683 1193   5.718 <.0001
##  Soca - Sogr  0.634650 0.316 1192   2.009 0.9856
##  Soca - Sora  0.874210 0.376 1192   2.327 0.9095
##  Soca - Syla  2.889404 0.963 1194   3.002 0.4272
##  Soca - Sypi  1.463030 0.242 1193   6.038 <.0001
##  Soca - Syur -0.055035 0.963 1194  -0.057 1.0000
##  Soca - Taof  2.402570 0.270 1186   8.898 <.0001
##  Soca - Trsp  0.251168 0.196 1181   1.282 1.0000
##  Soca - Vear  3.847737 0.681 1194   5.646 <.0001
##  Soga - Sogr -3.270139 0.740 1189  -4.421 0.0047
##  Soga - Sora -3.030578 0.772 1192  -3.926 0.0328
##  Soga - Syla -1.015385 1.176 1194  -0.863 1.0000
##  Soga - Sypi -2.441759 0.715 1193  -3.413 0.1661
##  Soga - Syur -3.959824 1.176 1194  -3.367 0.1879
##  Soga - Taof -1.502219 0.724 1189  -2.075 0.9772
##  Soga - Trsp -3.653621 0.702 1193  -5.206 0.0001
##  Soga - Vear -0.057052 0.957 1194  -0.060 1.0000
##  Sogr - Sora  0.239561 0.475 1182   0.504 1.0000
##  Sogr - Syla  2.254755 1.009 1194   2.236 0.9419
##  Sogr - Sypi  0.828380 0.382 1193   2.169 0.9595
##  Sogr - Syur -0.689684 1.009 1194  -0.684 1.0000
##  Sogr - Taof  1.767920 0.397 1186   4.455 0.0040
##  Sogr - Trsp -0.383482 0.355 1190  -1.080 1.0000
##  Sogr - Vear  3.213087 0.740 1193   4.341 0.0065
##  Sora - Syla  2.015194 1.029 1194   1.959 0.9900
##  Sora - Sypi  0.588820 0.435 1192   1.354 1.0000
##  Sora - Syur -0.929245 1.029 1194  -0.903 1.0000
##  Sora - Taof  1.528359 0.446 1192   3.430 0.1584
##  Sora - Trsp -0.623043 0.409 1190  -1.524 0.9999
##  Sora - Vear  2.973527 0.767 1193   3.876 0.0391
##  Syla - Sypi -1.426374 0.985 1192  -1.448 1.0000
##  Syla - Syur -2.944439 1.347 1170  -2.185 0.9557
##  Syla - Taof -0.486835 0.994 1193  -0.490 1.0000
##  Syla - Trsp -2.638237 0.977 1193  -2.701 0.6746
##  Syla - Vear  0.958333 1.175 1194   0.815 1.0000
##  Sypi - Syur -1.518065 0.985 1192  -1.541 0.9999
##  Sypi - Taof  0.939540 0.345 1193   2.720 0.6593
##  Sypi - Trsp -1.211862 0.292 1191  -4.157 0.0138
##  Sypi - Vear  2.384707 0.715 1194   3.336 0.2034
##  Syur - Taof  2.457604 0.994 1193   2.472 0.8368
##  Syur - Trsp  0.306202 0.977 1193   0.314 1.0000
##  Syur - Vear  3.902772 1.175 1194   3.321 0.2117
##  Taof - Trsp -2.151402 0.311 1193  -6.910 <.0001
##  Taof - Vear  1.445167 0.723 1193   1.999 0.9866
##  Trsp - Vear  3.596569 0.700 1193   5.136 0.0002
```

```
##
## Results are averaged over the levels of: state, year_factor, insecticide
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## P value adjustment: tukey method for comparing a family of 33 estimates
```

```
emmeans(mod7c, list(pairwise ~ insecticide), adjust = "tukey")
```

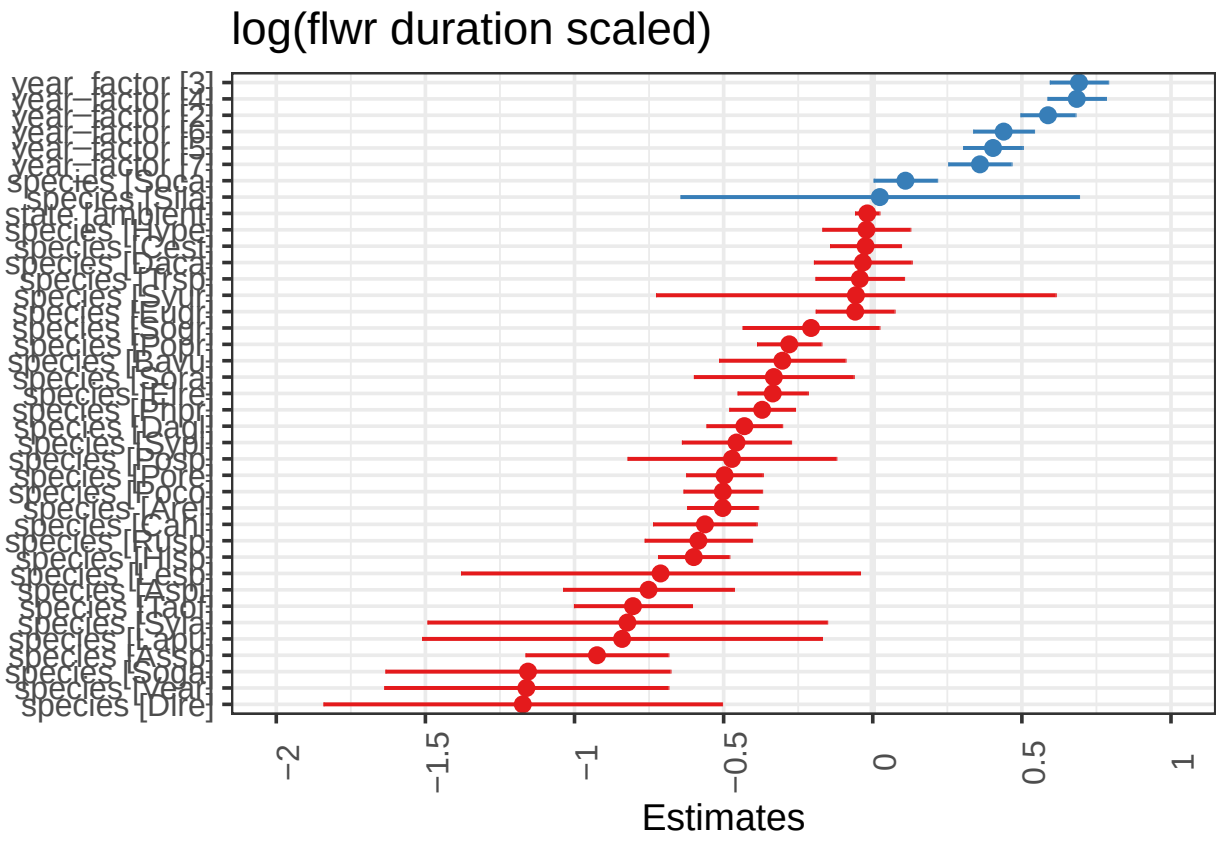
```
## $`emmeans of insecticide`
##  insecticide emmean     SE  df lower.CL upper.CL
##  insects       1.79 0.0901 338     1.61     1.97
##  no_insects    1.85 0.0903 360     1.68     2.03
##
## Results are averaged over the levels of: state, species, year_factor
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
## $`pairwise differences of insecticide`
##  1                    estimate     SE   df t.ratio p.value
##  insects - no_insects  -0.0628 0.0592 24.1 -1.061  0.2993
##
## Results are averaged over the levels of: state, species, year_factor
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
```

```
# Take a look at the estimates for each fixed effect. These are the estimates
# from summary(mod7a). You'll see that species vary a lot - and many of them are
# different from zero (meaning their half cover date is significantly different
# from zero).
plot_model(mod7a, sort.est = TRUE)
```



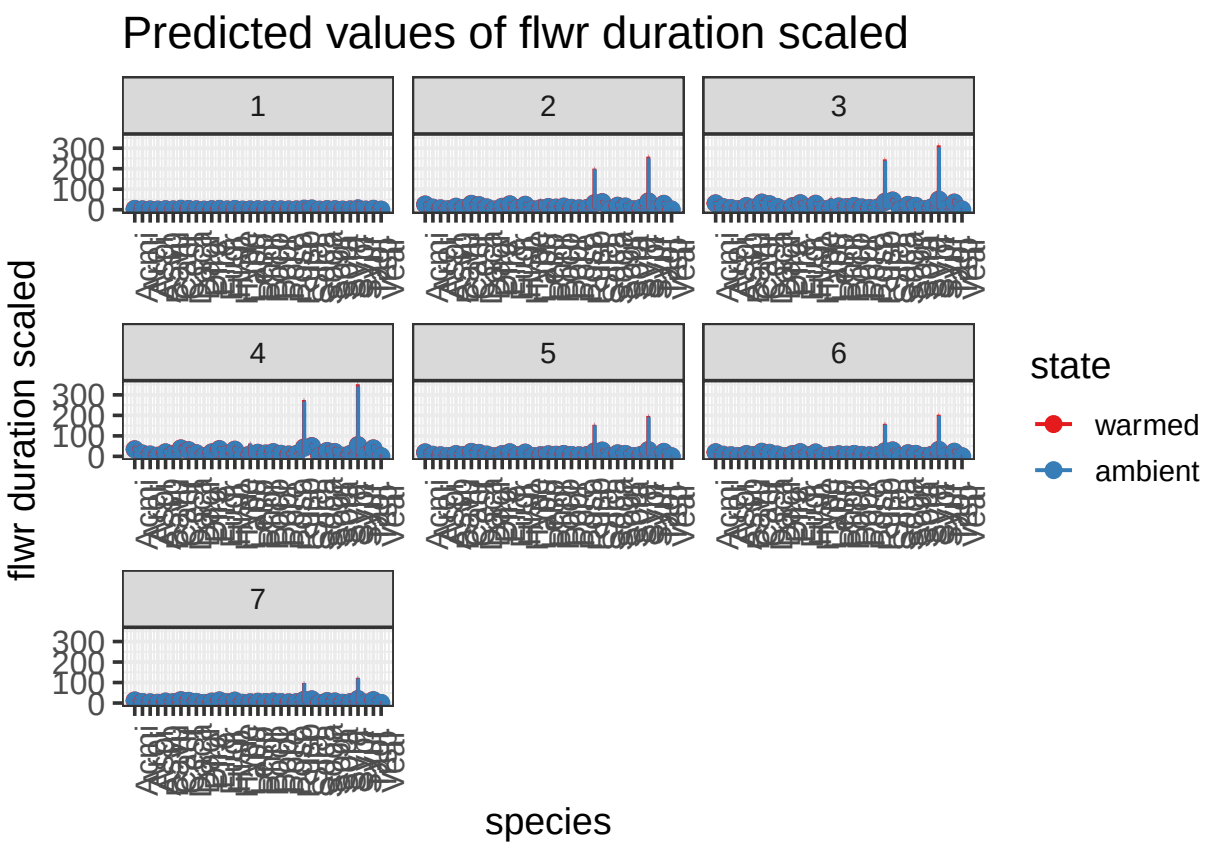

```
# if you want to standardize the estimates:
plot_model(mod7a, sort.est = TRUE, type = "std")
```

```
## Formula contains log- or sqrt-terms. See help("standardize") for how such terms are standardized.
```

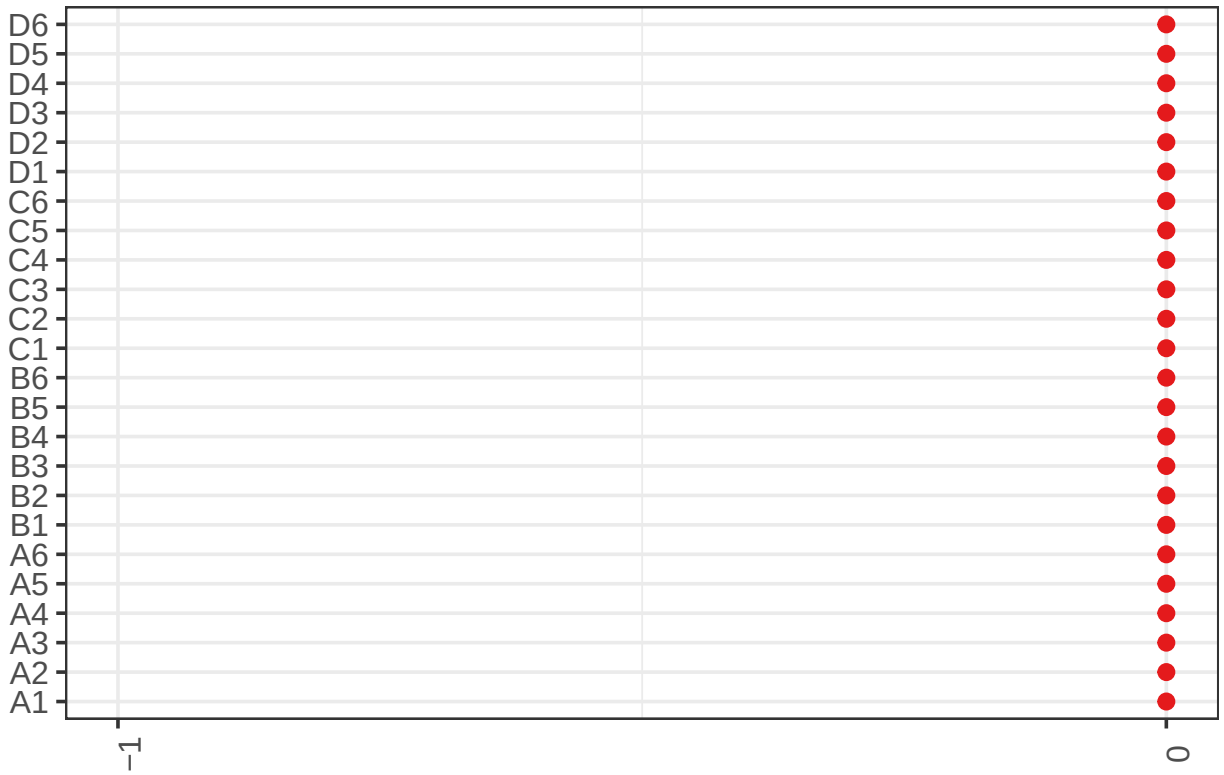



```
# these are the fixed predicted values: - note this is a new plot
plot_model(mod7a, type = "pred", terms = c("species", "state", "year_factor"))
```

```
## Model has log-transformed response. Back-transforming predictions to original response scale. Standa
```




```
# these are the random effects estimates
plot_model(mod7a, type = "re")
```




```
# including native vs. exotic
kbs_flwr_spp <- within(kbs_flwr_spp, origin <- relevel(factor(origin), ref = "Native"))  # releveling s
mod8 <- lmer(log(flwr_duration_scaled) ~ state * origin + (1 + factor(year_factor) |
    plot), kbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod9 <- lmer(log(flwr_duration_scaled) ~ state + origin + (1 + factor(year_factor) |
    plot), kbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod9a <- lmer(log(flwr_duration_scaled) ~ state + origin + factor(year_factor) +
    (1 | plot), kbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
anova(mod8, mod9)  # model 9 is a better fit to data
```

```
## Data: kbs_flwr_spp
## Models:
## mod9: log(flwr_duration_scaled) ~ state + origin + (1 + factor(year_factor) |
## mod9:     plot)
## mod8: log(flwr_duration_scaled) ~ state * origin + (1 + factor(year_factor) |
```

```
## mod8:     plot)
##      npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## mod9   34 3392.8 3563.6 -1662.4   3324.8
## mod8   37 3398.0 3584.0 -1662.0   3324.0 0.7217  3     0.8681
```

```
anova(mod9, mod9a)  # mod 9a
```

```
## Data: kbs_flwr_spp
## Models:
## mod9a: log(flwr_duration_scaled) ~ state + origin + factor(year_factor) +
## mod9a:     (1 | plot)
## mod9: log(flwr_duration_scaled) ~ state + origin + (1 + factor(year_factor) |
## mod9:     plot)
##       npar    AIC    BIC  logLik deviance Chisq Df Pr(>Chisq)
## mod9a   13 3305.0 3370.4 -1639.5   3279.0
## mod9    34 3392.8 3563.6 -1662.4   3324.8     0 21          1
```

```
summary(mod9a)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: log(flwr_duration_scaled) ~ state + origin + factor(year_factor) +
##     (1 | plot)
##    Data: kbs_flwr_spp
##
##      AIC      BIC   logLik deviance df.resid
##   3305.0   3370.4  -1639.5   3279.0     1112
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.4025 -0.3879  0.1925  0.5738  2.4878
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  plot     (Intercept) 0.00     0.000
##  Residual             1.08     1.039
## Number of obs: 1125, groups:  plot, 24
##
## Fixed effects:
##                         Estimate Std. Error         df t value Pr(>|t|)
## (Intercept)              1.94928    0.13671 1125.00000  14.259  < 2e-16 ***
## stateambient            -0.07433    0.06240 1125.00000  -1.191  0.23383
## origin                  -1.91211    0.53645 1125.00000  -3.564  0.00038 ***
## originBoth              -1.08630    0.11221 1125.00000  -9.681  < 2e-16 ***
## originExotic            -0.76838    0.07475 1125.00000 -10.279  < 2e-16 ***
## factor(year_factor)2     1.52687    0.13767 1125.00000  11.091  < 2e-16 ***
## factor(year_factor)3     1.58408    0.14217 1125.00000  11.142  < 2e-16 ***
## factor(year_factor)4     1.66077    0.14113 1125.00000  11.767  < 2e-16 ***
## factor(year_factor)5     1.10392    0.14407 1125.00000   7.662 3.92e-14 ***
## factor(year_factor)6     1.16807    0.14646 1125.00000   7.975 3.72e-15 ***
## factor(year_factor)7     0.66663    0.15292 1125.00000   4.359 1.42e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## Correlation of Fixed Effects:
##             (Intr) sttmbn origin orgnBt orgnEx fc(_)2 fc(_)3 fc(_)4 fc(_)5
## stateambint -0.216
## origin      -0.242 -0.003
## originBoth  -0.308 -0.054  0.082
## originExotc -0.424  0.023  0.107  0.488
## fctr(yr_f)2 -0.758 -0.031  0.195  0.018  0.021
## fctr(yr_f)3 -0.734 -0.033  0.189  0.028  0.017  0.728
## fctr(yr_f)4 -0.733 -0.040  0.189  0.061 -0.013  0.733  0.711
## fctr(yr_f)5 -0.733 -0.045  0.189  0.076  0.028  0.719  0.697  0.705
## fctr(yr_f)6 -0.722 -0.014  0.185  0.063  0.018  0.706  0.684  0.692  0.679
## fctr(yr_f)7 -0.714 -0.007  0.182  0.104  0.058  0.677  0.657  0.664  0.653
##             fc(_)6
## stateambint
## origin
## originBoth
## originExotc
## fctr(yr_f)2
## fctr(yr_f)3
## fctr(yr_f)4
## fctr(yr_f)5
## fctr(yr_f)6
## fctr(yr_f)7  0.641
## optimizer (nloptwrap) convergence code: 0 (OK)
## boundary (singular) fit: see ?isSingular
```

```
anova(mod9a)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##                       Sum Sq Mean Sq NumDF DenDF F value Pr(>F)
## state                  1.532   1.532     1  1125  1.4189 0.2338
## origin               150.676  50.225     3  1125 46.5116 <2e-16 ***
## factor(year_factor) 234.217  39.036     6  1125 36.1497 <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
emmeans(mod9a, list(pairwise ~ state + origin + year_factor), adjust = "tukey")
```

```
## boundary (singular) fit: see ?isSingular
```

```
## $`emmeans of state, origin, year_factor`
##  state   origin year_factor  emmean     SE   df  lower.CL upper.CL
##  warmed  Native           1  1.9493 0.1376  752  1.679182    2.219
##  ambient Native           1  1.8749 0.1383  799  1.603556    2.146
##  warmed                   1  0.0372 0.5239 1135 -0.990690    1.065
##  ambient                  1 -0.0372 0.5240 1134 -1.065228    0.991
##  warmed  Both             1  0.8630 0.1487  846  0.571169    1.155
##  ambient Both             1  0.7886 0.1468  852  0.500598    1.077
##  warmed  Exotic           1  1.1809 0.1257  655  0.933998    1.428
##  ambient Exotic           1  1.1066 0.1274  696  0.856483    1.357
##  warmed  Native           2  3.4761 0.0959  373  3.287528    3.665
```

```
##  ambient Native          2  3.4018 0.0942  352  3.216486    3.587
##  warmed                  2  1.5640 0.5422 1134  0.500134    2.628
##  ambient                 2  1.4897 0.5419 1132  0.426520    2.553
##  warmed  Both            2  2.3898 0.1139  549  2.166205    2.613
##  ambient Both            2  2.3155 0.1090  472  2.101250    2.530
##  warmed  Exotic          2  2.7078 0.0808  217  2.548545    2.867
##  ambient Exotic          2  2.6334 0.0802  199  2.475271    2.792
##  warmed  Native          3  3.5334 0.1024  430  3.332005    3.735
##  ambient Native          3  3.4590 0.1005  411  3.261405    3.657
##  warmed                  3  1.6212 0.5434 1135  0.555066    2.687
##  ambient                 3  1.5469 0.5430 1133  0.481571    2.612
##  warmed  Both            3  2.4471 0.1208  611  2.209790    2.684
##  ambient Both            3  2.3727 0.1160  541  2.144846    2.601
##  warmed  Exotic          3  2.7650 0.0881  273  2.591631    2.938
##  ambient Exotic          3  2.6907 0.0871  252  2.519030    2.862
##  warmed  Native          4  3.6100 0.1023  437  3.409010    3.811
##  ambient Native          4  3.5357 0.0998  403  3.339507    3.732
##  warmed                  4  1.6979 0.5432 1135  0.632178    2.764
##  ambient                 4  1.6236 0.5427 1133  0.558888    2.688
##  warmed  Both            4  2.5237 0.1249  647  2.278405    2.769
##  ambient Both            4  2.4494 0.1198  566  2.214059    2.685
##  warmed  Exotic          4  2.8417 0.0841  248  2.675984    3.007
##  ambient Exotic          4  2.7673 0.0825  215  2.604757    2.930
##  warmed  Native          5  3.0532 0.1035  445  2.849748    3.257
##  ambient Native          5  2.9789 0.1005  416  2.781327    3.176
##  warmed                  5  1.1411 0.5440 1135  0.073727    2.208
##  ambient                 5  1.0668 0.5434 1133  0.000645    2.133
##  warmed  Both            5  1.9669 0.1281  687  1.715478    2.218
##  ambient Both            5  1.8926 0.1226  617  1.651819    2.133
##  warmed  Exotic          5  2.2848 0.0906  302  2.106590    2.463
##  ambient Exotic          5  2.2105 0.0884  270  2.036452    2.385
##  warmed  Native          6  3.1174 0.1065  483  2.908073    3.327
##  ambient Native          6  3.0430 0.1064  466  2.834038    3.252
##  warmed                  6  1.2052 0.5445 1134  0.136990    2.273
##  ambient                 6  1.1309 0.5444 1132  0.062855    2.199
##  warmed  Both            6  2.0310 0.1289  703  1.777897    2.284
##  ambient Both            6  1.9567 0.1259  636  1.709572    2.204
##  warmed  Exotic          6  2.3490 0.0929  332  2.166161    2.532
##  ambient Exotic          6  2.2746 0.0940  314  2.089747    2.460
##  warmed  Native          7  2.6159 0.1113  516  2.397225    2.835
##  ambient Native          7  2.5416 0.1116  515  2.322246    2.761
##  warmed                  7  0.7038 0.5461 1135 -0.367725    1.775
##  ambient                 7  0.6295 0.5461 1133 -0.442053    1.701
##  warmed  Both            7  1.5296 0.1385  756  1.257720    1.801
##  ambient Both            7  1.4553 0.1360  711  1.188209    1.722
##  warmed  Exotic          7  1.8475 0.1030  425  1.645001    2.050
##  ambient Exotic          7  1.7732 0.1045  419  1.567802    1.979
##
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
## $`pairwise differences of state, origin, year_factor`
##  1                                  estimate     SE     df t.ratio p.value
```

```
##  warmed Native 1 - ambient Native 1   0.07433 0.0629   21.8   1.181 1.0000
##  warmed Native 1 - warmed  1          1.91211 0.5401 1136.1   3.540 0.2449
##  warmed Native 1 - ambient  1         1.98644 0.5437 1120.1   3.654 0.1809
##  warmed Native 1 - warmed Both 1      1.08630 0.1129 1135.0   9.622 <.0001
##  warmed Native 1 - ambient Both 1     1.16063 0.1263  272.6   9.188 <.0001
##  warmed Native 1 - warmed Exotic 1    0.76838 0.0752 1136.1  10.211 <.0001
##  warmed Native 1 - ambient Exotic 1   0.84271 0.0993  119.7   8.491 <.0001
##  warmed Native 1 - warmed Native 2   -1.52687 0.1385 1132.2 -11.025 <.0001
##  warmed Native 1 - ambient Native 2  -1.45254 0.1504  444.2  -9.655 <.0001
##  warmed Native 1 - warmed  2          0.38525 0.5833 1136.0   0.661 1.0000
##  warmed Native 1 - ambient  2         0.45958 0.5861 1121.6   0.784 1.0000
##  warmed Native 1 - warmed Both 2     -0.44056 0.1803 1135.5  -2.443 0.9745
##  warmed Native 1 - ambient Both 2    -0.36623 0.1877  672.5  -1.952 0.9998
##  warmed Native 1 - warmed Exotic 2   -0.75849 0.1590 1134.7  -4.770 0.0027
##  warmed Native 1 - ambient Exotic 2  -0.68416 0.1702  569.0  -4.020 0.0592
##  warmed Native 1 - warmed Native 3   -1.58408 0.1430 1132.5 -11.076 <.0001
##  warmed Native 1 - ambient Native 3  -1.50975 0.1544  475.7  -9.778 <.0001
##  warmed Native 1 - warmed  3          0.32803 0.5843 1136.1   0.561 1.0000
##  warmed Native 1 - ambient  3         0.40236 0.5872 1123.1   0.685 1.0000
##  warmed Native 1 - warmed Both 3     -0.49778 0.1847 1135.3  -2.694 0.8944
##  warmed Native 1 - ambient Both 3    -0.42345 0.1917  701.7  -2.208 0.9961
##  warmed Native 1 - warmed Exotic 3   -0.81570 0.1628 1135.0  -5.011 0.0009
##  warmed Native 1 - ambient Exotic 3  -0.74137 0.1735  592.4  -4.273 0.0235
##  warmed Native 1 - warmed Native 4   -1.66077 0.1420 1133.5 -11.696 <.0001
##  warmed Native 1 - ambient Native 4  -1.58644 0.1531  457.3 -10.363 <.0001
##  warmed Native 1 - warmed  4          0.25135 0.5839 1136.0   0.430 1.0000
##  warmed Native 1 - ambient  4         0.32567 0.5866 1122.5   0.555 1.0000
##  warmed Native 1 - warmed Both 4     -0.57446 0.1868 1135.9  -3.076 0.6196
##  warmed Native 1 - ambient Both 4    -0.50013 0.1934  697.5  -2.586 0.9378
##  warmed Native 1 - warmed Exotic 4   -0.89239 0.1599 1135.0  -5.582 <.0001
##  warmed Native 1 - ambient Exotic 4  -0.81806 0.1705  566.5  -4.799 0.0026
##  warmed Native 1 - warmed Native 5   -1.10392 0.1449 1129.3  -7.619 <.0001
##  warmed Native 1 - ambient Native 5  -1.02959 0.1554  493.5  -6.625 <.0001
##  warmed Native 1 - warmed  5          0.80819 0.5852 1136.1   1.381 1.0000
##  warmed Native 1 - ambient  5         0.88252 0.5878 1123.9   1.501 1.0000
##  warmed Native 1 - warmed Both 5     -0.01762 0.1904 1134.0  -0.093 1.0000
##  warmed Native 1 - ambient Both 5     0.05671 0.1966  741.1   0.288 1.0000
##  warmed Native 1 - warmed Exotic 5   -0.33554 0.1651 1133.2  -2.032 0.9994
##  warmed Native 1 - ambient Exotic 5  -0.26122 0.1751  614.1  -1.492 1.0000
##  warmed Native 1 - warmed Native 6   -1.16807 0.1474 1133.0  -7.927 <.0001
##  warmed Native 1 - ambient Native 6  -1.09375 0.1595  503.5  -6.855 <.0001
##  warmed Native 1 - warmed  6          0.74404 0.5857 1135.9   1.270 1.0000
##  warmed Native 1 - ambient  6         0.81837 0.5888 1121.2   1.390 1.0000
##  warmed Native 1 - warmed Both 6     -0.08177 0.1912 1135.1  -0.428 1.0000
##  warmed Native 1 - ambient Both 6    -0.00744 0.1989  736.2  -0.037 1.0000
##  warmed Native 1 - warmed Exotic 6   -0.39970 0.1667 1134.9  -2.398 0.9815
##  warmed Native 1 - ambient Exotic 6  -0.32537 0.1782  615.3  -1.826 1.0000
##  warmed Native 1 - warmed Native 7   -0.66663 0.1538 1131.7  -4.334 0.0175
##  warmed Native 1 - ambient Native 7  -0.59230 0.1659  560.2  -3.571 0.2298
##  warmed Native 1 - warmed  7          1.24548 0.5880 1136.1   2.118 0.9985
##  warmed Native 1 - ambient  7         1.31981 0.5912 1124.6   2.233 0.9953
##  warmed Native 1 - warmed Both 7      0.41968 0.2001 1134.9   2.098 0.9988
##  warmed Native 1 - ambient Both 7     0.49400 0.2077  788.0   2.379 0.9836
##  warmed Native 1 - warmed Exotic 7    0.10175 0.1751 1133.9   0.581 1.0000
```

```
##  warmed Native 1 - ambient Exotic 7   0.17608 0.1864  679.8   0.945 1.0000
##  ambient Native 1 - warmed  1         1.83778 0.5438 1129.0   3.379 0.3584
##  ambient Native 1 - ambient  1        1.91211 0.5401 1136.1   3.540 0.2449
##  ambient Native 1 - warmed Both 1     1.01197 0.1321  332.1   7.659 <.0001
##  ambient Native 1 - ambient Both 1    1.08630 0.1129 1135.0   9.622 <.0001
##  ambient Native 1 - warmed Exotic 1   0.69405 0.0969  116.6   7.161 <.0001
##  ambient Native 1 - ambient Exotic 1  0.76838 0.0752 1136.1  10.211 <.0001
##  ambient Native 1 - warmed Native 2  -1.60119 0.1538  517.6 -10.413 <.0001
##  ambient Native 1 - ambient Native 2 -1.52687 0.1385 1132.2 -11.025 <.0001
##  ambient Native 1 - warmed  2         0.31092 0.5871 1130.2   0.530 1.0000
##  ambient Native 1 - ambient  2        0.38525 0.5833 1136.0   0.661 1.0000
##  ambient Native 1 - warmed Both 2    -0.51489 0.1942  776.8  -2.651 0.9134
##  ambient Native 1 - ambient Both 2   -0.44056 0.1803 1135.5  -2.443 0.9745
##  ambient Native 1 - warmed Exotic 2  -0.83282 0.1718  647.4  -4.847 0.0020
##  ambient Native 1 - ambient Exotic 2 -0.75849 0.1590 1134.7  -4.770 0.0027
##  ambient Native 1 - warmed Native 3  -1.65841 0.1581  546.8 -10.491 <.0001
##  ambient Native 1 - ambient Native 3 -1.58408 0.1430 1132.5 -11.076 <.0001
##  ambient Native 1 - warmed  3         0.25370 0.5883 1131.0   0.431 1.0000
##  ambient Native 1 - ambient  3        0.32803 0.5843 1136.1   0.561 1.0000
##  ambient Native 1 - warmed Both 3    -0.57210 0.1985  799.1  -2.882 0.7785
##  ambient Native 1 - ambient Both 3   -0.49778 0.1847 1135.3  -2.694 0.8944
##  ambient Native 1 - warmed Exotic 3  -0.89003 0.1755  667.2  -5.071 0.0007
##  ambient Native 1 - ambient Exotic 3 -0.81570 0.1628 1135.0  -5.011 0.0009
##  ambient Native 1 - warmed Native 4  -1.73510 0.1575  544.0 -11.016 <.0001
##  ambient Native 1 - ambient Native 4 -1.66077 0.1420 1133.5 -11.696 <.0001
##  ambient Native 1 - warmed  4         0.17702 0.5879 1130.9   0.301 1.0000
##  ambient Native 1 - ambient  4        0.25135 0.5839 1136.0   0.430 1.0000
##  ambient Native 1 - warmed Both 4    -0.64879 0.2007  805.3  -3.233 0.4811
##  ambient Native 1 - ambient Both 4   -0.57446 0.1868 1135.9  -3.076 0.6196
##  ambient Native 1 - warmed Exotic 4  -0.96672 0.1731  656.9  -5.584 0.0001
##  ambient Native 1 - ambient Exotic 4 -0.89239 0.1599 1135.0  -5.582 <.0001
##  ambient Native 1 - warmed Native 5  -1.17825 0.1605  573.9  -7.342 <.0001
##  ambient Native 1 - ambient Native 5 -1.10392 0.1449 1129.3  -7.619 <.0001
##  ambient Native 1 - warmed  5         0.73386 0.5893 1131.5   1.245 1.0000
##  ambient Native 1 - ambient  5        0.80819 0.5852 1136.1   1.381 1.0000
##  ambient Native 1 - warmed Both 5    -0.09195 0.2044  836.8  -0.450 1.0000
##  ambient Native 1 - ambient Both 5   -0.01762 0.1904 1134.0  -0.093 1.0000
##  ambient Native 1 - warmed Exotic 5  -0.40987 0.1783  695.2  -2.299 0.9912
##  ambient Native 1 - ambient Exotic 5 -0.33554 0.1651 1133.2  -2.032 0.9994
##  ambient Native 1 - warmed Native 6  -1.24240 0.1609  575.8  -7.721 <.0001
##  ambient Native 1 - ambient Native 6 -1.16807 0.1474 1133.0  -7.927 <.0001
##  ambient Native 1 - warmed  6         0.66971 0.5893 1130.1   1.136 1.0000
##  ambient Native 1 - ambient  6        0.74404 0.5857 1135.9   1.270 1.0000
##  ambient Native 1 - warmed Both 6    -0.15610 0.2037  833.7  -0.766 1.0000
##  ambient Native 1 - ambient Both 6   -0.08177 0.1912 1135.1  -0.428 1.0000
##  ambient Native 1 - warmed Exotic 6  -0.47403 0.1782  693.4  -2.661 0.9088
##  ambient Native 1 - ambient Exotic 6 -0.39970 0.1667 1134.9  -2.398 0.9815
##  ambient Native 1 - warmed Native 7  -0.74096 0.1665  616.2  -4.449 0.0116
##  ambient Native 1 - ambient Native 7 -0.66663 0.1538 1131.7  -4.334 0.0175
##  ambient Native 1 - warmed  7         1.17116 0.5915 1132.0   1.980 0.9997
##  ambient Native 1 - ambient  7        1.24548 0.5880 1136.1   2.118 0.9985
##  ambient Native 1 - warmed Both 7     0.34535 0.2118  865.6   1.631 1.0000
##  ambient Native 1 - ambient Both 7    0.41968 0.2001 1134.9   2.098 0.9988
##  ambient Native 1 - warmed Exotic 7   0.02742 0.1858  741.3   0.148 1.0000
```

```
##  ambient Native 1 - ambient Exotic 7  0.10175 0.1751 1133.9   0.581 1.0000
##  warmed  1 - ambient  1                0.07433 0.0629   21.8   1.181 1.0000
##  warmed  1 - warmed Both 1           -0.82581 0.5427 1136.1  -1.522 1.0000
##  warmed  1 - ambient Both 1          -0.75148 0.5457 1128.5  -1.377 1.0000
##  warmed  1 - warmed Exotic 1         -1.14374 0.5372 1136.1  -2.129 0.9983
##  warmed  1 - ambient Exotic 1        -1.06941 0.5412 1130.2  -1.976 0.9997
##  warmed  1 - warmed Native 2         -3.43898 0.5306 1135.9  -6.481 <.0001
##  warmed  1 - ambient Native 2        -3.36465 0.5339 1130.7  -6.302 <.0001
##  warmed  1 - warmed  2               -1.52687 0.1385 1132.2 -11.025 <.0001
##  warmed  1 - ambient  2              -1.45254 0.1504  444.2  -9.655 <.0001
##  warmed  1 - warmed Both 2           -2.35268 0.5338 1136.0  -4.407 0.0130
##  warmed  1 - ambient Both 2          -2.27835 0.5364 1129.8  -4.247 0.0246
##  warmed  1 - warmed Exotic 2         -2.67060 0.5281 1135.5  -5.057 0.0007
##  warmed  1 - ambient Exotic 2        -2.59627 0.5317 1131.7  -4.883 0.0016
##  warmed  1 - warmed Native 3         -3.49619 0.5319 1136.1  -6.574 <.0001
##  warmed  1 - ambient Native 3        -3.42186 0.5351 1129.8  -6.395 <.0001
##  warmed  1 - warmed  3               -1.58408 0.1430 1132.5 -11.076 <.0001
##  warmed  1 - ambient  3              -1.50975 0.1544  475.7  -9.778 <.0001
##  warmed  1 - warmed Both 3           -2.40989 0.5354 1136.1  -4.501 0.0088
##  warmed  1 - ambient Both 3          -2.33556 0.5379 1129.0  -4.342 0.0170
##  warmed  1 - warmed Exotic 3         -2.72782 0.5293 1135.8  -5.154 0.0004
##  warmed  1 - ambient Exotic 3        -2.65349 0.5328 1130.8  -4.980 0.0010
##  warmed  1 - warmed Native 4         -3.57288 0.5318 1136.0  -6.719 <.0001
##  warmed  1 - ambient Native 4        -3.49855 0.5349 1129.6  -6.540 <.0001
##  warmed  1 - warmed  4               -1.66077 0.1420 1133.5 -11.696 <.0001
##  warmed  1 - ambient  4              -1.58644 0.1531  457.3 -10.363 <.0001
##  warmed  1 - warmed Both 4           -2.48658 0.5363 1136.1  -4.637 0.0049
##  warmed  1 - ambient Both 4          -2.41225 0.5387 1128.7  -4.478 0.0097
##  warmed  1 - warmed Exotic 4         -2.80450 0.5286 1135.8  -5.305 0.0002
##  warmed  1 - ambient Exotic 4        -2.73018 0.5320 1130.8  -5.132 0.0005
##  warmed  1 - warmed Native 5         -3.01603 0.5320 1136.1  -5.670 <.0001
##  warmed  1 - ambient Native 5        -2.94170 0.5350 1129.7  -5.499 0.0001
##  warmed  1 - warmed  5               -1.10392 0.1449 1129.3  -7.619 <.0001
##  warmed  1 - ambient  5              -1.02959 0.1554  493.5  -6.625 <.0001
##  warmed  1 - warmed Both 5           -1.92973 0.5369 1136.1  -3.594 0.2129
##  warmed  1 - ambient Both 5          -1.85540 0.5392 1129.1  -3.441 0.3121
##  warmed  1 - warmed Exotic 5         -2.24766 0.5296 1135.8  -4.244 0.0249
##  warmed  1 - ambient Exotic 5        -2.17333 0.5329 1130.8  -4.078 0.0463
##  warmed  1 - warmed Native 6         -3.08019 0.5328 1135.9  -5.782 <.0001
##  warmed  1 - ambient Native 6        -3.00586 0.5363 1130.9  -5.604 <.0001
##  warmed  1 - warmed  6               -1.16807 0.1474 1133.0  -7.927 <.0001
##  warmed  1 - ambient  6              -1.09375 0.1595  503.5  -6.855 <.0001
##  warmed  1 - warmed Both 6           -1.99388 0.5374 1136.0  -3.711 0.1538
##  warmed  1 - ambient Both 6          -1.91955 0.5402 1130.3  -3.553 0.2368
##  warmed  1 - warmed Exotic 6         -2.31181 0.5302 1135.5  -4.360 0.0158
##  warmed  1 - ambient Exotic 6        -2.23748 0.5340 1131.9  -4.190 0.0307
##  warmed  1 - warmed Native 7         -2.57874 0.5339 1136.1  -4.830 0.0020
##  warmed  1 - ambient Native 7        -2.50441 0.5375 1129.0  -4.659 0.0044
##  warmed  1 - warmed  7               -0.66663 0.1538 1131.7  -4.334 0.0175
##  warmed  1 - ambient  7              -0.59230 0.1659  560.2  -3.571 0.2298
##  warmed  1 - warmed Both 7           -1.49244 0.5399 1136.1  -2.765 0.8569
##  warmed  1 - ambient Both 7          -1.41811 0.5428 1128.4  -2.613 0.9294
##  warmed  1 - warmed Exotic 7         -1.81036 0.5322 1136.0  -3.401 0.3414
##  warmed  1 - ambient Exotic 7        -1.73603 0.5361 1130.3  -3.238 0.4757
```

```
##  ambient  1 - warmed Both 1          -0.90014 0.5469 1120.8  -1.646 1.0000
##  ambient  1 - ambient Both 1         -0.82581 0.5427 1136.1  -1.522 1.0000
##  ambient  1 - warmed Exotic 1        -1.21806 0.5406 1122.6  -2.253 0.9943
##  ambient  1 - ambient Exotic 1       -1.14374 0.5372 1136.1  -2.129 0.9983
##  ambient  1 - warmed Native 2        -3.51331 0.5348 1124.4  -6.570 <.0001
##  ambient  1 - ambient Native 2       -3.43898 0.5306 1135.9  -6.481 <.0001
##  ambient  1 - warmed  2              -1.60119 0.1538  517.6 -10.413 <.0001
##  ambient  1 - ambient  2             -1.52687 0.1385 1132.2 -11.025 <.0001
##  ambient  1 - warmed Both 2         -2.42700 0.5386 1124.3  -4.506 0.0086
##  ambient  1 - ambient Both 2        -2.35268 0.5338 1136.0  -4.407 0.0130
##  ambient  1 - warmed Exotic 2       -2.74493 0.5321 1126.5  -5.159 0.0004
##  ambient  1 - ambient Exotic 2      -2.67060 0.5281 1135.5  -5.057 0.0007
##  ambient  1 - warmed Native 3       -3.57052 0.5360 1123.0  -6.661 <.0001
##  ambient  1 - ambient Native 3      -3.49619 0.5319 1136.1  -6.574 <.0001
##  ambient  1 - warmed  3             -1.65841 0.1581  546.8 -10.491 <.0001
##  ambient  1 - ambient  3            -1.58408 0.1430 1132.5 -11.076 <.0001
##  ambient  1 - warmed Both 3         -2.48422 0.5402 1123.0  -4.599 0.0058
##  ambient  1 - ambient Both 3        -2.40989 0.5354 1136.1  -4.501 0.0088
##  ambient  1 - warmed Exotic 3       -2.80214 0.5333 1125.1  -5.254 0.0003
##  ambient  1 - ambient Exotic 3      -2.72782 0.5293 1135.8  -5.154 0.0004
##  ambient  1 - warmed Native 4       -3.64721 0.5361 1123.2  -6.804 <.0001
##  ambient  1 - ambient Native 4      -3.57288 0.5318 1136.0  -6.719 <.0001
##  ambient  1 - warmed  4             -1.73510 0.1575  544.0 -11.016 <.0001
##  ambient  1 - ambient  4            -1.66077 0.1420 1133.5 -11.696 <.0001
##  ambient  1 - warmed Both 4         -2.56091 0.5412 1123.2  -4.732 0.0032
##  ambient  1 - ambient Both 4        -2.48658 0.5363 1136.1  -4.637 0.0049
##  ambient  1 - warmed Exotic 4       -2.87883 0.5327 1125.4  -5.404 0.0001
##  ambient  1 - ambient Exotic 4      -2.80450 0.5286 1135.8  -5.305 0.0002
##  ambient  1 - warmed Native 5       -3.09036 0.5363 1122.8  -5.762 <.0001
##  ambient  1 - ambient Native 5      -3.01603 0.5320 1136.1  -5.670 <.0001
##  ambient  1 - warmed  5             -1.17825 0.1605  573.9  -7.342 <.0001
##  ambient  1 - ambient  5            -1.10392 0.1449 1129.3  -7.619 <.0001
##  ambient  1 - warmed Both 5         -2.00406 0.5420 1123.2  -3.698 0.1596
##  ambient  1 - ambient Both 5        -1.92973 0.5369 1136.1  -3.594 0.2129
##  ambient  1 - warmed Exotic 5       -2.32199 0.5338 1125.0  -4.350 0.0164
##  ambient  1 - ambient Exotic 5      -2.24766 0.5296 1135.8  -4.244 0.0249
##  ambient  1 - warmed Native 6       -3.15452 0.5366 1125.2  -5.879 <.0001
##  ambient  1 - ambient Native 6      -3.08019 0.5328 1135.9  -5.782 <.0001
##  ambient  1 - warmed  6             -1.24240 0.1609  575.8  -7.721 <.0001
##  ambient  1 - ambient  6            -1.16807 0.1474 1133.0  -7.927 <.0001
##  ambient  1 - warmed Both 6         -2.06821 0.5419 1125.5  -3.817 0.1116
##  ambient  1 - ambient Both 6        -1.99388 0.5374 1136.0  -3.711 0.1538
##  ambient  1 - warmed Exotic 6       -2.38614 0.5339 1127.2  -4.469 0.0101
##  ambient  1 - ambient Exotic 6      -2.31181 0.5302 1135.5  -4.360 0.0158
##  ambient  1 - warmed Native 7       -2.65307 0.5376 1122.1  -4.935 0.0012
##  ambient  1 - ambient Native 7      -2.57874 0.5339 1136.1  -4.830 0.0020
##  ambient  1 - warmed  7             -0.74096 0.1665  616.2  -4.449 0.0116
##  ambient  1 - ambient  7            -0.66663 0.1538 1131.7  -4.334 0.0175
##  ambient  1 - warmed Both 7         -1.56677 0.5442 1122.5  -2.879 0.7813
##  ambient  1 - ambient Both 7        -1.49244 0.5399 1136.1  -2.765 0.8569
##  ambient  1 - warmed Exotic 7       -1.88469 0.5358 1124.5  -3.518 0.2593
##  ambient  1 - ambient Exotic 7      -1.81036 0.5322 1136.0  -3.401 0.3414
##  warmed Both 1 - ambient Both 1      0.07433 0.0629   21.8   1.181 1.0000
##  warmed Both 1 - warmed Exotic 1    -0.31793 0.1006 1136.1  -3.159 0.5454
```

```
##  warmed Both 1 - ambient Exotic 1    -0.24360 0.1227  254.3  -1.985 0.9995
##  warmed Both 1 - warmed Native 2     -2.61317 0.1770 1129.9 -14.762 <.0001
##  warmed Both 1 - ambient Native 2    -2.53884 0.1885  731.9 -13.467 <.0001
##  warmed Both 1 - warmed  2           -0.70106 0.5852 1136.0  -1.198 1.0000
##  warmed Both 1 - ambient  2          -0.62673 0.5887 1122.6  -1.065 1.0000
##  warmed Both 1 - warmed Both 2       -1.52687 0.1385 1132.2 -11.025 <.0001
##  warmed Both 1 - ambient Both 2      -1.45254 0.1504  444.2  -9.655 <.0001
##  warmed Both 1 - warmed Exotic 2     -1.84479 0.1708 1132.3 -10.803 <.0001
##  warmed Both 1 - ambient Exotic 2    -1.77046 0.1833  680.3  -9.659 <.0001
##  warmed Both 1 - warmed Native 3     -2.67038 0.1796 1130.8 -14.865 <.0001
##  warmed Both 1 - ambient Native 3    -2.59605 0.1908  744.3 -13.605 <.0001
##  warmed Both 1 - warmed  3           -0.75827 0.5859 1136.1  -1.294 1.0000
##  warmed Both 1 - ambient  3          -0.68394 0.5894 1123.9  -1.160 1.0000
##  warmed Both 1 - warmed Both 3       -1.58408 0.1430 1132.5 -11.076 <.0001
##  warmed Both 1 - ambient Both 3      -1.50975 0.1544  475.7  -9.778 <.0001
##  warmed Both 1 - warmed Exotic 3     -1.90201 0.1733 1133.3 -10.976 <.0001
##  warmed Both 1 - ambient Exotic 3    -1.82768 0.1855  691.5  -9.855 <.0001
##  warmed Both 1 - warmed Native 4     -2.74707 0.1759 1130.0 -15.619 <.0001
##  warmed Both 1 - ambient Native 4    -2.67274 0.1870  719.7 -14.295 <.0001
##  warmed Both 1 - warmed  4           -0.83496 0.5846 1136.1  -1.428 1.0000
##  warmed Both 1 - ambient  4          -0.76063 0.5880 1123.5  -1.294 1.0000
##  warmed Both 1 - warmed Both 4       -1.66077 0.1420 1133.5 -11.696 <.0001
##  warmed Both 1 - ambient Both 4      -1.58644 0.1531  457.3 -10.363 <.0001
##  warmed Both 1 - warmed Exotic 4     -1.97869 0.1675 1131.8 -11.815 <.0001
##  warmed Both 1 - ambient Exotic 4    -1.90437 0.1797  656.8 -10.596 <.0001
##  warmed Both 1 - warmed Native 5     -2.19022 0.1767 1128.8 -12.393 <.0001
##  warmed Both 1 - ambient Native 5    -2.11590 0.1875  732.9 -11.287 <.0001
##  warmed Both 1 - warmed  5           -0.27811 0.5854 1136.1  -0.475 1.0000
##  warmed Both 1 - ambient  5          -0.20378 0.5887 1124.4  -0.346 1.0000
##  warmed Both 1 - warmed Both 5       -1.10392 0.1449 1129.3  -7.619 <.0001
##  warmed Both 1 - ambient Both 5      -1.02959 0.1554  493.5  -6.625 <.0001
##  warmed Both 1 - warmed Exotic 5     -1.42185 0.1709 1131.6  -8.318 <.0001
##  warmed Both 1 - ambient Exotic 5    -1.34752 0.1826  682.9  -7.378 <.0001
##  warmed Both 1 - warmed Native 6     -2.25438 0.1799 1131.8 -12.534 <.0001
##  warmed Both 1 - ambient Native 6    -2.18005 0.1919  738.1 -11.357 <.0001
##  warmed Both 1 - warmed  6           -0.34226 0.5863 1135.9  -0.584 1.0000
##  warmed Both 1 - ambient  6          -0.26794 0.5900 1121.9  -0.454 1.0000
##  warmed Both 1 - warmed Both 6       -1.16807 0.1474 1133.0  -7.927 <.0001
##  warmed Both 1 - ambient Both 6      -1.09375 0.1595  503.5  -6.855 <.0001
##  warmed Both 1 - warmed Exotic 6     -1.48600 0.1736 1133.9  -8.559 <.0001
##  warmed Both 1 - ambient Exotic 6    -1.41167 0.1867  687.6  -7.560 <.0001
##  warmed Both 1 - warmed Native 7     -1.75293 0.1811 1129.7  -9.680 <.0001
##  warmed Both 1 - ambient Native 7    -1.67860 0.1934  760.4  -8.681 <.0001
##  warmed Both 1 - warmed  7            0.15918 0.5873 1136.1   0.271 1.0000
##  warmed Both 1 - ambient  7           0.23351 0.5911 1125.2   0.395 1.0000
##  warmed Both 1 - warmed Both 7       -0.66663 0.1538 1131.7  -4.334 0.0175
##  warmed Both 1 - ambient Both 7      -0.59230 0.1659  560.2  -3.571 0.2298
##  warmed Both 1 - warmed Exotic 7     -0.98455 0.1775 1131.9  -5.546 0.0001
##  warmed Both 1 - ambient Exotic 7    -0.91023 0.1906  726.9  -4.774 0.0028
##  ambient Both 1 - warmed Exotic 1    -0.39226 0.1145  199.5  -3.426 0.3359
##  ambient Both 1 - ambient Exotic 1   -0.31793 0.1006 1136.1  -3.159 0.5454
##  ambient Both 1 - warmed Native 2    -2.68750 0.1872  748.2 -14.354 <.0001
##  ambient Both 1 - ambient Native 2   -2.61317 0.1770 1129.9 -14.762 <.0001
##  ambient Both 1 - warmed  2          -0.77539 0.5884 1130.2  -1.318 1.0000
```

```
##  ambient Both 1 - ambient  2         -0.70106 0.5852 1136.0  -1.198 1.0000
##  ambient Both 1 - warmed Both 2      -1.60119 0.1538  517.6 -10.413 <.0001
##  ambient Both 1 - ambient Both 2     -1.52687 0.1385 1132.2 -11.025 <.0001
##  ambient Both 1 - warmed Exotic 2    -1.91912 0.1807  706.9 -10.621 <.0001
##  ambient Both 1 - ambient Exotic 2   -1.84479 0.1708 1132.3 -10.803 <.0001
##  ambient Both 1 - warmed Native 3    -2.74471 0.1899  757.6 -14.455 <.0001
##  ambient Both 1 - ambient Native 3   -2.67038 0.1796 1130.8 -14.865 <.0001
##  ambient Both 1 - warmed  3          -0.83260 0.5892 1130.9  -1.413 1.0000
##  ambient Both 1 - ambient  3         -0.75827 0.5859 1136.1  -1.294 1.0000
##  ambient Both 1 - warmed Both 3      -1.65841 0.1581  546.8 -10.491 <.0001
##  ambient Both 1 - ambient Both 3     -1.58408 0.1430 1132.5 -11.076 <.0001
##  ambient Both 1 - warmed Exotic 3    -1.97634 0.1833  715.1 -10.784 <.0001
##  ambient Both 1 - ambient Exotic 3   -1.90201 0.1733 1133.3 -10.976 <.0001
##  ambient Both 1 - warmed Native 4    -2.82140 0.1866  746.8 -15.118 <.0001
##  ambient Both 1 - ambient Native 4   -2.74707 0.1759 1130.0 -15.619 <.0001
##  ambient Both 1 - warmed  4          -0.90929 0.5880 1130.9  -1.546 1.0000
##  ambient Both 1 - ambient  4         -0.83496 0.5846 1136.1  -1.428 1.0000
##  ambient Both 1 - warmed Both 4      -1.73510 0.1575  544.0 -11.016 <.0001
##  ambient Both 1 - ambient Both 4     -1.66077 0.1420 1133.5 -11.696 <.0001
##  ambient Both 1 - warmed Exotic 4    -2.05302 0.1781  695.0 -11.528 <.0001
##  ambient Both 1 - ambient Exotic 4   -1.97869 0.1675 1131.8 -11.815 <.0001
##  ambient Both 1 - warmed Native 5    -2.26455 0.1877  751.5 -12.062 <.0001
##  ambient Both 1 - ambient Native 5   -2.19022 0.1767 1128.8 -12.393 <.0001
##  ambient Both 1 - warmed  5          -0.35244 0.5889 1131.3  -0.598 1.0000
##  ambient Both 1 - ambient  5         -0.27811 0.5854 1136.1  -0.475 1.0000
##  ambient Both 1 - warmed Both 5      -1.17825 0.1605  573.9  -7.342 <.0001
##  ambient Both 1 - ambient Both 5     -1.10392 0.1449 1129.3  -7.619 <.0001
##  ambient Both 1 - warmed Exotic 5    -1.49618 0.1817  712.6  -8.236 <.0001
##  ambient Both 1 - ambient Exotic 5   -1.42185 0.1709 1131.6  -8.318 <.0001
##  ambient Both 1 - warmed Native 6    -2.32871 0.1892  757.6 -12.311 <.0001
##  ambient Both 1 - ambient Native 6   -2.25438 0.1799 1131.8 -12.534 <.0001
##  ambient Both 1 - warmed  6          -0.41659 0.5892 1129.9  -0.707 1.0000
##  ambient Both 1 - ambient  6         -0.34226 0.5863 1135.9  -0.584 1.0000
##  ambient Both 1 - warmed Both 6      -1.24240 0.1609  575.8  -7.721 <.0001
##  ambient Both 1 - ambient Both 6     -1.16807 0.1474 1133.0  -7.927 <.0001
##  ambient Both 1 - warmed Exotic 6    -1.56033 0.1826  716.6  -8.545 <.0001
##  ambient Both 1 - ambient Exotic 6   -1.48600 0.1736 1133.9  -8.559 <.0001
##  ambient Both 1 - warmed Native 7    -1.82726 0.1900  766.4  -9.615 <.0001
##  ambient Both 1 - ambient Native 7   -1.75293 0.1811 1129.7  -9.680 <.0001
##  ambient Both 1 - warmed  7           0.08485 0.5902 1131.8   0.144 1.0000
##  ambient Both 1 - ambient  7          0.15918 0.5873 1136.1   0.271 1.0000
##  ambient Both 1 - warmed Both 7      -0.74096 0.1665  616.2  -4.449 0.0116
##  ambient Both 1 - ambient Both 7     -0.66663 0.1538 1131.7  -4.334 0.0175
##  ambient Both 1 - warmed Exotic 7    -1.05888 0.1860  742.6  -5.692 <.0001
##  ambient Both 1 - ambient Exotic 7   -0.98455 0.1775 1131.9  -5.546 0.0001
##  warmed Exotic 1 - ambient Exotic 1   0.07433 0.0629   21.8   1.181 1.0000
##  warmed Exotic 1 - warmed Native 2   -2.29524 0.1562 1132.8 -14.695 <.0001
##  warmed Exotic 1 - ambient Native 2  -2.22091 0.1662  568.4 -13.363 <.0001
##  warmed Exotic 1 - warmed  2         -0.38313 0.5802 1136.1  -0.660 1.0000
##  warmed Exotic 1 - ambient  2        -0.30880 0.5829 1123.7  -0.530 1.0000
##  warmed Exotic 1 - warmed Both 2     -1.20894 0.1716 1135.8  -7.045 <.0001
##  warmed Exotic 1 - ambient Both 2    -1.13461 0.1787  622.1  -6.350 <.0001
##  warmed Exotic 1 - warmed Exotic 2   -1.52687 0.1385 1132.2 -11.025 <.0001
##  warmed Exotic 1 - ambient Exotic 2  -1.45254 0.1504  444.2  -9.655 <.0001
```

```
##  warmed Exotic 1 - warmed Native 3   -2.35246 0.1604 1132.6 -14.663 <.0001
##  warmed Exotic 1 - ambient Native 3  -2.27813 0.1700  598.9 -13.401 <.0001
##  warmed Exotic 1 - warmed  3         -0.44034 0.5814 1136.1  -0.757 1.0000
##  warmed Exotic 1 - ambient  3        -0.36601 0.5840 1125.2  -0.627 1.0000
##  warmed Exotic 1 - warmed Both 3     -1.26615 0.1764 1135.4  -7.176 <.0001
##  warmed Exotic 1 - ambient Both 3    -1.19182 0.1831  657.3  -6.508 <.0001
##  warmed Exotic 1 - warmed Exotic 3   -1.58408 0.1430 1132.5 -11.076 <.0001
##  warmed Exotic 1 - ambient Exotic 3  -1.50975 0.1544  475.7  -9.778 <.0001
##  warmed Exotic 1 - warmed Native 4   -2.42914 0.1615 1134.2 -15.039 <.0001
##  warmed Exotic 1 - ambient Native 4  -2.35481 0.1707  590.8 -13.796 <.0001
##  warmed Exotic 1 - warmed  4         -0.51703 0.5815 1136.1  -0.889 1.0000
##  warmed Exotic 1 - ambient  4        -0.44270 0.5840 1124.6  -0.758 1.0000
##  warmed Exotic 1 - warmed Both 4     -1.34284 0.1804 1136.1  -7.445 <.0001
##  warmed Exotic 1 - ambient Both 4    -1.26851 0.1866  661.0  -6.798 <.0001
##  warmed Exotic 1 - warmed Exotic 4   -1.66077 0.1420 1133.5 -11.696 <.0001
##  warmed Exotic 1 - ambient Exotic 4  -1.58644 0.1531  457.3 -10.363 <.0001
##  warmed Exotic 1 - warmed Native 5   -1.87230 0.1614 1130.5 -11.600 <.0001
##  warmed Exotic 1 - ambient Native 5  -1.79797 0.1702  610.2 -10.562 <.0001
##  warmed Exotic 1 - warmed  5          0.03982 0.5820 1136.1   0.068 1.0000
##  warmed Exotic 1 - ambient  5         0.11414 0.5844 1125.9   0.195 1.0000
##  warmed Exotic 1 - warmed Both 5     -0.78599 0.1817 1134.1  -4.325 0.0181
##  warmed Exotic 1 - ambient Both 5    -0.71166 0.1876  696.3  -3.793 0.1220
##  warmed Exotic 1 - warmed Exotic 5   -1.10392 0.1449 1129.3  -7.619 <.0001
##  warmed Exotic 1 - ambient Exotic 5  -1.02959 0.1554  493.5  -6.625 <.0001
##  warmed Exotic 1 - warmed Native 6   -1.93645 0.1642 1133.3 -11.792 <.0001
##  warmed Exotic 1 - ambient Native 6  -1.86212 0.1746  618.6 -10.666 <.0001
##  warmed Exotic 1 - warmed  6         -0.02434 0.5827 1136.1  -0.042 1.0000
##  warmed Exotic 1 - ambient  6         0.04999 0.5856 1123.4   0.085 1.0000
##  warmed Exotic 1 - warmed Both 6     -0.85015 0.1831 1135.3  -4.642 0.0048
##  warmed Exotic 1 - ambient Both 6    -0.77582 0.1905  694.9  -4.072 0.0487
##  warmed Exotic 1 - warmed Exotic 6   -1.16807 0.1474 1133.0  -7.927 <.0001
##  warmed Exotic 1 - ambient Exotic 6  -1.09375 0.1595  503.5  -6.855 <.0001
##  warmed Exotic 1 - warmed Native 7   -1.43500 0.1673 1132.5  -8.579 <.0001
##  warmed Exotic 1 - ambient Native 7  -1.36068 0.1778  649.5  -7.654 <.0001
##  warmed Exotic 1 - warmed  7          0.47711 0.5842 1136.0   0.817 1.0000
##  warmed Exotic 1 - ambient  7         0.55144 0.5872 1126.4   0.939 1.0000
##  warmed Exotic 1 - warmed Both 7     -0.34870 0.1899 1135.2  -1.836 1.0000
##  warmed Exotic 1 - ambient Both 7    -0.27437 0.1973  739.0  -1.391 1.0000
##  warmed Exotic 1 - warmed Exotic 7   -0.66663 0.1538 1131.7  -4.334 0.0175
##  warmed Exotic 1 - ambient Exotic 7  -0.59230 0.1659  560.2  -3.571 0.2298
##  ambient Exotic 1 - warmed Native 2  -2.36957 0.1706  629.4 -13.893 <.0001
##  ambient Exotic 1 - ambient Native 2 -2.29524 0.1562 1132.8 -14.695 <.0001
##  ambient Exotic 1 - warmed  2        -0.45746 0.5843 1131.2  -0.783 1.0000
##  ambient Exotic 1 - ambient  2       -0.38313 0.5802 1136.1  -0.660 1.0000
##  ambient Exotic 1 - warmed Both 2    -1.28327 0.1868  724.3  -6.870 <.0001
##  ambient Exotic 1 - ambient Both 2   -1.20894 0.1716 1135.8  -7.045 <.0001
##  ambient Exotic 1 - warmed Exotic 2  -1.60119 0.1538  517.6 -10.413 <.0001
##  ambient Exotic 1 - ambient Exotic 2 -1.52687 0.1385 1132.2 -11.025 <.0001
##  ambient Exotic 1 - warmed Native 3  -2.42679 0.1746  655.6 -13.895 <.0001
##  ambient Exotic 1 - ambient Native 3 -2.35246 0.1604 1132.6 -14.663 <.0001
##  ambient Exotic 1 - warmed  3        -0.51467 0.5855 1132.0  -0.879 1.0000
##  ambient Exotic 1 - ambient  3       -0.44034 0.5814 1136.1  -0.757 1.0000
##  ambient Exotic 1 - warmed Both 3    -1.34048 0.1914  752.5  -7.002 <.0001
##  ambient Exotic 1 - ambient Both 3   -1.26615 0.1764 1135.4  -7.176 <.0001
```

```
##  ambient Exotic 1 - warmed Exotic 3  -1.65841 0.1581  546.8 -10.491 <.0001
##  ambient Exotic 1 - ambient Exotic 3 -1.58408 0.1430 1132.5 -11.076 <.0001
##  ambient Exotic 1 - warmed Native 4  -2.50347 0.1760  661.7 -14.226 <.0001
##  ambient Exotic 1 - ambient Native 4 -2.42914 0.1615 1134.2 -15.039 <.0001
##  ambient Exotic 1 - warmed  4        -0.59136 0.5857 1131.9  -1.010 1.0000
##  ambient Exotic 1 - ambient  4       -0.51703 0.5815 1136.1  -0.889 1.0000
##  ambient Exotic 1 - warmed Both 4    -1.41717 0.1953  765.4  -7.255 <.0001
##  ambient Exotic 1 - ambient Both 4   -1.34284 0.1804 1136.1  -7.445 <.0001
##  ambient Exotic 1 - warmed Exotic 4  -1.73510 0.1575  544.0 -11.016 <.0001
##  ambient Exotic 1 - ambient Exotic 4 -1.66077 0.1420 1133.5 -11.696 <.0001
##  ambient Exotic 1 - warmed Native 5  -1.94663 0.1762  673.5 -11.049 <.0001
##  ambient Exotic 1 - ambient Native 5 -1.87230 0.1614 1130.5 -11.600 <.0001
##  ambient Exotic 1 - warmed  5        -0.03451 0.5863 1132.4  -0.059 1.0000
##  ambient Exotic 1 - ambient  5        0.03982 0.5820 1136.1   0.068 1.0000
##  ambient Exotic 1 - warmed Both 5    -0.86032 0.1969  791.0  -4.370 0.0156
##  ambient Exotic 1 - ambient Both 5   -0.78599 0.1817 1134.1  -4.325 0.0181
##  ambient Exotic 1 - warmed Exotic 5  -1.17825 0.1605  573.9  -7.342 <.0001
##  ambient Exotic 1 - ambient Exotic 5 -1.10392 0.1449 1129.3  -7.619 <.0001
##  ambient Exotic 1 - warmed Native 6  -2.01078 0.1771  678.1 -11.352 <.0001
##  ambient Exotic 1 - ambient Native 6 -1.93645 0.1642 1133.3 -11.792 <.0001
##  ambient Exotic 1 - warmed  6        -0.09867 0.5865 1131.2  -0.168 1.0000
##  ambient Exotic 1 - ambient  6       -0.02434 0.5827 1136.1  -0.042 1.0000
##  ambient Exotic 1 - warmed Both 6    -0.92448 0.1967  789.6  -4.700 0.0039
##  ambient Exotic 1 - ambient Both 6   -0.85015 0.1831 1135.3  -4.642 0.0048
##  ambient Exotic 1 - warmed Exotic 6  -1.24240 0.1609  575.8  -7.721 <.0001
##  ambient Exotic 1 - ambient Exotic 6 -1.16807 0.1474 1133.0  -7.927 <.0001
##  ambient Exotic 1 - warmed Native 7  -1.50933 0.1797  692.7  -8.401 <.0001
##  ambient Exotic 1 - ambient Native 7 -1.43500 0.1673 1132.5  -8.579 <.0001
##  ambient Exotic 1 - warmed  7         0.40278 0.5879 1132.8   0.685 1.0000
##  ambient Exotic 1 - ambient  7        0.47711 0.5842 1136.0   0.817 1.0000
##  ambient Exotic 1 - warmed Both 7    -0.42303 0.2028  814.8  -2.086 0.9989
##  ambient Exotic 1 - ambient Both 7   -0.34870 0.1899 1135.2  -1.836 1.0000
##  ambient Exotic 1 - warmed Exotic 7  -0.74096 0.1665  616.2  -4.449 0.0116
##  ambient Exotic 1 - ambient Exotic 7 -0.66663 0.1538 1131.7  -4.334 0.0175
##  warmed Native 2 - ambient Native 2   0.07433 0.0629   21.8   1.181 1.0000
##  warmed Native 2 - warmed  2          1.91211 0.5401 1136.1   3.540 0.2449
##  warmed Native 2 - ambient  2         1.98644 0.5437 1120.1   3.654 0.1809
##  warmed Native 2 - warmed Both 2      1.08630 0.1129 1135.0   9.622 <.0001
##  warmed Native 2 - ambient Both 2     1.16063 0.1263  272.6   9.188 <.0001
##  warmed Native 2 - warmed Exotic 2    0.76838 0.0752 1136.1  10.211 <.0001
##  warmed Native 2 - ambient Exotic 2   0.84271 0.0993  119.7   8.491 <.0001
##  warmed Native 2 - warmed Native 3   -0.05721 0.1039 1126.2  -0.550 1.0000
##  warmed Native 2 - ambient Native 3   0.01712 0.1212  259.4   0.141 1.0000
##  warmed Native 2 - warmed  3          1.85490 0.5500 1136.1   3.373 0.3636
##  warmed Native 2 - ambient  3         1.92923 0.5534 1123.6   3.486 0.2805
##  warmed Native 2 - warmed Both 3      1.02909 0.1546 1131.2   6.658 <.0001
##  warmed Native 2 - ambient Both 3     1.10342 0.1644  567.4   6.711 <.0001
##  warmed Native 2 - warmed Exotic 3    0.71116 0.1281 1132.6   5.553 0.0001
##  warmed Native 2 - ambient Exotic 3   0.78549 0.1433  404.9   5.483 0.0001
##  warmed Native 2 - warmed Native 4   -0.13390 0.1025 1123.8  -1.306 1.0000
##  warmed Native 2 - ambient Native 4  -0.05957 0.1195  245.7  -0.498 1.0000
##  warmed Native 2 - warmed  4          1.77821 0.5495 1136.1   3.236 0.4777
##  warmed Native 2 - ambient  4         1.85254 0.5529 1123.2   3.351 0.3811
##  warmed Native 2 - warmed Both 4      0.95240 0.1570 1132.5   6.067 <.0001
```

```
##  warmed Native 2 - ambient Both 4     1.02673 0.1663  571.2   6.172 <.0001
##  warmed Native 2 - warmed Exotic 4    0.63448 0.1243 1129.7   5.103 0.0005
##  warmed Native 2 - ambient Exotic 4   0.70881 0.1395  377.8   5.080 0.0008
##  warmed Native 2 - warmed Native 5    0.42295 0.1064 1129.7   3.975 0.0666
##  warmed Native 2 - ambient Native 5   0.49727 0.1224  265.2   4.062 0.0562
##  warmed Native 2 - warmed  5          2.33506 0.5508 1136.1   4.239 0.0254
##  warmed Native 2 - ambient  5         2.40939 0.5541 1124.0   4.348 0.0165
##  warmed Native 2 - warmed Both 5      1.50925 0.1612 1131.9   9.362 <.0001
##  warmed Native 2 - ambient Both 5     1.58358 0.1700  606.4   9.315 <.0001
##  warmed Native 2 - warmed Exotic 5    1.19132 0.1309 1133.5   9.098 <.0001
##  warmed Native 2 - ambient Exotic 5   1.26565 0.1450  416.6   8.726 <.0001
##  warmed Native 2 - warmed Native 6    0.35879 0.1099 1131.2   3.265 0.4528
##  warmed Native 2 - ambient Native 6   0.43312 0.1278  293.1   3.390 0.3579
##  warmed Native 2 - warmed  6          2.27090 0.5514 1136.1   4.118 0.0400
##  warmed Native 2 - ambient  6         2.34523 0.5552 1121.4   4.224 0.0269
##  warmed Native 2 - warmed Both 6      1.44510 0.1623 1132.1   8.903 <.0001
##  warmed Native 2 - ambient Both 6     1.51942 0.1727  614.3   8.796 <.0001
##  warmed Native 2 - warmed Exotic 6    1.12717 0.1331 1134.0   8.471 <.0001
##  warmed Native 2 - ambient Exotic 6   1.20150 0.1489  435.0   8.067 <.0001
##  warmed Native 2 - warmed Native 7    0.86024 0.1183 1133.8   7.269 <.0001
##  warmed Native 2 - ambient Native 7   0.93457 0.1355  349.1   6.897 <.0001
##  warmed Native 2 - warmed  7          2.77235 0.5538 1136.0   5.006 0.0009
##  warmed Native 2 - ambient  7         2.84668 0.5577 1124.8   5.104 0.0005
##  warmed Native 2 - warmed Both 7      1.94654 0.1726 1134.1  11.280 <.0001
##  warmed Native 2 - ambient Both 7     2.02087 0.1827  676.3  11.060 <.0001
##  warmed Native 2 - warmed Exotic 7    1.62861 0.1434 1134.8  11.356 <.0001
##  warmed Native 2 - ambient Exotic 7   1.70294 0.1586  508.7  10.738 <.0001
##  ambient Native 2 - warmed  2         1.83778 0.5438 1129.0   3.379 0.3584
##  ambient Native 2 - ambient  2        1.91211 0.5401 1136.1   3.540 0.2449
##  ambient Native 2 - warmed Both 2     1.01197 0.1321  332.1   7.659 <.0001
##  ambient Native 2 - ambient Both 2    1.08630 0.1129 1135.0   9.622 <.0001
##  ambient Native 2 - warmed Exotic 2   0.69405 0.0969  116.6   7.161 <.0001
##  ambient Native 2 - ambient Exotic 2  0.76838 0.0752 1136.1  10.211 <.0001
##  ambient Native 2 - warmed Native 3  -0.13154 0.1218  259.3  -1.080 1.0000
##  ambient Native 2 - ambient Native 3 -0.05721 0.1039 1126.2  -0.550 1.0000
##  ambient Native 2 - warmed  3         1.78057 0.5537 1130.9   3.216 0.4953
##  ambient Native 2 - ambient  3        1.85490 0.5500 1136.1   3.373 0.3636
##  ambient Native 2 - warmed Both 3     0.95476 0.1693  621.3   5.639 <.0001
##  ambient Native 2 - ambient Both 3    1.02909 0.1546 1131.2   6.658 <.0001
##  ambient Native 2 - warmed Exotic 3   0.63683 0.1421  409.0   4.481 0.0109
##  ambient Native 2 - ambient Exotic 3  0.71116 0.1281 1132.6   5.553 0.0001
##  ambient Native 2 - warmed Native 4  -0.20823 0.1210  259.6  -1.720 1.0000
##  ambient Native 2 - ambient Native 4 -0.13390 0.1025 1123.8  -1.306 1.0000
##  ambient Native 2 - warmed  4         1.70388 0.5533 1130.9   3.079 0.6166
##  ambient Native 2 - ambient  4        1.77821 0.5495 1136.1   3.236 0.4777
##  ambient Native 2 - warmed Both 4     0.87807 0.1718  639.3   5.110 0.0006
##  ambient Native 2 - ambient Both 4    0.95240 0.1570 1132.5   6.067 <.0001
##  ambient Native 2 - warmed Exotic 4   0.56015 0.1392  397.3   4.025 0.0603
##  ambient Native 2 - ambient Exotic 4  0.63448 0.1243 1129.7   5.103 0.0005
##  ambient Native 2 - warmed Native 5   0.34862 0.1248  276.2   2.793 0.8338
##  ambient Native 2 - ambient Native 5  0.42295 0.1064 1129.7   3.975 0.0666
##  ambient Native 2 - warmed  5         2.26073 0.5548 1131.1   4.075 0.0468
##  ambient Native 2 - ambient  5        2.33506 0.5508 1136.1   4.239 0.0254
##  ambient Native 2 - warmed Both 5     1.43492 0.1761  664.1   8.150 <.0001
```

```
##  ambient Native 2 - ambient Both 5    1.50925 0.1612 1131.9   9.362 <.0001
##  ambient Native 2 - warmed Exotic 5   1.11699 0.1455  431.0   7.676 <.0001
##  ambient Native 2 - ambient Exotic 5  1.19132 0.1309 1133.5   9.098 <.0001
##  ambient Native 2 - warmed Native 6   0.28446 0.1255  287.3   2.267 0.9922
##  ambient Native 2 - ambient Native 6  0.35879 0.1099 1131.2   3.265 0.4528
##  ambient Native 2 - warmed  6         2.19658 0.5548 1129.8   3.959 0.0702
##  ambient Native 2 - ambient  6        2.27090 0.5514 1136.1   4.118 0.0400
##  ambient Native 2 - warmed Both 6     1.37077 0.1754  669.1   7.815 <.0001
##  ambient Native 2 - ambient Both 6    1.44510 0.1623 1132.1   8.903 <.0001
##  ambient Native 2 - warmed Exotic 6   1.05284 0.1454  438.7   7.239 <.0001
##  ambient Native 2 - ambient Exotic 6  1.12717 0.1331 1134.0   8.471 <.0001
##  ambient Native 2 - warmed Native 7   0.78591 0.1326  328.7   5.929 <.0001
##  ambient Native 2 - ambient Native 7  0.86024 0.1183 1133.8   7.269 <.0001
##  ambient Native 2 - warmed  7         2.69802 0.5571 1131.7   4.843 0.0019
##  ambient Native 2 - ambient  7        2.77235 0.5538 1136.0   5.006 0.0009
##  ambient Native 2 - warmed Both 7     1.87221 0.1847  712.3  10.139 <.0001
##  ambient Native 2 - ambient Both 7    1.94654 0.1726 1134.1  11.280 <.0001
##  ambient Native 2 - warmed Exotic 7   1.55429 0.1546  498.9  10.053 <.0001
##  ambient Native 2 - ambient Exotic 7  1.62861 0.1434 1134.8  11.356 <.0001
##  warmed  2 - ambient  2               0.07433 0.0629   21.8   1.181 1.0000
##  warmed  2 - warmed Both 2           -0.82581 0.5427 1136.1  -1.522 1.0000
##  warmed  2 - ambient Both 2          -0.75148 0.5457 1128.5  -1.377 1.0000
##  warmed  2 - warmed Exotic 2         -1.14374 0.5372 1136.1  -2.129 0.9983
##  warmed  2 - ambient Exotic 2        -1.06941 0.5412 1130.2  -1.976 0.9997
##  warmed  2 - warmed Native 3         -1.96933 0.5500 1136.1  -3.580 0.2207
##  warmed  2 - ambient Native 3        -1.89500 0.5536 1129.1  -3.423 0.3253
##  warmed  2 - warmed  3               -0.05721 0.1039 1126.2  -0.550 1.0000
##  warmed  2 - ambient  3               0.01712 0.1212  259.4   0.141 1.0000
##  warmed  2 - warmed Both 3           -0.88302 0.5529 1136.0  -1.597 1.0000
##  warmed  2 - ambient Both 3          -0.80869 0.5558 1128.7  -1.455 1.0000
##  warmed  2 - warmed Exotic 3         -1.20095 0.5472 1136.1  -2.195 0.9967
##  warmed  2 - ambient Exotic 3        -1.12662 0.5510 1130.2  -2.045 0.9994
##  warmed  2 - warmed Native 4         -2.04601 0.5499 1136.1  -3.720 0.1494
##  warmed  2 - ambient Native 4        -1.97168 0.5534 1129.1  -3.563 0.2313
##  warmed  2 - warmed  4               -0.13390 0.1025 1123.8  -1.306 1.0000
##  warmed  2 - ambient  4              -0.05957 0.1195  245.7  -0.498 1.0000
##  warmed  2 - warmed Both 4           -0.95971 0.5537 1136.0  -1.733 1.0000
##  warmed  2 - ambient Both 4          -0.88538 0.5565 1128.7  -1.591 1.0000
##  warmed  2 - warmed Exotic 4         -1.27764 0.5465 1136.1  -2.338 0.9883
##  warmed  2 - ambient Exotic 4        -1.20331 0.5502 1130.3  -2.187 0.9969
##  warmed  2 - warmed Native 5         -1.48917 0.5501 1136.0  -2.707 0.8882
##  warmed  2 - ambient Native 5        -1.41484 0.5535 1128.6  -2.556 0.9483
##  warmed  2 - warmed  5                0.42295 0.1064 1129.7   3.975 0.0666
##  warmed  2 - ambient  5               0.49727 0.1224  265.2   4.062 0.0562
##  warmed  2 - warmed Both 5           -0.40286 0.5544 1136.0  -0.727 1.0000
##  warmed  2 - ambient Both 5          -0.32854 0.5571 1128.5  -0.590 1.0000
##  warmed  2 - warmed Exotic 5         -0.72079 0.5474 1136.1  -1.317 1.0000
##  warmed  2 - ambient Exotic 5        -0.64646 0.5511 1129.8  -1.173 1.0000
##  warmed  2 - warmed Native 6         -1.55332 0.5509 1136.1  -2.820 0.8227
##  warmed  2 - ambient Native 6        -1.47899 0.5548 1130.1  -2.666 0.9078
##  warmed  2 - warmed  6                0.35879 0.1099 1131.2   3.265 0.4528
##  warmed  2 - ambient  6               0.43312 0.1278  293.1   3.390 0.3579
##  warmed  2 - warmed Both 6           -0.46702 0.5548 1136.1  -0.842 1.0000
##  warmed  2 - ambient Both 6          -0.39269 0.5580 1129.9  -0.704 1.0000
```

```
##  warmed  2 - warmed Exotic 6        -0.78495 0.5481 1136.0  -1.432 1.0000
##  warmed  2 - ambient Exotic 6       -0.71062 0.5522 1131.2  -1.287 1.0000
##  warmed  2 - warmed Native 7        -1.05187 0.5520 1135.9  -1.906 0.9999
##  warmed  2 - ambient Native 7       -0.97754 0.5560 1127.9  -1.758 1.0000
##  warmed  2 - warmed  7               0.86024 0.1183 1133.8   7.269 <.0001
##  warmed  2 - ambient  7              0.93457 0.1355  349.1   6.897 <.0001
##  warmed  2 - warmed Both 7          0.03443 0.5572 1135.9   0.062 1.0000
##  warmed  2 - ambient Both 7         0.10876 0.5605 1127.7   0.194 1.0000
##  warmed  2 - warmed Exotic 7       -0.28350 0.5500 1136.1  -0.515 1.0000
##  warmed  2 - ambient Exotic 7      -0.20917 0.5542 1129.3  -0.377 1.0000
##  ambient  2 - warmed Both 2        -0.90014 0.5469 1120.8  -1.646 1.0000
##  ambient  2 - ambient Both 2       -0.82581 0.5427 1136.1  -1.522 1.0000
##  ambient  2 - warmed Exotic 2      -1.21806 0.5406 1122.6  -2.253 0.9943
##  ambient  2 - ambient Exotic 2     -1.14374 0.5372 1136.1  -2.129 0.9983
##  ambient  2 - warmed Native 3      -2.04366 0.5536 1120.5  -3.691 0.1625
##  ambient  2 - ambient Native 3     -1.96933 0.5500 1136.1  -3.580 0.2207
##  ambient  2 - warmed  3            -0.13154 0.1218  259.3  -1.080 1.0000
##  ambient  2 - ambient  3           -0.05721 0.1039 1126.2  -0.550 1.0000
##  ambient  2 - warmed Both 3        -0.95735 0.5571 1121.2  -1.718 1.0000
##  ambient  2 - ambient Both 3       -0.88302 0.5529 1136.0  -1.597 1.0000
##  ambient  2 - warmed Exotic 3      -1.27528 0.5505 1122.8  -2.316 0.9902
##  ambient  2 - ambient Exotic 3     -1.20095 0.5472 1136.1  -2.195 0.9967
##  ambient  2 - warmed Native 4      -2.12034 0.5536 1121.0  -3.830 0.1071
##  ambient  2 - ambient Native 4     -2.04601 0.5499 1136.1  -3.720 0.1494
##  ambient  2 - warmed  4            -0.20823 0.1210  259.6  -1.720 1.0000
##  ambient  2 - ambient  4           -0.13390 0.1025 1123.8  -1.306 1.0000
##  ambient  2 - warmed Both 4        -1.03404 0.5581 1121.6  -1.853 1.0000
##  ambient  2 - ambient Both 4       -0.95971 0.5537 1136.0  -1.733 1.0000
##  ambient  2 - warmed Exotic 4      -1.35197 0.5500 1123.3  -2.458 0.9718
##  ambient  2 - ambient Exotic 4     -1.27764 0.5465 1136.1  -2.338 0.9883
##  ambient  2 - warmed Native 5      -1.56350 0.5539 1119.8  -2.823 0.8205
##  ambient  2 - ambient Native 5     -1.48917 0.5501 1136.0  -2.707 0.8882
##  ambient  2 - warmed  5            0.34862 0.1248  276.2   2.793 0.8338
##  ambient  2 - ambient  5           0.42295 0.1064 1129.7   3.975 0.0666
##  ambient  2 - warmed Both 5        -0.47719 0.5588 1120.9  -0.854 1.0000
##  ambient  2 - ambient Both 5       -0.40286 0.5544 1136.0  -0.727 1.0000
##  ambient  2 - warmed Exotic 5      -0.79512 0.5510 1122.2  -1.443 1.0000
##  ambient  2 - ambient Exotic 5     -0.72079 0.5474 1136.1  -1.317 1.0000
##  ambient  2 - warmed Native 6      -1.62765 0.5542 1122.6  -2.937 0.7368
##  ambient  2 - ambient Native 6     -1.55332 0.5509 1136.1  -2.820 0.8227
##  ambient  2 - warmed  6            0.28446 0.1255  287.3   2.267 0.9922
##  ambient  2 - ambient  6           0.35879 0.1099 1131.2   3.265 0.4528
##  ambient  2 - warmed Both 6        -0.54135 0.5587 1123.5  -0.969 1.0000
##  ambient  2 - ambient Both 6       -0.46702 0.5548 1136.1  -0.842 1.0000
##  ambient  2 - warmed Exotic 6      -0.85927 0.5511 1124.8  -1.559 1.0000
##  ambient  2 - ambient Exotic 6     -0.78495 0.5481 1136.0  -1.432 1.0000
##  ambient  2 - warmed Native 7      -1.12620 0.5551 1119.0  -2.029 0.9995
##  ambient  2 - ambient Native 7     -1.05187 0.5520 1135.9  -1.906 0.9999
##  ambient  2 - warmed  7            0.78591 0.1326  328.7   5.929 <.0001
##  ambient  2 - ambient  7           0.86024 0.1183 1133.8   7.269 <.0001
##  ambient  2 - warmed Both 7        -0.03990 0.5610 1120.1  -0.071 1.0000
##  ambient  2 - ambient Both 7       0.03443 0.5572 1135.9   0.062 1.0000
##  ambient  2 - warmed Exotic 7      -0.35783 0.5529 1121.6  -0.647 1.0000
##  ambient  2 - ambient Exotic 7     -0.28350 0.5500 1136.1  -0.515 1.0000
```

```
##  warmed Both 2 - ambient Both 2      0.07433 0.0629   21.8   1.181 1.0000
##  warmed Both 2 - warmed Exotic 2    -0.31793 0.1006 1136.1  -3.159 0.5454
##  warmed Both 2 - ambient Exotic 2   -0.24360 0.1227  254.3  -1.985 0.9995
##  warmed Both 2 - warmed Native 3    -1.14352 0.1523 1132.7  -7.506 <.0001
##  warmed Both 2 - ambient Native 3   -1.06919 0.1669  603.4  -6.406 <.0001
##  warmed Both 2 - warmed  3           0.76860 0.5522 1136.1   1.392 1.0000
##  warmed Both 2 - ambient  3          0.84293 0.5563 1123.9   1.515 1.0000
##  warmed Both 2 - warmed Both 3      -0.05721 0.1039 1126.2  -0.550 1.0000
##  warmed Both 2 - ambient Both 3      0.01712 0.1212  259.4   0.141 1.0000
##  warmed Both 2 - warmed Exotic 3    -0.37514 0.1433 1134.5  -2.619 0.9272
##  warmed Both 2 - ambient Exotic 3   -0.30081 0.1594  530.8  -1.888 0.9999
##  warmed Both 2 - warmed Native 4    -1.22020 0.1479 1129.9  -8.252 <.0001
##  warmed Both 2 - ambient Native 4   -1.14587 0.1625  575.4  -7.053 <.0001
##  warmed Both 2 - warmed  4           0.69191 0.5508 1136.1   1.256 1.0000
##  warmed Both 2 - ambient  4          0.76624 0.5548 1123.7   1.381 1.0000
##  warmed Both 2 - warmed Both 4      -0.13390 0.1025 1123.8  -1.306 1.0000
##  warmed Both 2 - ambient Both 4     -0.05957 0.1195  245.7  -0.498 1.0000
##  warmed Both 2 - warmed Exotic 4    -0.45183 0.1362 1130.7  -3.319 0.4073
##  warmed Both 2 - ambient Exotic 4   -0.37750 0.1526  488.0  -2.473 0.9672
##  warmed Both 2 - warmed Native 5    -0.66336 0.1488 1134.1  -4.457 0.0106
##  warmed Both 2 - ambient Native 5   -0.58903 0.1630  570.0  -3.614 0.2052
##  warmed Both 2 - warmed  5           1.24876 0.5516 1136.1   2.264 0.9937
##  warmed Both 2 - ambient  5          1.32308 0.5556 1124.1   2.382 0.9836
##  warmed Both 2 - warmed Both 5       0.42295 0.1064 1129.7   3.975 0.0666
##  warmed Both 2 - ambient Both 5      0.49727 0.1224  265.2   4.062 0.0562
##  warmed Both 2 - warmed Exotic 5     0.10502 0.1403 1135.4   0.748 1.0000
##  warmed Both 2 - ambient Exotic 5    0.17935 0.1560  501.6   1.150 1.0000
##  warmed Both 2 - warmed Native 6    -0.72751 0.1527 1134.6  -4.766 0.0027
##  warmed Both 2 - ambient Native 6   -0.65318 0.1682  594.4  -3.883 0.0931
##  warmed Both 2 - warmed  6           1.18460 0.5526 1136.1   2.144 0.9980
##  warmed Both 2 - ambient  6          1.25893 0.5570 1121.5   2.260 0.9939
##  warmed Both 2 - warmed Both 6       0.35879 0.1099 1131.2   3.265 0.4528
##  warmed Both 2 - ambient Both 6      0.43312 0.1278  293.1   3.390 0.3579
##  warmed Both 2 - warmed Exotic 6     0.04086 0.1437 1135.7   0.284 1.0000
##  warmed Both 2 - ambient Exotic 6    0.11519 0.1609  525.2   0.716 1.0000
##  warmed Both 2 - warmed Native 7    -0.22606 0.1540 1134.7  -1.468 1.0000
##  warmed Both 2 - ambient Native 7   -0.15174 0.1698  610.2  -0.894 1.0000
##  warmed Both 2 - warmed  7           1.68605 0.5536 1136.0   3.045 0.6463
##  warmed Both 2 - ambient  7          1.76038 0.5582 1124.9   3.154 0.5503
##  warmed Both 2 - warmed Both 7       0.86024 0.1183 1133.8   7.269 <.0001
##  warmed Both 2 - ambient Both 7      0.93457 0.1355  349.1   6.897 <.0001
##  warmed Both 2 - warmed Exotic 7     0.54231 0.1483 1135.5   3.656 0.1797
##  warmed Both 2 - ambient Exotic 7    0.61664 0.1653  563.9   3.729 0.1488
##  ambient Both 2 - warmed Exotic 2   -0.39226 0.1145  199.5  -3.426 0.3359
##  ambient Both 2 - ambient Exotic 2  -0.31793 0.1006 1136.1  -3.159 0.5454
##  ambient Both 2 - warmed Native 3   -1.21785 0.1627  544.2  -7.483 <.0001
##  ambient Both 2 - ambient Native 3  -1.14352 0.1523 1132.7  -7.506 <.0001
##  ambient Both 2 - warmed  3          0.69427 0.5552 1130.4   1.250 1.0000
##  ambient Both 2 - ambient  3         0.76860 0.5522 1136.1   1.392 1.0000
##  ambient Both 2 - warmed Both 3     -0.13154 0.1218  259.3  -1.080 1.0000
##  ambient Both 2 - ambient Both 3    -0.05721 0.1039 1126.2  -0.550 1.0000
##  ambient Both 2 - warmed Exotic 3   -0.44947 0.1535  477.3  -2.928 0.7425
##  ambient Both 2 - ambient Exotic 3  -0.37514 0.1433 1134.5  -2.619 0.9272
##  ambient Both 2 - warmed Native 4   -1.29453 0.1589  530.3  -8.146 <.0001
```

```
##  ambient Both 2 - ambient Native 4   -1.22020 0.1479 1129.9  -8.252 <.0001
##  ambient Both 2 - warmed  4           0.61758 0.5539 1130.5   1.115 1.0000
##  ambient Both 2 - ambient  4          0.69191 0.5508 1136.1   1.256 1.0000
##  ambient Both 2 - warmed Both 4      -0.20823 0.1210  259.6  -1.720 1.0000
##  ambient Both 2 - ambient Both 4     -0.13390 0.1025 1123.8  -1.306 1.0000
##  ambient Both 2 - warmed Exotic 4    -0.52616 0.1473  447.8  -3.572 0.2308
##  ambient Both 2 - ambient Exotic 4   -0.45183 0.1362 1130.7  -3.319 0.4073
##  ambient Both 2 - warmed Native 5    -0.73769 0.1602  518.3  -4.606 0.0062
##  ambient Both 2 - ambient Native 5   -0.66336 0.1488 1134.1  -4.457 0.0106
##  ambient Both 2 - warmed  5           1.17443 0.5549 1130.5   2.117 0.9985
##  ambient Both 2 - ambient  5          1.24876 0.5516 1136.1   2.264 0.9937
##  ambient Both 2 - warmed Both 5       0.34862 0.1248  276.2   2.793 0.8338
##  ambient Both 2 - ambient Both 5      0.42295 0.1064 1129.7   3.975 0.0666
##  ambient Both 2 - warmed Exotic 5     0.03069 0.1516  456.5   0.202 1.0000
##  ambient Both 2 - ambient Exotic 5    0.10502 0.1403 1135.4   0.748 1.0000
##  ambient Both 2 - warmed Native 6    -0.80184 0.1619  538.4  -4.951 0.0013
##  ambient Both 2 - ambient Native 6   -0.72751 0.1527 1134.6  -4.766 0.0027
##  ambient Both 2 - warmed  6           1.11027 0.5553 1129.1   2.000 0.9996
##  ambient Both 2 - ambient  6          1.18460 0.5526 1136.1   2.144 0.9980
##  ambient Both 2 - warmed Both 6       0.28446 0.1255  287.3   2.267 0.9922
##  ambient Both 2 - ambient Both 6      0.35879 0.1099 1131.2   3.265 0.4528
##  ambient Both 2 - warmed Exotic 6    -0.03346 0.1528  473.0  -0.219 1.0000
##  ambient Both 2 - ambient Exotic 6    0.04086 0.1437 1135.7   0.284 1.0000
##  ambient Both 2 - warmed Native 7    -0.30039 0.1629  538.7  -1.844 1.0000
##  ambient Both 2 - ambient Native 7   -0.22606 0.1540 1134.7  -1.468 1.0000
##  ambient Both 2 - warmed  7           1.61172 0.5562 1131.1   2.897 0.7674
##  ambient Both 2 - ambient  7          1.68605 0.5536 1136.0   3.045 0.6463
##  ambient Both 2 - warmed Both 7       0.78591 0.1326  328.7   5.929 <.0001
##  ambient Both 2 - ambient Both 7      0.86024 0.1183 1133.8   7.269 <.0001
##  ambient Both 2 - warmed Exotic 7     0.46798 0.1568  497.9   2.984 0.6971
##  ambient Both 2 - ambient Exotic 7    0.54231 0.1483 1135.5   3.656 0.1797
##  warmed Exotic 2 - ambient Exotic 2   0.07433 0.0629   21.8   1.181 1.0000
##  warmed Exotic 2 - warmed Native 3   -0.82559 0.1286 1131.3  -6.421 <.0001
##  warmed Exotic 2 - ambient Native 3  -0.75126 0.1421  417.0  -5.286 0.0003
##  warmed Exotic 2 - warmed  3          1.08652 0.5472 1135.9   1.986 0.9997
##  warmed Exotic 2 - ambient  3         1.16085 0.5505 1125.8   2.109 0.9987
##  warmed Exotic 2 - warmed Both 3      0.26071 0.1461 1132.3   1.785 1.0000
##  warmed Exotic 2 - ambient Both 3     0.33504 0.1557  507.8   2.151 0.9976
##  warmed Exotic 2 - warmed Exotic 3   -0.05721 0.1039 1126.2  -0.550 1.0000
##  warmed Exotic 2 - ambient Exotic 3   0.01712 0.1212  259.4   0.141 1.0000
##  warmed Exotic 2 - warmed Native 4   -0.90228 0.1299 1132.2  -6.944 <.0001
##  warmed Exotic 2 - ambient Native 4  -0.82795 0.1429  416.4  -5.792 <.0001
##  warmed Exotic 2 - warmed  4          1.00984 0.5474 1135.9   1.845 1.0000
##  warmed Exotic 2 - ambient  4         1.08417 0.5505 1125.4   1.969 0.9998
##  warmed Exotic 2 - warmed Both 4      0.18403 0.1508 1134.4   1.221 1.0000
##  warmed Exotic 2 - ambient Both 4     0.25836 0.1598  524.1   1.617 1.0000
##  warmed Exotic 2 - warmed Exotic 4   -0.13390 0.1025 1123.8  -1.306 1.0000
##  warmed Exotic 2 - ambient Exotic 4  -0.05957 0.1195  245.7  -0.498 1.0000
##  warmed Exotic 2 - warmed Native 5   -0.34543 0.1297 1133.2  -2.663 0.9089
##  warmed Exotic 2 - ambient Native 5  -0.27110 0.1423  414.9  -1.905 0.9999
##  warmed Exotic 2 - warmed  5          1.56668 0.5479 1135.8   2.860 0.7952
##  warmed Exotic 2 - ambient  5         1.64101 0.5509 1126.1   2.979 0.7031
##  warmed Exotic 2 - warmed Both 5      0.74087 0.1523 1133.2   4.863 0.0017
##  warmed Exotic 2 - ambient Both 5     0.81520 0.1609  544.6   5.066 0.0008
```

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##  warmed Exotic 2 - warmed Exotic 5    0.42295 0.1064 1129.7   3.975 0.0666
##  warmed Exotic 2 - ambient Exotic 5   0.49727 0.1224  265.2   4.062 0.0562
##  warmed Exotic 2 - warmed Native 6   -0.40958 0.1333 1133.9  -3.072 0.6227
##  warmed Exotic 2 - ambient Native 6  -0.33526 0.1476  443.3  -2.271 0.9926
##  warmed Exotic 2 - warmed  6          1.50253 0.5486 1136.1   2.739 0.8716
##  warmed Exotic 2 - ambient  6         1.57686 0.5522 1123.7   2.856 0.7980
##  warmed Exotic 2 - warmed Both 6      0.67672 0.1541 1133.5   4.390 0.0139
##  warmed Exotic 2 - ambient Both 6     0.75105 0.1644  558.5   4.569 0.0072
##  warmed Exotic 2 - warmed Exotic 6    0.35879 0.1099 1131.2   3.265 0.4528
##  warmed Exotic 2 - ambient Exotic 6   0.43312 0.1278  293.1   3.390 0.3579
##  warmed Exotic 2 - warmed Native 7    0.09186 0.1370 1135.2   0.671 1.0000
##  warmed Exotic 2 - ambient Native 7   0.16619 0.1513  470.3   1.098 1.0000
##  warmed Exotic 2 - warmed  7          2.00398 0.5502 1135.7   3.642 0.1868
##  warmed Exotic 2 - ambient  7         2.07830 0.5539 1126.7   3.752 0.1360
##  warmed Exotic 2 - warmed Both 7      1.17816 0.1621 1135.2   7.270 <.0001
##  warmed Exotic 2 - ambient Both 7     1.25249 0.1722  608.0   7.276 <.0001
##  warmed Exotic 2 - warmed Exotic 7    0.86024 0.1183 1133.8   7.269 <.0001
##  warmed Exotic 2 - ambient Exotic 7   0.93457 0.1355  349.1   6.897 <.0001
##  ambient Exotic 2 - warmed Native 3  -0.89992 0.1442  410.1  -6.242 <.0001
##  ambient Exotic 2 - ambient Native 3 -0.82559 0.1286 1131.3  -6.421 <.0001
##  ambient Exotic 2 - warmed  3         1.01219 0.5512 1132.0   1.836 1.0000
##  ambient Exotic 2 - ambient  3        1.08652 0.5472 1135.9   1.986 0.9997
##  ambient Exotic 2 - warmed Both 3     0.18638 0.1623  556.4   1.148 1.0000
##  ambient Exotic 2 - ambient Both 3    0.26071 0.1461 1132.3   1.785 1.0000
##  ambient Exotic 2 - warmed Exotic 3  -0.13154 0.1218  259.3  -1.080 1.0000
##  ambient Exotic 2 - ambient Exotic 3 -0.05721 0.1039 1126.2  -0.550 1.0000
##  ambient Exotic 2 - warmed Native 4  -0.97661 0.1458  425.2  -6.699 <.0001
##  ambient Exotic 2 - ambient Native 4 -0.90228 0.1299 1132.2  -6.944 <.0001
##  ambient Exotic 2 - warmed  4         0.93551 0.5514 1131.9   1.697 1.0000
##  ambient Exotic 2 - ambient  4        1.00984 0.5474 1135.9   1.845 1.0000
##  ambient Exotic 2 - warmed Both 4     0.10970 0.1669  585.9   0.657 1.0000
##  ambient Exotic 2 - ambient Both 4    0.18403 0.1508 1134.4   1.221 1.0000
##  ambient Exotic 2 - warmed Exotic 4  -0.20823 0.1210  259.6  -1.720 1.0000
##  ambient Exotic 2 - ambient Exotic 4 -0.13390 0.1025 1123.8  -1.306 1.0000
##  ambient Exotic 2 - warmed Native 5  -0.41976 0.1460  418.0  -2.876 0.7809
##  ambient Exotic 2 - ambient Native 5 -0.34543 0.1297 1133.2  -2.663 0.9089
##  ambient Exotic 2 - warmed  5         1.49235 0.5520 1132.1   2.703 0.8900
##  ambient Exotic 2 - ambient  5        1.56668 0.5479 1135.8   2.860 0.7952
##  ambient Exotic 2 - warmed Both 5     0.66654 0.1687  598.0   3.952 0.0742
##  ambient Exotic 2 - ambient Both 5    0.74087 0.1523 1133.2   4.863 0.0017
##  ambient Exotic 2 - warmed Exotic 5   0.34862 0.1248  276.2   2.793 0.8338
##  ambient Exotic 2 - ambient Exotic 5  0.42295 0.1064 1129.7   3.975 0.0666
##  ambient Exotic 2 - warmed Native 6  -0.48391 0.1472  434.8  -3.287 0.4369
##  ambient Exotic 2 - ambient Native 6 -0.40958 0.1333 1133.9  -3.072 0.6227
##  ambient Exotic 2 - warmed  6         1.42820 0.5522 1131.0   2.586 0.9388
##  ambient Exotic 2 - ambient  6        1.50253 0.5486 1136.1   2.739 0.8716
##  ambient Exotic 2 - warmed Both 6     0.60239 0.1686  606.3   3.574 0.2275
##  ambient Exotic 2 - ambient Both 6    0.67672 0.1541 1133.5   4.390 0.0139
##  ambient Exotic 2 - warmed Exotic 6   0.28446 0.1255  287.3   2.267 0.9922
##  ambient Exotic 2 - ambient Exotic 6  0.35879 0.1099 1131.2   3.265 0.4528
##  ambient Exotic 2 - warmed Native 7   0.01753 0.1502  445.3   0.117 1.0000
##  ambient Exotic 2 - ambient Native 7  0.09186 0.1370 1135.2   0.671 1.0000
##  ambient Exotic 2 - warmed  7         1.92965 0.5537 1132.5   3.485 0.2812
##  ambient Exotic 2 - ambient  7        2.00398 0.5502 1135.7   3.642 0.1868
```

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##  ambient Exotic 2 - warmed Both 7     1.10384 0.1755  637.0   6.289 <.0001
##  ambient Exotic 2 - ambient Both 7    1.17816 0.1621 1135.2   7.270 <.0001
##  ambient Exotic 2 - warmed Exotic 7   0.78591 0.1326  328.7   5.929 <.0001
##  ambient Exotic 2 - ambient Exotic 7  0.86024 0.1183 1133.8   7.269 <.0001
##  warmed Native 3 - ambient Native 3   0.07433 0.0629   21.8   1.181 1.0000
##  warmed Native 3 - warmed  3          1.91211 0.5401 1136.1   3.540 0.2449
##  warmed Native 3 - ambient  3         1.98644 0.5437 1120.1   3.654 0.1809
##  warmed Native 3 - warmed Both 3      1.08630 0.1129 1135.0   9.622 <.0001
##  warmed Native 3 - ambient Both 3     1.16063 0.1263  272.6   9.188 <.0001
##  warmed Native 3 - warmed Exotic 3    0.76838 0.0752 1136.1  10.211 <.0001
##  warmed Native 3 - ambient Exotic 3   0.84271 0.0993  119.7   8.491 <.0001
##  warmed Native 3 - warmed Native 4   -0.07669 0.1083 1120.3  -0.708 1.0000
##  warmed Native 3 - ambient Native 4  -0.00236 0.1248  283.4  -0.019 1.0000
##  warmed Native 3 - warmed  4          1.83543 0.5507 1136.1   3.333 0.3953
##  warmed Native 3 - ambient  4         1.90975 0.5541 1122.0   3.447 0.3079
##  warmed Native 3 - warmed Both 4      1.00962 0.1598 1132.0   6.320 <.0001
##  warmed Native 3 - ambient Both 4     1.08394 0.1692  590.9   6.408 <.0001
##  warmed Native 3 - warmed Exotic 4    0.69169 0.1294 1126.6   5.345 0.0002
##  warmed Native 3 - ambient Exotic 4   0.76602 0.1443  417.4   5.309 0.0003
##  warmed Native 3 - warmed Native 5    0.48016 0.1120 1129.6   4.285 0.0212
##  warmed Native 3 - ambient Native 5   0.55449 0.1276  300.2   4.345 0.0199
##  warmed Native 3 - warmed  5          2.39227 0.5520 1136.1   4.334 0.0175
##  warmed Native 3 - ambient  5         2.46660 0.5553 1122.7   4.442 0.0113
##  warmed Native 3 - warmed Both 5      1.56646 0.1639 1132.4   9.555 <.0001
##  warmed Native 3 - ambient Both 5     1.64079 0.1728  621.1   9.495 <.0001
##  warmed Native 3 - warmed Exotic 5    1.24853 0.1358 1132.8   9.193 <.0001
##  warmed Native 3 - ambient Exotic 5   1.32286 0.1497  451.6   8.838 <.0001
##  warmed Native 3 - warmed Native 6    0.41601 0.1154 1134.5   3.604 0.2075
##  warmed Native 3 - ambient Native 6   0.49033 0.1328  320.8   3.692 0.1709
##  warmed Native 3 - warmed  6          2.32812 0.5526 1136.0   4.213 0.0281
##  warmed Native 3 - ambient  6         2.40245 0.5564 1119.6   4.318 0.0187
##  warmed Native 3 - warmed Both 6      1.50231 0.1651 1134.2   9.100 <.0001
##  warmed Native 3 - ambient Both 6     1.57664 0.1755  620.5   8.982 <.0001
##  warmed Native 3 - warmed Exotic 6    1.18438 0.1379 1135.2   8.587 <.0001
##  warmed Native 3 - ambient Exotic 6   1.25871 0.1535  461.0   8.199 <.0001
##  warmed Native 3 - warmed Native 7    0.91745 0.1235 1136.0   7.430 <.0001
##  warmed Native 3 - ambient Native 7   0.99178 0.1403  372.2   7.072 <.0001
##  warmed Native 3 - warmed  7          2.82956 0.5550 1136.1   5.098 0.0006
##  warmed Native 3 - ambient  7         2.90389 0.5589 1123.1   5.196 0.0003
##  warmed Native 3 - warmed Both 7      2.00375 0.1752 1135.6  11.439 <.0001
##  warmed Native 3 - ambient Both 7     2.07808 0.1853  677.1  11.212 <.0001
##  warmed Native 3 - warmed Exotic 7    1.68583 0.1479 1135.9  11.397 <.0001
##  warmed Native 3 - ambient Exotic 7   1.76016 0.1629  528.2  10.807 <.0001
##  ambient Native 3 - warmed  3         1.83778 0.5438 1129.0   3.379 0.3584
##  ambient Native 3 - ambient  3        1.91211 0.5401 1136.1   3.540 0.2449
##  ambient Native 3 - warmed Both 3     1.01197 0.1321  332.1   7.659 <.0001
##  ambient Native 3 - ambient Both 3    1.08630 0.1129 1135.0   9.622 <.0001
##  ambient Native 3 - warmed Exotic 3   0.69405 0.0969  116.6   7.161 <.0001
##  ambient Native 3 - ambient Exotic 3  0.76838 0.0752 1136.1  10.211 <.0001
##  ambient Native 3 - warmed Native 4  -0.15102 0.1257  298.2  -1.201 1.0000
##  ambient Native 3 - ambient Native 4 -0.07669 0.1083 1120.3  -0.708 1.0000
##  ambient Native 3 - warmed  4         1.76110 0.5544 1130.2   3.176 0.5301
##  ambient Native 3 - ambient  4        1.83543 0.5507 1136.1   3.333 0.3953
##  ambient Native 3 - warmed Both 4     0.93529 0.1742  660.0   5.369 0.0002
```

```
##  ambient Native 3 - ambient Both 4    1.00962 0.1598 1132.0   6.320 <.0001
##  ambient Native 3 - warmed Exotic 4   0.61736 0.1435  439.8   4.302 0.0218
##  ambient Native 3 - ambient Exotic 4  0.69169 0.1294 1126.6   5.345 0.0002
##  ambient Native 3 - warmed Native 5   0.40583 0.1294  311.3   3.136 0.5673
##  ambient Native 3 - ambient Native 5  0.48016 0.1120 1129.6   4.285 0.0212
##  ambient Native 3 - warmed  5         2.31794 0.5558 1130.4   4.170 0.0330
##  ambient Native 3 - ambient  5        2.39227 0.5520 1136.1   4.334 0.0175
##  ambient Native 3 - warmed Both 5     1.49213 0.1784  679.9   8.365 <.0001
##  ambient Native 3 - ambient Both 5    1.56646 0.1639 1132.4   9.555 <.0001
##  ambient Native 3 - warmed Exotic 5   1.17421 0.1497  467.9   7.844 <.0001
##  ambient Native 3 - ambient Exotic 5  1.24853 0.1358 1132.8   9.193 <.0001
##  ambient Native 3 - warmed Native 6   0.34168 0.1301  316.2   2.626 0.9198
##  ambient Native 3 - ambient Native 6  0.41601 0.1154 1134.5   3.604 0.2075
##  ambient Native 3 - warmed  6         2.25379 0.5559 1128.7   4.054 0.0504
##  ambient Native 3 - ambient  6        2.32812 0.5526 1136.0   4.213 0.0281
##  ambient Native 3 - warmed Both 6     1.42798 0.1778  676.6   8.032 <.0001
##  ambient Native 3 - ambient Both 6    1.50231 0.1651 1134.2   9.100 <.0001
##  ambient Native 3 - warmed Exotic 6   1.11005 0.1497  467.7   7.417 <.0001
##  ambient Native 3 - ambient Exotic 6  1.18438 0.1379 1135.2   8.587 <.0001
##  ambient Native 3 - warmed Native 7   0.84312 0.1369  353.4   6.158 <.0001
##  ambient Native 3 - ambient Native 7  0.91745 0.1235 1136.0   7.430 <.0001
##  ambient Native 3 - warmed  7         2.75523 0.5582 1130.7   4.936 0.0012
##  ambient Native 3 - ambient  7        2.82956 0.5550 1136.1   5.098 0.0006
##  ambient Native 3 - warmed Both 7     1.92943 0.1869  714.9  10.323 <.0001
##  ambient Native 3 - ambient Both 7    2.00375 0.1752 1135.6  11.439 <.0001
##  ambient Native 3 - warmed Exotic 7   1.61150 0.1586  521.5  10.162 <.0001
##  ambient Native 3 - ambient Exotic 7  1.68583 0.1479 1135.9  11.397 <.0001
##  warmed  3 - ambient  3               0.07433 0.0629   21.8   1.181 1.0000
##  warmed  3 - warmed Both 3           -0.82581 0.5427 1136.1  -1.522 1.0000
##  warmed  3 - ambient Both 3          -0.75148 0.5457 1128.5  -1.377 1.0000
##  warmed  3 - warmed Exotic 3         -1.14374 0.5372 1136.1  -2.129 0.9983
##  warmed  3 - ambient Exotic 3        -1.06941 0.5412 1130.2  -1.976 0.9997
##  warmed  3 - warmed Native 4         -1.98880 0.5510 1136.1  -3.609 0.2044
##  warmed  3 - ambient Native 4        -1.91447 0.5546 1130.2  -3.452 0.3040
##  warmed  3 - warmed  4               -0.07669 0.1083 1120.3  -0.708 1.0000
##  warmed  3 - ambient  4              -0.00236 0.1248  283.4  -0.019 1.0000
##  warmed  3 - warmed Both 4           -0.90250 0.5545 1136.1  -1.628 1.0000
##  warmed  3 - ambient Both 4          -0.82817 0.5574 1129.7  -1.486 1.0000
##  warmed  3 - warmed Exotic 4         -1.22042 0.5476 1136.0  -2.229 0.9955
##  warmed  3 - ambient Exotic 4        -1.14610 0.5514 1131.4  -2.078 0.9990
##  warmed  3 - warmed Native 5         -1.43195 0.5512 1136.1  -2.598 0.9348
##  warmed  3 - ambient Native 5        -1.35763 0.5546 1129.7  -2.448 0.9737
##  warmed  3 - warmed  5                0.48016 0.1120 1129.6   4.285 0.0212
##  warmed  3 - ambient  5               0.55449 0.1276  300.2   4.345 0.0199
##  warmed  3 - warmed Both 5           -0.34565 0.5552 1136.1  -0.623 1.0000
##  warmed  3 - ambient Both 5          -0.27132 0.5579 1129.5  -0.486 1.0000
##  warmed  3 - warmed Exotic 5         -0.66358 0.5486 1136.1  -1.210 1.0000
##  warmed  3 - ambient Exotic 5        -0.58925 0.5523 1130.9  -1.067 1.0000
##  warmed  3 - warmed Native 6         -1.49611 0.5520 1136.1  -2.710 0.8866
##  warmed  3 - ambient Native 6        -1.42178 0.5560 1130.8  -2.557 0.9479
##  warmed  3 - warmed  6                0.41601 0.1154 1134.5   3.604 0.2075
##  warmed  3 - ambient  6               0.49033 0.1328  320.8   3.692 0.1709
##  warmed  3 - warmed Both 6           -0.40980 0.5556 1136.1  -0.738 1.0000
##  warmed  3 - ambient Both 6          -0.33548 0.5589 1130.6  -0.600 1.0000
```

```
##  warmed  3 - warmed Exotic 6        -0.72773 0.5492 1135.9  -1.325 1.0000
##  warmed  3 - ambient Exotic 6       -0.65340 0.5534 1131.9  -1.181 1.0000
##  warmed  3 - warmed Native 7        -0.99466 0.5531 1136.0  -1.798 1.0000
##  warmed  3 - ambient Native 7       -0.92033 0.5571 1128.7  -1.652 1.0000
##  warmed  3 - warmed  7               0.91745 0.1235 1136.0   7.430 <.0001
##  warmed  3 - ambient  7              0.99178 0.1403  372.2   7.072 <.0001
##  warmed  3 - warmed Both 7           0.09164 0.5580 1136.0   0.164 1.0000
##  warmed  3 - ambient Both 7          0.16597 0.5614 1128.4   0.296 1.0000
##  warmed  3 - warmed Exotic 7        -0.22628 0.5511 1136.1  -0.411 1.0000
##  warmed  3 - ambient Exotic 7       -0.15196 0.5554 1130.0  -0.274 1.0000
##  ambient  3 - warmed Both 3         -0.90014 0.5469 1120.8  -1.646 1.0000
##  ambient  3 - ambient Both 3        -0.82581 0.5427 1136.1  -1.522 1.0000
##  ambient  3 - warmed Exotic 3       -1.21806 0.5406 1122.6  -2.253 0.9943
##  ambient  3 - ambient Exotic 3      -1.14374 0.5372 1136.1  -2.129 0.9983
##  ambient  3 - warmed Native 4       -2.06313 0.5546 1122.9  -3.720 0.1497
##  ambient  3 - ambient Native 4      -1.98880 0.5510 1136.1  -3.609 0.2044
##  ambient  3 - warmed  4             -0.15102 0.1257  298.2  -1.201 1.0000
##  ambient  3 - ambient  4            -0.07669 0.1083 1120.3  -0.708 1.0000
##  ambient  3 - warmed Both 4         -0.97683 0.5588 1123.3  -1.748 1.0000
##  ambient  3 - ambient Both 4        -0.90250 0.5545 1136.1  -1.628 1.0000
##  ambient  3 - warmed Exotic 4       -1.29475 0.5511 1125.1  -2.350 0.9872
##  ambient  3 - ambient Exotic 4      -1.22042 0.5476 1136.0  -2.229 0.9955
##  ambient  3 - warmed Native 5       -1.50628 0.5549 1121.6  -2.714 0.8844
##  ambient  3 - ambient Native 5      -1.43195 0.5512 1136.1  -2.598 0.9348
##  ambient  3 - warmed  5              0.40583 0.1294  311.3   3.136 0.5673
##  ambient  3 - ambient  5             0.48016 0.1120 1129.6   4.285 0.0212
##  ambient  3 - warmed Both 5         -0.41998 0.5595 1122.5  -0.751 1.0000
##  ambient  3 - ambient Both 5        -0.34565 0.5552 1136.1  -0.623 1.0000
##  ambient  3 - warmed Exotic 5       -0.73791 0.5521 1124.0  -1.336 1.0000
##  ambient  3 - ambient Exotic 5      -0.66358 0.5486 1136.1  -1.210 1.0000
##  ambient  3 - warmed Native 6       -1.57044 0.5552 1124.0  -2.829 0.8166
##  ambient  3 - ambient Native 6      -1.49611 0.5520 1136.1  -2.710 0.8866
##  ambient  3 - warmed  6              0.34168 0.1301  316.2   2.626 0.9198
##  ambient  3 - ambient  6             0.41601 0.1154 1134.5   3.604 0.2075
##  ambient  3 - warmed Both 6         -0.48413 0.5595 1124.7  -0.865 1.0000
##  ambient  3 - ambient Both 6        -0.40980 0.5556 1136.1  -0.738 1.0000
##  ambient  3 - warmed Exotic 6       -0.80206 0.5522 1126.1  -1.452 1.0000
##  ambient  3 - ambient Exotic 6      -0.72773 0.5492 1135.9  -1.325 1.0000
##  ambient  3 - warmed Native 7       -1.06899 0.5562 1120.4  -1.922 0.9999
##  ambient  3 - ambient Native 7      -0.99466 0.5531 1136.0  -1.798 1.0000
##  ambient  3 - warmed  7              0.84312 0.1369  353.4   6.158 <.0001
##  ambient  3 - ambient  7             0.91745 0.1235 1136.0   7.430 <.0001
##  ambient  3 - warmed Both 7          0.01731 0.5617 1121.3   0.031 1.0000
##  ambient  3 - ambient Both 7         0.09164 0.5580 1136.0   0.164 1.0000
##  ambient  3 - warmed Exotic 7       -0.30061 0.5540 1122.9  -0.543 1.0000
##  ambient  3 - ambient Exotic 7      -0.22628 0.5511 1136.1  -0.411 1.0000
##  warmed Both 3 - ambient Both 3      0.07433 0.0629   21.8   1.181 1.0000
##  warmed Both 3 - warmed Exotic 3    -0.31793 0.1006 1136.1  -3.159 0.5454
##  warmed Both 3 - ambient Exotic 3   -0.24360 0.1227  254.3  -1.985 0.9995
##  warmed Both 3 - warmed Native 4    -1.16299 0.1531 1127.3  -7.598 <.0001
##  warmed Both 3 - ambient Native 4   -1.08866 0.1674  616.7  -6.503 <.0001
##  warmed Both 3 - warmed  4           0.74912 0.5523 1136.1   1.356 1.0000
##  warmed Both 3 - ambient  4          0.82345 0.5563 1122.7   1.480 1.0000
##  warmed Both 3 - warmed Both 4      -0.07669 0.1083 1120.3  -0.708 1.0000
```

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##  warmed Both 3 - ambient Both 4      -0.00236 0.1248  283.4  -0.019 1.0000
##  warmed Both 3 - warmed Exotic 4     -0.39461 0.1420 1127.0  -2.779 0.8484
##  warmed Both 3 - ambient Exotic 4    -0.32028 0.1581  536.3  -2.026 0.9994
##  warmed Both 3 - warmed Native 5     -0.60615 0.1540 1133.3  -3.936 0.0760
##  warmed Both 3 - ambient Native 5    -0.53182 0.1679  606.9  -3.167 0.5395
##  warmed Both 3 - warmed  5            1.30597 0.5531 1136.1   2.361 0.9860
##  warmed Both 3 - ambient  5           1.38030 0.5571 1123.0   2.478 0.9679
##  warmed Both 3 - warmed Both 5        0.48016 0.1120 1129.6   4.285 0.0212
##  warmed Both 3 - ambient Both 5       0.55449 0.1276  300.2   4.345 0.0199
##  warmed Both 3 - warmed Exotic 5      0.16223 0.1461 1134.4   1.111 1.0000
##  warmed Both 3 - ambient Exotic 5     0.23656 0.1614  544.3   1.466 1.0000
##  warmed Both 3 - warmed Native 6     -0.67030 0.1578 1135.2  -4.248 0.0245
##  warmed Both 3 - ambient Native 6    -0.59597 0.1731  620.8  -3.443 0.3129
##  warmed Both 3 - warmed  6            1.24181 0.5540 1136.0   2.241 0.9949
##  warmed Both 3 - ambient  6           1.31614 0.5585 1119.9   2.356 0.9865
##  warmed Both 3 - warmed Both 6        0.41601 0.1154 1134.5   3.604 0.2075
##  warmed Both 3 - ambient Both 6       0.49033 0.1328  320.8   3.692 0.1709
##  warmed Both 3 - warmed Exotic 6      0.09808 0.1494 1135.8   0.657 1.0000
##  warmed Both 3 - ambient Exotic 6     0.17241 0.1661  557.8   1.038 1.0000
##  warmed Both 3 - warmed Native 7     -0.16885 0.1591 1135.7  -1.061 1.0000
##  warmed Both 3 - ambient Native 7    -0.09452 0.1746  632.2  -0.541 1.0000
##  warmed Both 3 - warmed  7            1.74326 0.5551 1136.1   3.140 0.5622
##  warmed Both 3 - ambient  7           1.81759 0.5597 1123.3   3.248 0.4676
##  warmed Both 3 - warmed Both 7        0.91745 0.1235 1136.0   7.430 <.0001
##  warmed Both 3 - ambient Both 7       0.99178 0.1403  372.2   7.072 <.0001
##  warmed Both 3 - warmed Exotic 7      0.59952 0.1538 1136.0   3.898 0.0860
##  warmed Both 3 - ambient Exotic 7     0.67385 0.1705  590.9   3.953 0.0740
##  ambient Both 3 - warmed Exotic 3    -0.39226 0.1145  199.5  -3.426 0.3359
##  ambient Both 3 - ambient Exotic 3   -0.31793 0.1006 1136.1  -3.159 0.5454
##  ambient Both 3 - warmed Native 4    -1.23732 0.1636  575.3  -7.565 <.0001
##  ambient Both 3 - ambient Native 4   -1.16299 0.1531 1127.3  -7.598 <.0001
##  ambient Both 3 - warmed  4           0.67479 0.5553 1130.0   1.215 1.0000
##  ambient Both 3 - ambient  4          0.74912 0.5523 1136.1   1.356 1.0000
##  ambient Both 3 - warmed Both 4      -0.15102 0.1257  298.2  -1.201 1.0000
##  ambient Both 3 - ambient Both 4     -0.07669 0.1083 1120.3  -0.708 1.0000
##  ambient Both 3 - warmed Exotic 4    -0.46894 0.1525  499.9  -3.075 0.6204
##  ambient Both 3 - ambient Exotic 4   -0.39461 0.1420 1127.0  -2.779 0.8484
##  ambient Both 3 - warmed Native 5    -0.68047 0.1648  558.4  -4.129 0.0404
##  ambient Both 3 - ambient Native 5   -0.60615 0.1540 1133.3  -3.936 0.0760
##  ambient Both 3 - warmed  5           1.23164 0.5563 1129.8   2.214 0.9960
##  ambient Both 3 - ambient  5          1.30597 0.5531 1136.1   2.361 0.9860
##  ambient Both 3 - warmed Both 5       0.40583 0.1294  311.3   3.136 0.5673
##  ambient Both 3 - ambient Both 5      0.48016 0.1120 1129.6   4.285 0.0212
##  ambient Both 3 - warmed Exotic 5     0.08790 0.1567  502.4   0.561 1.0000
##  ambient Both 3 - ambient Exotic 5    0.16223 0.1461 1134.4   1.111 1.0000
##  ambient Both 3 - warmed Native 6    -0.74463 0.1666  569.8  -4.470 0.0108
##  ambient Both 3 - ambient Native 6   -0.67030 0.1578 1135.2  -4.248 0.0245
##  ambient Both 3 - warmed  6           1.16749 0.5567 1128.1   2.097 0.9988
##  ambient Both 3 - ambient  6          1.24181 0.5540 1136.0   2.241 0.9949
##  ambient Both 3 - warmed Both 6       0.34168 0.1301  316.2   2.626 0.9198
##  ambient Both 3 - ambient Both 6      0.41601 0.1154 1134.5   3.604 0.2075
##  ambient Both 3 - warmed Exotic 6     0.02375 0.1579  510.8   0.150 1.0000
##  ambient Both 3 - ambient Exotic 6    0.09808 0.1494 1135.8   0.657 1.0000
##  ambient Both 3 - warmed Native 7    -0.24318 0.1675  566.2  -1.452 1.0000
```

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##  ambient Both 3 - ambient Native 7   -0.16885 0.1591 1135.7  -1.061 1.0000
##  ambient Both 3 - warmed  7           1.66893 0.5576 1130.2   2.993 0.6912
##  ambient Both 3 - ambient  7          1.74326 0.5551 1136.1   3.140 0.5622
##  ambient Both 3 - warmed Both 7       0.84312 0.1369  353.4   6.158 <.0001
##  ambient Both 3 - ambient Both 7      0.91745 0.1235 1136.0   7.430 <.0001
##  ambient Both 3 - warmed Exotic 7     0.52520 0.1618  530.5   3.246 0.4705
##  ambient Both 3 - ambient Exotic 7    0.59952 0.1538 1136.0   3.898 0.0860
##  warmed Exotic 3 - ambient Exotic 3   0.07433 0.0629   21.8   1.181 1.0000
##  warmed Exotic 3 - warmed Native 4   -0.84506 0.1343 1131.0  -6.293 <.0001
##  warmed Exotic 3 - ambient Native 4  -0.77073 0.1472  449.5  -5.238 0.0003
##  warmed Exotic 3 - warmed  4          1.06705 0.5484 1136.0   1.946 0.9998
##  warmed Exotic 3 - ambient  4         1.14138 0.5517 1124.2   2.069 0.9991
##  warmed Exotic 3 - warmed Both 4      0.24124 0.1534 1134.3   1.572 1.0000
##  warmed Exotic 3 - ambient Both 4     0.31557 0.1625  542.1   1.942 0.9998
##  warmed Exotic 3 - warmed Exotic 4   -0.07669 0.1083 1120.3  -0.708 1.0000
##  warmed Exotic 3 - ambient Exotic 4  -0.00236 0.1248  283.4  -0.019 1.0000
##  warmed Exotic 3 - warmed Native 5   -0.28822 0.1341 1133.4  -2.149 0.9979
##  warmed Exotic 3 - ambient Native 5  -0.21389 0.1466  444.4  -1.459 1.0000
##  warmed Exotic 3 - warmed  5          1.62390 0.5490 1136.0   2.958 0.7199
##  warmed Exotic 3 - ambient  5         1.69822 0.5521 1124.8   3.076 0.6194
##  warmed Exotic 3 - warmed Both 5      0.79809 0.1550 1133.9   5.148 0.0004
##  warmed Exotic 3 - ambient Both 5     0.87241 0.1637  558.5   5.331 0.0002
##  warmed Exotic 3 - warmed Exotic 5    0.48016 0.1120 1129.6   4.285 0.0212
##  warmed Exotic 3 - ambient Exotic 5   0.55449 0.1276  300.2   4.345 0.0199
##  warmed Exotic 3 - warmed Native 6   -0.35237 0.1377 1135.6  -2.559 0.9473
##  warmed Exotic 3 - ambient Native 6  -0.27804 0.1518  463.5  -1.832 1.0000
##  warmed Exotic 3 - warmed  6          1.55974 0.5497 1136.1   2.837 0.8107
##  warmed Exotic 3 - ambient  6         1.63407 0.5534 1122.0   2.953 0.7241
##  warmed Exotic 3 - warmed Both 6      0.73393 0.1568 1135.4   4.679 0.0040
##  warmed Exotic 3 - ambient Both 6     0.80826 0.1671  563.7   4.836 0.0022
##  warmed Exotic 3 - warmed Exotic 6    0.41601 0.1154 1134.5   3.604 0.2075
##  warmed Exotic 3 - ambient Exotic 6   0.49033 0.1328  320.8   3.692 0.1709
##  warmed Exotic 3 - warmed Native 7    0.14908 0.1412 1136.1   1.056 1.0000
##  warmed Exotic 3 - ambient Native 7   0.22340 0.1554  485.8   1.438 1.0000
##  warmed Exotic 3 - warmed  7          2.06119 0.5513 1136.0   3.739 0.1416
##  warmed Exotic 3 - ambient  7         2.13552 0.5551 1125.0   3.847 0.1013
##  warmed Exotic 3 - warmed Both 7      1.23538 0.1646 1136.1   7.505 <.0001
##  warmed Exotic 3 - ambient Both 7     1.30971 0.1748  608.0   7.495 <.0001
##  warmed Exotic 3 - warmed Exotic 7    0.91745 0.1235 1136.0   7.430 <.0001
##  warmed Exotic 3 - ambient Exotic 7   0.99178 0.1403  372.2   7.072 <.0001
##  ambient Exotic 3 - warmed Native 4  -0.91939 0.1495  459.0  -6.152 <.0001
##  ambient Exotic 3 - ambient Native 4 -0.84506 0.1343 1131.0  -6.293 <.0001
##  ambient Exotic 3 - warmed  4         0.99272 0.5524 1131.3   1.797 1.0000
##  ambient Exotic 3 - ambient  4        1.06705 0.5484 1136.0   1.946 0.9998
##  ambient Exotic 3 - warmed Both 4     0.16691 0.1691  604.8   0.987 1.0000
##  ambient Exotic 3 - ambient Both 4    0.24124 0.1534 1134.3   1.572 1.0000
##  ambient Exotic 3 - warmed Exotic 4  -0.15102 0.1257  298.2  -1.201 1.0000
##  ambient Exotic 3 - ambient Exotic 4 -0.07669 0.1083 1120.3  -0.708 1.0000
##  ambient Exotic 3 - warmed Native 5  -0.36255 0.1497  447.8  -2.422 0.9765
##  ambient Exotic 3 - ambient Native 5 -0.28822 0.1341 1133.4  -2.149 0.9979
##  ambient Exotic 3 - warmed  5         1.54957 0.5531 1131.4   2.802 0.8341
##  ambient Exotic 3 - ambient  5        1.62390 0.5490 1136.0   2.958 0.7199
##  ambient Exotic 3 - warmed Both 5     0.72376 0.1709  612.6   4.235 0.0270
##  ambient Exotic 3 - ambient Both 5    0.79809 0.1550 1133.9   5.148 0.0004
```

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##  ambient Exotic 3 - warmed Exotic 5   0.40583 0.1294  311.3   3.136 0.5673
##  ambient Exotic 3 - ambient Exotic 5  0.48016 0.1120 1129.6   4.285 0.0212
##  ambient Exotic 3 - warmed Native 6  -0.42670 0.1510  456.7  -2.826 0.8153
##  ambient Exotic 3 - ambient Native 6 -0.35237 0.1377 1135.6  -2.559 0.9473
##  ambient Exotic 3 - warmed  6         1.48541 0.5533 1129.9   2.685 0.8991
##  ambient Exotic 3 - ambient  6        1.55974 0.5497 1136.1   2.837 0.8107
##  ambient Exotic 3 - warmed Both 6     0.65960 0.1708  612.5   3.861 0.0995
##  ambient Exotic 3 - ambient Both 6    0.73393 0.1568 1135.4   4.679 0.0040
##  ambient Exotic 3 - warmed Exotic 6   0.34168 0.1301  316.2   2.626 0.9198
##  ambient Exotic 3 - ambient Exotic 6  0.41601 0.1154 1134.5   3.604 0.2075
##  ambient Exotic 3 - warmed Native 7   0.07475 0.1539  463.0   0.486 1.0000
##  ambient Exotic 3 - ambient Native 7  0.14908 0.1412 1136.1   1.056 1.0000
##  ambient Exotic 3 - warmed  7         1.98686 0.5548 1131.6   3.581 0.2201
##  ambient Exotic 3 - ambient  7        2.06119 0.5513 1136.0   3.739 0.1416
##  ambient Exotic 3 - warmed Both 7     1.16105 0.1777  638.7   6.534 <.0001
##  ambient Exotic 3 - ambient Both 7    1.23538 0.1646 1136.1   7.505 <.0001
##  ambient Exotic 3 - warmed Exotic 7   0.84312 0.1369  353.4   6.158 <.0001
##  ambient Exotic 3 - ambient Exotic 7  0.91745 0.1235 1136.0   7.430 <.0001
##  warmed Native 4 - ambient Native 4   0.07433 0.0629   21.8   1.181 1.0000
##  warmed Native 4 - warmed  4          1.91211 0.5401 1136.1   3.540 0.2449
##  warmed Native 4 - ambient  4         1.98644 0.5437 1120.1   3.654 0.1809
##  warmed Native 4 - warmed Both 4      1.08630 0.1129 1135.0   9.622 <.0001
##  warmed Native 4 - ambient Both 4     1.16063 0.1263  272.6   9.188 <.0001
##  warmed Native 4 - warmed Exotic 4    0.76838 0.0752 1136.1  10.211 <.0001
##  warmed Native 4 - ambient Exotic 4   0.84271 0.0993  119.7   8.491 <.0001
##  warmed Native 4 - warmed Native 5    0.55685 0.1101 1127.2   5.057 0.0007
##  warmed Native 4 - ambient Native 5   0.63118 0.1264  297.9   4.995 0.0013
##  warmed Native 4 - warmed  5          2.46896 0.5518 1136.1   4.475 0.0098
##  warmed Native 4 - ambient  5         2.54329 0.5552 1123.2   4.581 0.0062
##  warmed Native 4 - warmed Both 5      1.64315 0.1594 1129.6  10.309 <.0001
##  warmed Native 4 - ambient Both 5     1.71748 0.1688  608.7  10.174 <.0001
##  warmed Native 4 - warmed Exotic 5    1.32522 0.1366 1133.2   9.701 <.0001
##  warmed Native 4 - ambient Exotic 5   1.39955 0.1508  463.9   9.282 <.0001
##  warmed Native 4 - warmed Native 6    0.49269 0.1136 1132.6   4.337 0.0173
##  warmed Native 4 - ambient Native 6   0.56702 0.1317  320.8   4.307 0.0227
##  warmed Native 4 - warmed  6          2.40481 0.5524 1136.0   4.354 0.0162
##  warmed Native 4 - ambient  6         2.47913 0.5563 1120.2   4.457 0.0106
##  warmed Native 4 - warmed Both 6      1.57900 0.1606 1131.8   9.833 <.0001
##  warmed Native 4 - ambient Both 6     1.65332 0.1716  610.7   9.632 <.0001
##  warmed Native 4 - warmed Exotic 6    1.26107 0.1387 1135.0   9.090 <.0001
##  warmed Native 4 - ambient Exotic 6   1.33540 0.1546  475.1   8.637 <.0001
##  warmed Native 4 - warmed Native 7    0.99414 0.1217 1135.3   8.167 <.0001
##  warmed Native 4 - ambient Native 7   1.06847 0.1391  373.0   7.681 <.0001
##  warmed Native 4 - warmed  7          2.90625 0.5548 1136.1   5.238 0.0003
##  warmed Native 4 - ambient  7         2.98058 0.5588 1123.7   5.334 0.0002
##  warmed Native 4 - warmed Both 7      2.08044 0.1709 1134.4  12.173 <.0001
##  warmed Native 4 - ambient Both 7     2.15477 0.1816  670.0  11.863 <.0001
##  warmed Native 4 - warmed Exotic 7    1.76252 0.1486 1135.8  11.858 <.0001
##  warmed Native 4 - ambient Exotic 7   1.83684 0.1639  541.8  11.209 <.0001
##  ambient Native 4 - warmed  4         1.83778 0.5438 1129.0   3.379 0.3584
##  ambient Native 4 - ambient  4        1.91211 0.5401 1136.1   3.540 0.2449
##  ambient Native 4 - warmed Both 4     1.01197 0.1321  332.1   7.659 <.0001
##  ambient Native 4 - ambient Both 4    1.08630 0.1129 1135.0   9.622 <.0001
##  ambient Native 4 - warmed Exotic 4   0.69405 0.0969  116.6   7.161 <.0001
```

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##  ambient Native 4 - ambient Exotic 4  0.76838 0.0752 1136.1  10.211 <.0001
##  ambient Native 4 - warmed Native 5   0.48252 0.1273  294.4   3.791 0.1299
##  ambient Native 4 - ambient Native 5  0.55685 0.1101 1127.2   5.057 0.0007
##  ambient Native 4 - warmed  5         2.39463 0.5555 1130.4   4.311 0.0192
##  ambient Native 4 - ambient  5        2.46896 0.5518 1136.1   4.475 0.0098
##  ambient Native 4 - warmed Both 5     1.56882 0.1739  654.9   9.023 <.0001
##  ambient Native 4 - ambient Both 5    1.64315 0.1594 1129.6  10.309 <.0001
##  ambient Native 4 - warmed Exotic 5   1.25089 0.1500  464.3   8.338 <.0001
##  ambient Native 4 - ambient Exotic 5  1.32522 0.1366 1133.2   9.701 <.0001
##  ambient Native 4 - warmed Native 6   0.41836 0.1281  301.3   3.267 0.4556
##  ambient Native 4 - ambient Native 6  0.49269 0.1136 1132.6   4.337 0.0173
##  ambient Native 4 - warmed  6         2.33048 0.5556 1128.8   4.195 0.0301
##  ambient Native 4 - ambient  6        2.40481 0.5524 1136.0   4.354 0.0162
##  ambient Native 4 - warmed Both 6     1.50467 0.1733  653.6   8.683 <.0001
##  ambient Native 4 - ambient Both 6    1.57900 0.1606 1131.8   9.833 <.0001
##  ambient Native 4 - warmed Exotic 6   1.18674 0.1500  466.4   7.910 <.0001
##  ambient Native 4 - ambient Exotic 6  1.26107 0.1387 1135.0   9.090 <.0001
##  ambient Native 4 - warmed Native 7   0.91981 0.1349  338.8   6.818 <.0001
##  ambient Native 4 - ambient Native 7  0.99414 0.1217 1135.3   8.167 <.0001
##  ambient Native 4 - warmed  7         2.83192 0.5579 1130.8   5.076 0.0006
##  ambient Native 4 - ambient  7        2.90625 0.5548 1136.1   5.238 0.0003
##  ambient Native 4 - warmed Both 7     2.00611 0.1826  695.1  10.986 <.0001
##  ambient Native 4 - ambient Both 7    2.08044 0.1709 1134.4  12.173 <.0001
##  ambient Native 4 - warmed Exotic 7   1.68819 0.1589  519.9  10.624 <.0001
##  ambient Native 4 - ambient Exotic 7  1.76252 0.1486 1135.8  11.858 <.0001
##  warmed  4 - ambient  4               0.07433 0.0629   21.8   1.181 1.0000
##  warmed  4 - warmed Both 4           -0.82581 0.5427 1136.1  -1.522 1.0000
##  warmed  4 - ambient Both 4          -0.75148 0.5457 1128.5  -1.377 1.0000
##  warmed  4 - warmed Exotic 4         -1.14374 0.5372 1136.1  -2.129 0.9983
##  warmed  4 - ambient Exotic 4        -1.06941 0.5412 1130.2  -1.976 0.9997
##  warmed  4 - warmed Native 5         -1.35527 0.5506 1136.1  -2.461 0.9712
##  warmed  4 - ambient Native 5        -1.28094 0.5542 1129.8  -2.311 0.9906
##  warmed  4 - warmed  5                0.55685 0.1101 1127.2   5.057 0.0007
##  warmed  4 - ambient  5               0.63118 0.1264  297.9   4.995 0.0013
##  warmed  4 - warmed Both 5           -0.26896 0.5537 1136.1  -0.486 1.0000
##  warmed  4 - ambient Both 5          -0.19463 0.5565 1129.6  -0.350 1.0000
##  warmed  4 - warmed Exotic 5         -0.58689 0.5486 1136.1  -1.070 1.0000
##  warmed  4 - ambient Exotic 5        -0.51256 0.5524 1130.9  -0.928 1.0000
##  warmed  4 - warmed Native 6         -1.41942 0.5515 1136.1  -2.574 0.9428
##  warmed  4 - ambient Native 6        -1.34509 0.5555 1130.9  -2.421 0.9781
##  warmed  4 - warmed  6                0.49269 0.1136 1132.6   4.337 0.0173
##  warmed  4 - ambient  6               0.56702 0.1317  320.8   4.307 0.0227
##  warmed  4 - warmed Both 6           -0.33312 0.5541 1136.1  -0.601 1.0000
##  warmed  4 - ambient Both 6          -0.25879 0.5575 1130.8  -0.464 1.0000
##  warmed  4 - warmed Exotic 6         -0.65104 0.5493 1135.9  -1.185 1.0000
##  warmed  4 - ambient Exotic 6        -0.57671 0.5536 1131.9  -1.042 1.0000
##  warmed  4 - warmed Native 7         -0.91797 0.5525 1136.0  -1.662 1.0000
##  warmed  4 - ambient Native 7        -0.84364 0.5566 1128.8  -1.516 1.0000
##  warmed  4 - warmed  7                0.99414 0.1217 1135.3   8.167 <.0001
##  warmed  4 - ambient  7               1.06847 0.1391  373.0   7.681 <.0001
##  warmed  4 - warmed Both 7            0.16833 0.5565 1136.0   0.302 1.0000
##  warmed  4 - ambient Both 7           0.24266 0.5600 1128.7   0.433 1.0000
##  warmed  4 - warmed Exotic 7         -0.14960 0.5512 1136.1  -0.271 1.0000
##  warmed  4 - ambient Exotic 7        -0.07527 0.5555 1130.1  -0.135 1.0000
```

```
##  ambient  4 - warmed Both 4          -0.90014 0.5469 1120.8  -1.646 1.0000
##  ambient  4 - ambient Both 4         -0.82581 0.5427 1136.1  -1.522 1.0000
##  ambient  4 - warmed Exotic 4        -1.21806 0.5406 1122.6  -2.253 0.9943
##  ambient  4 - ambient Exotic 4       -1.14374 0.5372 1136.1  -2.129 0.9983
##  ambient  4 - warmed Native 5        -1.42960 0.5543 1121.3  -2.579 0.9410
##  ambient  4 - ambient Native 5       -1.35527 0.5506 1136.1  -2.461 0.9712
##  ambient  4 - warmed  5               0.48252 0.1273  294.4   3.791 0.1299
##  ambient  4 - ambient  5              0.55685 0.1101 1127.2   5.057 0.0007
##  ambient  4 - warmed Both 5          -0.34329 0.5579 1122.2  -0.615 1.0000
##  ambient  4 - ambient Both 5         -0.26896 0.5537 1136.1  -0.486 1.0000
##  ambient  4 - warmed Exotic 5        -0.66122 0.5520 1123.5  -1.198 1.0000
##  ambient  4 - ambient Exotic 5       -0.58689 0.5486 1136.1  -1.070 1.0000
##  ambient  4 - warmed Native 6        -1.49375 0.5545 1123.7  -2.694 0.8948
##  ambient  4 - ambient Native 6       -1.41942 0.5515 1136.1  -2.574 0.9428
##  ambient  4 - warmed  6               0.41836 0.1281  301.3   3.267 0.4556
##  ambient  4 - ambient  6              0.49269 0.1136 1132.6   4.337 0.0173
##  ambient  4 - warmed Both 6          -0.40745 0.5579 1124.5  -0.730 1.0000
##  ambient  4 - ambient Both 6         -0.33312 0.5541 1136.1  -0.601 1.0000
##  ambient  4 - warmed Exotic 6        -0.72537 0.5522 1125.8  -1.314 1.0000
##  ambient  4 - ambient Exotic 6       -0.65104 0.5493 1135.9  -1.185 1.0000
##  ambient  4 - warmed Native 7        -0.99230 0.5555 1120.1  -1.786 1.0000
##  ambient  4 - ambient Native 7       -0.91797 0.5525 1136.0  -1.662 1.0000
##  ambient  4 - warmed  7               0.91981 0.1349  338.8   6.818 <.0001
##  ambient  4 - ambient  7              0.99414 0.1217 1135.3   8.167 <.0001
##  ambient  4 - warmed Both 7           0.09400 0.5601 1121.1   0.168 1.0000
##  ambient  4 - ambient Both 7          0.16833 0.5565 1136.0   0.302 1.0000
##  ambient  4 - warmed Exotic 7        -0.22393 0.5539 1122.6  -0.404 1.0000
##  ambient  4 - ambient Exotic 7       -0.14960 0.5512 1136.1  -0.271 1.0000
##  warmed Both 4 - ambient Both 4       0.07433 0.0629   21.8   1.181 1.0000
##  warmed Both 4 - warmed Exotic 4     -0.31793 0.1006 1136.1  -3.159 0.5454
##  warmed Both 4 - ambient Exotic 4    -0.24360 0.1227  254.3  -1.985 0.9995
##  warmed Both 4 - warmed Native 5     -0.52946 0.1560 1134.1  -3.394 0.3472
##  warmed Both 4 - ambient Native 5    -0.45513 0.1701  623.5  -2.676 0.9017
##  warmed Both 4 - warmed  5            1.38266 0.5538 1136.1   2.496 0.9639
##  warmed Both 4 - ambient  5           1.45698 0.5579 1123.3   2.612 0.9298
##  warmed Both 4 - warmed Both 5        0.55685 0.1101 1127.2   5.057 0.0007
##  warmed Both 4 - ambient Both 5       0.63118 0.1264  297.9   4.995 0.0013
##  warmed Both 4 - warmed Exotic 5      0.23892 0.1503 1135.5   1.590 1.0000
##  warmed Both 4 - ambient Exotic 5     0.31325 0.1656  572.2   1.892 0.9999
##  warmed Both 4 - warmed Native 6     -0.59361 0.1597 1135.4  -3.716 0.1514
##  warmed Both 4 - ambient Native 6    -0.51928 0.1752  638.6  -2.964 0.7144
##  warmed Both 4 - warmed  6            1.31850 0.5548 1136.0   2.377 0.9842
##  warmed Both 4 - ambient  6           1.39283 0.5594 1120.4   2.490 0.9653
##  warmed Both 4 - warmed Both 6        0.49269 0.1136 1132.6   4.337 0.0173
##  warmed Both 4 - ambient Both 6       0.56702 0.1317  320.8   4.307 0.0227
##  warmed Both 4 - warmed Exotic 6      0.17477 0.1536 1136.1   1.138 1.0000
##  warmed Both 4 - ambient Exotic 6     0.24909 0.1703  586.3   1.463 1.0000
##  warmed Both 4 - warmed Native 7     -0.09216 0.1610 1135.8  -0.572 1.0000
##  warmed Both 4 - ambient Native 7    -0.01784 0.1767  649.8  -0.101 1.0000
##  warmed Both 4 - warmed  7            1.81995 0.5558 1136.1   3.274 0.4446
##  warmed Both 4 - ambient  7           1.89428 0.5605 1123.8   3.380 0.3582
##  warmed Both 4 - warmed Both 7        0.99414 0.1217 1135.3   8.167 <.0001
##  warmed Both 4 - ambient Both 7       1.06847 0.1391  373.0   7.681 <.0001
##  warmed Both 4 - warmed Exotic 7      0.67621 0.1578 1136.1   4.284 0.0213
```

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##  warmed Both 4 - ambient Exotic 7     0.75054 0.1744  618.0   4.303 0.0209
##  ambient Both 4 - warmed Exotic 4    -0.39226 0.1145  199.5  -3.426 0.3359
##  ambient Both 4 - ambient Exotic 4   -0.31793 0.1006 1136.1  -3.159 0.5454
##  ambient Both 4 - warmed Native 5    -0.60379 0.1663  560.4  -3.630 0.1965
##  ambient Both 4 - ambient Native 5   -0.52946 0.1560 1134.1  -3.394 0.3472
##  ambient Both 4 - warmed  5           1.30833 0.5569 1129.8   2.349 0.9872
##  ambient Both 4 - ambient  5          1.38266 0.5538 1136.1   2.496 0.9639
##  ambient Both 4 - warmed Both 5       0.48252 0.1273  294.4   3.791 0.1299
##  ambient Both 4 - ambient Both 5      0.55685 0.1101 1127.2   5.057 0.0007
##  ambient Both 4 - warmed Exotic 5     0.16459 0.1603  516.4   1.027 1.0000
##  ambient Both 4 - ambient Exotic 5    0.23892 0.1503 1135.5   1.590 1.0000
##  ambient Both 4 - warmed Native 6    -0.66794 0.1681  573.8  -3.973 0.0693
##  ambient Both 4 - ambient Native 6   -0.59361 0.1597 1135.4  -3.716 0.1514
##  ambient Both 4 - warmed  6           1.24417 0.5573 1128.1   2.232 0.9953
##  ambient Both 4 - ambient  6          1.31850 0.5548 1136.0   2.377 0.9842
##  ambient Both 4 - warmed Both 6       0.41836 0.1281  301.3   3.267 0.4556
##  ambient Both 4 - ambient Both 6      0.49269 0.1136 1132.6   4.337 0.0173
##  ambient Both 4 - warmed Exotic 6     0.10044 0.1615  526.6   0.622 1.0000
##  ambient Both 4 - ambient Exotic 6    0.17477 0.1536 1136.1   1.138 1.0000
##  ambient Both 4 - warmed Native 7    -0.16649 0.1690  570.1  -0.985 1.0000
##  ambient Both 4 - ambient Native 7   -0.09216 0.1610 1135.8  -0.572 1.0000
##  ambient Both 4 - warmed  7           1.74562 0.5583 1130.2   3.127 0.5743
##  ambient Both 4 - ambient  7          1.81995 0.5558 1136.1   3.274 0.4446
##  ambient Both 4 - warmed Both 7       0.91981 0.1349  338.8   6.818 <.0001
##  ambient Both 4 - ambient Both 7      0.99414 0.1217 1135.3   8.167 <.0001
##  ambient Both 4 - warmed Exotic 7     0.60188 0.1653  545.4   3.641 0.1908
##  ambient Both 4 - ambient Exotic 7    0.67621 0.1578 1136.1   4.284 0.0213
##  warmed Exotic 4 - ambient Exotic 4   0.07433 0.0629   21.8   1.181 1.0000
##  warmed Exotic 4 - warmed Native 5   -0.21153 0.1301 1130.8  -1.626 1.0000
##  warmed Exotic 4 - ambient Native 5  -0.13720 0.1433  431.0  -0.958 1.0000
##  warmed Exotic 4 - warmed  5          1.70058 0.5482 1136.0   3.102 0.5962
##  warmed Exotic 4 - ambient  5         1.77491 0.5514 1125.3   3.219 0.4926
##  warmed Exotic 4 - warmed Both 5      0.87477 0.1480 1130.0   5.909 <.0001
##  warmed Exotic 4 - ambient Both 5     0.94910 0.1574  531.9   6.030 <.0001
##  warmed Exotic 4 - warmed Exotic 5    0.55685 0.1101 1127.2   5.057 0.0007
##  warmed Exotic 4 - ambient Exotic 5   0.63118 0.1264  297.9   4.995 0.0013
##  warmed Exotic 4 - warmed Native 6   -0.27568 0.1338 1133.9  -2.061 0.9992
##  warmed Exotic 4 - ambient Native 6  -0.20136 0.1486  453.4  -1.355 1.0000
##  warmed Exotic 4 - warmed  6          1.63643 0.5489 1136.1   2.981 0.7011
##  warmed Exotic 4 - ambient  6         1.71076 0.5527 1122.6   3.095 0.6023
##  warmed Exotic 4 - warmed Both 6      0.81062 0.1500 1132.5   5.406 0.0001
##  warmed Exotic 4 - ambient Both 6     0.88495 0.1610  540.6   5.495 0.0001
##  warmed Exotic 4 - warmed Exotic 6    0.49269 0.1136 1132.6   4.337 0.0173
##  warmed Exotic 4 - ambient Exotic 6   0.56702 0.1317  320.8   4.307 0.0227
##  warmed Exotic 4 - warmed Native 7    0.22576 0.1374 1135.7   1.644 1.0000
##  warmed Exotic 4 - ambient Native 7   0.30009 0.1522  476.5   1.971 0.9997
##  warmed Exotic 4 - warmed  7          2.13788 0.5505 1135.9   3.883 0.0903
##  warmed Exotic 4 - ambient  7         2.21220 0.5544 1125.6   3.991 0.0631
##  warmed Exotic 4 - warmed Both 7      1.31207 0.1580 1135.2   8.302 <.0001
##  warmed Exotic 4 - ambient Both 7     1.38640 0.1689  588.5   8.208 <.0001
##  warmed Exotic 4 - warmed Exotic 7    0.99414 0.1217 1135.3   8.167 <.0001
##  warmed Exotic 4 - ambient Exotic 7   1.06847 0.1391  373.0   7.681 <.0001
##  ambient Exotic 4 - warmed Native 5  -0.28586 0.1457  419.2  -1.962 0.9997
##  ambient Exotic 4 - ambient Native 5 -0.21153 0.1301 1130.8  -1.626 1.0000
```

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##  ambient Exotic 4 - warmed  5         1.62625 0.5522 1131.5   2.945 0.7303
##  ambient Exotic 4 - ambient  5        1.70058 0.5482 1136.0   3.102 0.5962
##  ambient Exotic 4 - warmed Both 5     0.80044 0.1642  574.1   4.874 0.0018
##  ambient Exotic 4 - ambient Both 5    0.87477 0.1480 1130.0   5.909 <.0001
##  ambient Exotic 4 - warmed Exotic 5   0.48252 0.1273  294.4   3.791 0.1299
##  ambient Exotic 4 - ambient Exotic 5  0.55685 0.1101 1127.2   5.057 0.0007
##  ambient Exotic 4 - warmed Native 6  -0.35001 0.1470  430.5  -2.381 0.9823
##  ambient Exotic 4 - ambient Native 6 -0.27568 0.1338 1133.9  -2.061 0.9992
##  ambient Exotic 4 - warmed  6         1.56210 0.5524 1130.1   2.828 0.8171
##  ambient Exotic 4 - ambient  6        1.63643 0.5489 1136.1   2.981 0.7011
##  ambient Exotic 4 - warmed Both 6     0.73629 0.1642  576.3   4.484 0.0102
##  ambient Exotic 4 - ambient Both 6    0.81062 0.1500 1132.5   5.406 0.0001
##  ambient Exotic 4 - warmed Exotic 6   0.41836 0.1281  301.3   3.267 0.4556
##  ambient Exotic 4 - ambient Exotic 6  0.49269 0.1136 1132.6   4.337 0.0173
##  ambient Exotic 4 - warmed Native 7   0.15143 0.1499  437.7   1.010 1.0000
##  ambient Exotic 4 - ambient Native 7  0.22576 0.1374 1135.7   1.644 1.0000
##  ambient Exotic 4 - warmed  7         2.06355 0.5539 1131.8   3.726 0.1471
##  ambient Exotic 4 - ambient  7        2.13788 0.5505 1135.9   3.883 0.0903
##  ambient Exotic 4 - warmed Both 7     1.23774 0.1713  606.0   7.226 <.0001
##  ambient Exotic 4 - ambient Both 7    1.31207 0.1580 1135.2   8.302 <.0001
##  ambient Exotic 4 - warmed Exotic 7   0.91981 0.1349  338.8   6.818 <.0001
##  ambient Exotic 4 - ambient Exotic 7  0.99414 0.1217 1135.3   8.167 <.0001
##  warmed Native 5 - ambient Native 5   0.07433 0.0629   21.8   1.181 1.0000
##  warmed Native 5 - warmed  5          1.91211 0.5401 1136.1   3.540 0.2449
##  warmed Native 5 - ambient  5         1.98644 0.5437 1120.1   3.654 0.1809
##  warmed Native 5 - warmed Both 5      1.08630 0.1129 1135.0   9.622 <.0001
##  warmed Native 5 - ambient Both 5     1.16063 0.1263  272.6   9.188 <.0001
##  warmed Native 5 - warmed Exotic 5    0.76838 0.0752 1136.1  10.211 <.0001
##  warmed Native 5 - ambient Exotic 5   0.84271 0.0993  119.7   8.491 <.0001
##  warmed Native 5 - warmed Native 6   -0.06415 0.1171 1126.1  -0.548 1.0000
##  warmed Native 5 - ambient Native 6   0.01018 0.1351  350.5   0.075 1.0000
##  warmed Native 5 - warmed  6          1.84796 0.5525 1136.0   3.345 0.3860
##  warmed Native 5 - ambient  6         1.92229 0.5566 1119.8   3.454 0.3027
##  warmed Native 5 - warmed Both 6      1.02215 0.1614 1131.1   6.332 <.0001
##  warmed Native 5 - ambient Both 6     1.09648 0.1728  614.8   6.346 <.0001
##  warmed Native 5 - warmed Exotic 6    0.70422 0.1385 1131.1   5.085 0.0006
##  warmed Native 5 - ambient Exotic 6   0.77855 0.1548  484.3   5.030 0.0009
##  warmed Native 5 - warmed Native 7    0.43729 0.1247 1127.3   3.507 0.2664
##  warmed Native 5 - ambient Native 7   0.51162 0.1421  408.4   3.600 0.2157
##  warmed Native 5 - warmed  7          2.34941 0.5549 1136.1   4.234 0.0259
##  warmed Native 5 - ambient  7         2.42374 0.5590 1123.5   4.336 0.0174
##  warmed Native 5 - warmed Both 7      1.52360 0.1715 1132.5   8.885 <.0001
##  warmed Native 5 - ambient Both 7     1.59793 0.1825  680.2   8.756 <.0001
##  warmed Native 5 - warmed Exotic 7    1.20567 0.1482 1131.0   8.138 <.0001
##  warmed Native 5 - ambient Exotic 7   1.28000 0.1638  558.0   7.814 <.0001
##  ambient Native 5 - warmed  5         1.83778 0.5438 1129.0   3.379 0.3584
##  ambient Native 5 - ambient  5        1.91211 0.5401 1136.1   3.540 0.2449
##  ambient Native 5 - warmed Both 5     1.01197 0.1321  332.1   7.659 <.0001
##  ambient Native 5 - ambient Both 5    1.08630 0.1129 1135.0   9.622 <.0001
##  ambient Native 5 - warmed Exotic 5   0.69405 0.0969  116.6   7.161 <.0001
##  ambient Native 5 - ambient Exotic 5  0.76838 0.0752 1136.1  10.211 <.0001
##  ambient Native 5 - warmed Native 6  -0.13848 0.1307  335.6  -1.059 1.0000
##  ambient Native 5 - ambient Native 6 -0.06415 0.1171 1126.1  -0.548 1.0000
##  ambient Native 5 - warmed  6         1.77363 0.5556 1128.9   3.192 0.5163
```

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##  ambient Native 5 - ambient  6        1.84796 0.5525 1136.0   3.345 0.3860
##  ambient Native 5 - warmed Both 6     0.94782 0.1738  665.9   5.455 0.0001
##  ambient Native 5 - ambient Both 6    1.02215 0.1614 1131.1   6.332 <.0001
##  ambient Native 5 - warmed Exotic 6   0.62989 0.1494  482.8   4.215 0.0300
##  ambient Native 5 - ambient Exotic 6  0.70422 0.1385 1131.1   5.085 0.0006
##  ambient Native 5 - warmed Native 7   0.36296 0.1372  378.9   2.646 0.9126
##  ambient Native 5 - ambient Native 7  0.43729 0.1247 1127.3   3.507 0.2664
##  ambient Native 5 - warmed  7         2.27508 0.5579 1131.0   4.078 0.0463
##  ambient Native 5 - ambient  7        2.34941 0.5549 1136.1   4.234 0.0259
##  ambient Native 5 - warmed Both 7     1.44927 0.1828  713.6   7.927 <.0001
##  ambient Native 5 - ambient Both 7    1.52360 0.1715 1132.5   8.885 <.0001
##  ambient Native 5 - warmed Exotic 7   1.13134 0.1581  544.0   7.156 <.0001
##  ambient Native 5 - ambient Exotic 7  1.20567 0.1482 1131.0   8.138 <.0001
##  warmed  5 - ambient  5               0.07433 0.0629   21.8   1.181 1.0000
##  warmed  5 - warmed Both 5           -0.82581 0.5427 1136.1  -1.522 1.0000
##  warmed  5 - ambient Both 5          -0.75148 0.5457 1128.5  -1.377 1.0000
##  warmed  5 - warmed Exotic 5         -1.14374 0.5372 1136.1  -2.129 0.9983
##  warmed  5 - ambient Exotic 5        -1.06941 0.5412 1130.2  -1.976 0.9997
##  warmed  5 - warmed Native 6         -1.97627 0.5528 1136.0  -3.575 0.2237
##  warmed  5 - ambient Native 6        -1.90194 0.5569 1131.5  -3.415 0.3311
##  warmed  5 - warmed  6               -0.06415 0.1171 1126.1  -0.548 1.0000
##  warmed  5 - ambient  6               0.01018 0.1351  350.5   0.075 1.0000
##  warmed  5 - warmed Both 6           -0.88996 0.5549 1136.0  -1.604 1.0000
##  warmed  5 - ambient Both 6          -0.81563 0.5584 1131.2  -1.461 1.0000
##  warmed  5 - warmed Exotic 6         -1.20789 0.5498 1135.7  -2.197 0.9966
##  warmed  5 - ambient Exotic 6        -1.13356 0.5542 1132.5  -2.045 0.9993
##  warmed  5 - warmed Native 7         -1.47482 0.5537 1136.1  -2.663 0.9088
##  warmed  5 - ambient Native 7        -1.40049 0.5580 1129.7  -2.510 0.9607
##  warmed  5 - warmed  7                0.43729 0.1247 1127.3   3.507 0.2664
##  warmed  5 - ambient  7               0.51162 0.1421  408.4   3.600 0.2157
##  warmed  5 - warmed Both 7           -0.38852 0.5573 1136.1  -0.697 1.0000
##  warmed  5 - ambient Both 7          -0.31419 0.5608 1129.3  -0.560 1.0000
##  warmed  5 - warmed Exotic 7         -0.70644 0.5516 1136.1  -1.281 1.0000
##  warmed  5 - ambient Exotic 7        -0.63211 0.5561 1130.9  -1.137 1.0000
##  ambient  5 - warmed Both 5          -0.90014 0.5469 1120.8  -1.646 1.0000
##  ambient  5 - ambient Both 5         -0.82581 0.5427 1136.1  -1.522 1.0000
##  ambient  5 - warmed Exotic 5        -1.21806 0.5406 1122.6  -2.253 0.9943
##  ambient  5 - ambient Exotic 5       -1.14374 0.5372 1136.1  -2.129 0.9983
##  ambient  5 - warmed Native 6        -2.05059 0.5557 1125.1  -3.690 0.1633
##  ambient  5 - ambient Native 6       -1.97627 0.5528 1136.0  -3.575 0.2237
##  ambient  5 - warmed  6              -0.13848 0.1307  335.6  -1.059 1.0000
##  ambient  5 - ambient  6             -0.06415 0.1171 1126.1  -0.548 1.0000
##  ambient  5 - warmed Both 6          -0.96429 0.5586 1125.5  -1.726 1.0000
##  ambient  5 - ambient Both 6         -0.88996 0.5549 1136.0  -1.604 1.0000
##  ambient  5 - warmed Exotic 6        -1.28222 0.5526 1127.0  -2.320 0.9898
##  ambient  5 - ambient Exotic 6       -1.20789 0.5498 1135.7  -2.197 0.9966
##  ambient  5 - warmed Native 7        -1.54915 0.5566 1122.0  -2.783 0.8457
##  ambient  5 - ambient Native 7       -1.47482 0.5537 1136.1  -2.663 0.9088
##  ambient  5 - warmed  7               0.36296 0.1372  378.9   2.646 0.9126
##  ambient  5 - ambient  7              0.43729 0.1247 1127.3   3.507 0.2664
##  ambient  5 - warmed Both 7          -0.46285 0.5608 1122.5  -0.825 1.0000
##  ambient  5 - ambient Both 7         -0.38852 0.5573 1136.1  -0.697 1.0000
##  ambient  5 - warmed Exotic 7        -0.78077 0.5543 1124.3  -1.409 1.0000
##  ambient  5 - ambient Exotic 7       -0.70644 0.5516 1136.1  -1.281 1.0000
```

```
##  warmed Both 5 - ambient Both 5       0.07433 0.0629   21.8   1.181 1.0000
##  warmed Both 5 - warmed Exotic 5     -0.31793 0.1006 1136.1  -3.159 0.5454
##  warmed Both 5 - ambient Exotic 5    -0.24360 0.1227  254.3  -1.985 0.9995
##  warmed Both 5 - warmed Native 6     -1.15046 0.1639 1131.7  -7.020 <.0001
##  warmed Both 5 - ambient Native 6    -1.07613 0.1793  679.8  -6.001 <.0001
##  warmed Both 5 - warmed  6            0.76166 0.5554 1136.0   1.371 1.0000
##  warmed Both 5 - ambient  6           0.83598 0.5601 1120.4   1.493 1.0000
##  warmed Both 5 - warmed Both 6       -0.06415 0.1171 1126.1  -0.548 1.0000
##  warmed Both 5 - ambient Both 6       0.01018 0.1351  350.5   0.075 1.0000
##  warmed Both 5 - warmed Exotic 6     -0.38208 0.1551 1133.0  -2.464 0.9707
##  warmed Both 5 - ambient Exotic 6    -0.30775 0.1720  615.2  -1.790 1.0000
##  warmed Both 5 - warmed Native 7     -0.64901 0.1649 1130.6  -3.936 0.0758
##  warmed Both 5 - ambient Native 7    -0.57468 0.1805  697.6  -3.184 0.5245
##  warmed Both 5 - warmed  7            1.26310 0.5564 1136.1   2.270 0.9934
##  warmed Both 5 - ambient  7           1.33743 0.5612 1124.0   2.383 0.9834
##  warmed Both 5 - warmed Both 7        0.43729 0.1247 1127.3   3.507 0.2664
##  warmed Both 5 - ambient Both 7       0.51162 0.1421  408.4   3.600 0.2157
##  warmed Both 5 - warmed Exotic 7      0.11937 0.1591 1131.7   0.750 1.0000
##  warmed Both 5 - ambient Exotic 7     0.19370 0.1759  653.4   1.101 1.0000
##  ambient Both 5 - warmed Exotic 5    -0.39226 0.1145  199.5  -3.426 0.3359
##  ambient Both 5 - ambient Exotic 5   -0.31793 0.1006 1136.1  -3.159 0.5454
##  ambient Both 5 - warmed Native 6    -1.22479 0.1717  625.8  -7.133 <.0001
##  ambient Both 5 - ambient Native 6   -1.15046 0.1639 1131.7  -7.020 <.0001
##  ambient Both 5 - warmed  6           0.68733 0.5578 1128.4   1.232 1.0000
##  ambient Both 5 - ambient  6          0.76166 0.5554 1136.0   1.371 1.0000
##  ambient Both 5 - warmed Both 6      -0.13848 0.1307  335.6  -1.059 1.0000
##  ambient Both 5 - ambient Both 6     -0.06415 0.1171 1126.1  -0.548 1.0000
##  ambient Both 5 - warmed Exotic 6    -0.45641 0.1626  564.5  -2.807 0.8291
##  ambient Both 5 - ambient Exotic 6   -0.38208 0.1551 1133.0  -2.464 0.9707
##  ambient Both 5 - warmed Native 7    -0.72334 0.1723  628.6  -4.197 0.0311
##  ambient Both 5 - ambient Native 7   -0.64901 0.1649 1130.6  -3.936 0.0758
##  ambient Both 5 - warmed  7           1.18877 0.5587 1130.6   2.128 0.9983
##  ambient Both 5 - ambient  7          1.26310 0.5564 1136.1   2.270 0.9934
##  ambient Both 5 - warmed Both 7       0.36296 0.1372  378.9   2.646 0.9126
##  ambient Both 5 - ambient Both 7      0.43729 0.1247 1127.3   3.507 0.2664
##  ambient Both 5 - warmed Exotic 7     0.04504 0.1661  589.8   0.271 1.0000
##  ambient Both 5 - ambient Exotic 7    0.11937 0.1591 1131.7   0.750 1.0000
##  warmed Exotic 5 - ambient Exotic 5   0.07433 0.0629   21.8   1.181 1.0000
##  warmed Exotic 5 - warmed Native 6   -0.83253 0.1399 1131.4  -5.951 <.0001
##  warmed Exotic 5 - ambient Native 6  -0.75820 0.1546  500.5  -4.906 0.0016
##  warmed Exotic 5 - warmed  6          1.07958 0.5499 1136.1   1.963 0.9998
##  warmed Exotic 5 - ambient  6         1.15391 0.5537 1122.2   2.084 0.9990
##  warmed Exotic 5 - warmed Both 6      0.25377 0.1537 1132.7   1.651 1.0000
##  warmed Exotic 5 - ambient Both 6     0.32810 0.1649  562.0   1.989 0.9996
##  warmed Exotic 5 - warmed Exotic 6   -0.06415 0.1171 1126.1  -0.548 1.0000
##  warmed Exotic 5 - ambient Exotic 6   0.01018 0.1351  350.5   0.075 1.0000
##  warmed Exotic 5 - warmed Native 7   -0.33108 0.1431 1132.0  -2.314 0.9904
##  warmed Exotic 5 - ambient Native 7  -0.25675 0.1578  529.2  -1.627 1.0000
##  warmed Exotic 5 - warmed  7          1.58103 0.5514 1135.9   2.867 0.7897
##  warmed Exotic 5 - ambient  7         1.65536 0.5553 1125.5   2.981 0.7013
##  warmed Exotic 5 - warmed Both 7      0.75522 0.1614 1134.0   4.679 0.0040
##  warmed Exotic 5 - ambient Both 7     0.82955 0.1724  614.5   4.812 0.0024
##  warmed Exotic 5 - warmed Exotic 7    0.43729 0.1247 1127.3   3.507 0.2664
##  warmed Exotic 5 - ambient Exotic 7   0.51162 0.1421  408.4   3.600 0.2157
```

```
##  ambient Exotic 5 - warmed Native 6  -0.90686 0.1522  484.5  -5.957 <.0001
##  ambient Exotic 5 - ambient Native 6 -0.83253 0.1399 1131.4  -5.951 <.0001
##  ambient Exotic 5 - warmed  6         1.00525 0.5532 1130.1   1.817 1.0000
##  ambient Exotic 5 - ambient  6        1.07958 0.5499 1136.1   1.963 0.9998
##  ambient Exotic 5 - warmed Both 6     0.17944 0.1673  604.6   1.073 1.0000
##  ambient Exotic 5 - ambient Both 6    0.25377 0.1537 1132.7   1.651 1.0000
##  ambient Exotic 5 - warmed Exotic 6  -0.13848 0.1307  335.6  -1.059 1.0000
##  ambient Exotic 5 - ambient Exotic 6 -0.06415 0.1171 1126.1  -0.548 1.0000
##  ambient Exotic 5 - warmed Native 7  -0.40541 0.1548  496.8  -2.619 0.9249
##  ambient Exotic 5 - ambient Native 7 -0.33108 0.1431 1132.0  -2.314 0.9904
##  ambient Exotic 5 - warmed  7         1.50670 0.5546 1131.9   2.717 0.8834
##  ambient Exotic 5 - ambient  7        1.58103 0.5514 1135.9   2.867 0.7897
##  ambient Exotic 5 - warmed Both 7     0.68089 0.1741  639.4   3.912 0.0843
##  ambient Exotic 5 - ambient Both 7    0.75522 0.1614 1134.0   4.679 0.0040
##  ambient Exotic 5 - warmed Exotic 7   0.36296 0.1372  378.9   2.646 0.9126
##  ambient Exotic 5 - ambient Exotic 7  0.43729 0.1247 1127.3   3.507 0.2664
##  warmed Native 6 - ambient Native 6   0.07433 0.0629   21.8   1.181 1.0000
##  warmed Native 6 - warmed  6          1.91211 0.5401 1136.1   3.540 0.2449
##  warmed Native 6 - ambient  6         1.98644 0.5437 1120.1   3.654 0.1809
##  warmed Native 6 - warmed Both 6      1.08630 0.1129 1135.0   9.622 <.0001
##  warmed Native 6 - ambient Both 6     1.16063 0.1263  272.6   9.188 <.0001
##  warmed Native 6 - warmed Exotic 6    0.76838 0.0752 1136.1  10.211 <.0001
##  warmed Native 6 - ambient Exotic 6   0.84271 0.0993  119.7   8.491 <.0001
##  warmed Native 6 - warmed Native 7    0.50145 0.1277 1123.2   3.927 0.0782
##  warmed Native 6 - ambient Native 7   0.57578 0.1427  430.1   4.034 0.0579
##  warmed Native 6 - warmed  7          2.41356 0.5557 1135.9   4.343 0.0169
##  warmed Native 6 - ambient  7         2.48789 0.5593 1126.2   4.449 0.0110
##  warmed Native 6 - warmed Both 7      1.58775 0.1748 1131.2   9.082 <.0001
##  warmed Native 6 - ambient Both 7     1.66208 0.1841  705.9   9.030 <.0001
##  warmed Native 6 - warmed Exotic 7    1.26982 0.1513 1128.8   8.391 <.0001
##  warmed Native 6 - ambient Exotic 7   1.34415 0.1649  583.5   8.151 <.0001
##  ambient Native 6 - warmed  6         1.83778 0.5438 1129.0   3.379 0.3584
##  ambient Native 6 - ambient  6        1.91211 0.5401 1136.1   3.540 0.2449
##  ambient Native 6 - warmed Both 6     1.01197 0.1321  332.1   7.659 <.0001
##  ambient Native 6 - ambient Both 6    1.08630 0.1129 1135.0   9.622 <.0001
##  ambient Native 6 - warmed Exotic 6   0.69405 0.0969  116.6   7.161 <.0001
##  ambient Native 6 - ambient Exotic 6  0.76838 0.0752 1136.1  10.211 <.0001
##  ambient Native 6 - warmed Native 7   0.42712 0.1420  412.9   3.008 0.6769
##  ambient Native 6 - ambient Native 7  0.50145 0.1277 1123.2   3.927 0.0782
##  ambient Native 6 - warmed  7         2.33923 0.5592 1132.3   4.183 0.0315
##  ambient Native 6 - ambient  7        2.41356 0.5557 1135.9   4.343 0.0169
##  ambient Native 6 - warmed Both 7     1.51342 0.1875  738.2   8.071 <.0001
##  ambient Native 6 - ambient Both 7    1.58775 0.1748 1131.2   9.082 <.0001
##  ambient Native 6 - warmed Exotic 7   1.19549 0.1629  576.1   7.340 <.0001
##  ambient Native 6 - ambient Exotic 7  1.26982 0.1513 1128.8   8.391 <.0001
##  warmed  6 - ambient  6               0.07433 0.0629   21.8   1.181 1.0000
##  warmed  6 - warmed Both 6           -0.82581 0.5427 1136.1  -1.522 1.0000
##  warmed  6 - ambient Both 6          -0.75148 0.5457 1128.5  -1.377 1.0000
##  warmed  6 - warmed Exotic 6         -1.14374 0.5372 1136.1  -2.129 0.9983
##  warmed  6 - ambient Exotic 6        -1.06941 0.5412 1130.2  -1.976 0.9997
##  warmed  6 - warmed Native 7         -1.41067 0.5543 1136.0  -2.545 0.9515
##  warmed  6 - ambient Native 7        -1.33634 0.5580 1128.5  -2.395 0.9819
##  warmed  6 - warmed  7                0.50145 0.1277 1123.2   3.927 0.0782
##  warmed  6 - ambient  7               0.57578 0.1427  430.1   4.034 0.0579
```

```
##  warmed  6 - warmed Both 7          -0.32436 0.5582 1135.9  -0.581 1.0000
##  warmed  6 - ambient Both 7         -0.25003 0.5612 1128.1  -0.446 1.0000
##  warmed  6 - warmed Exotic 7        -0.64229 0.5523 1136.1  -1.163 1.0000
##  warmed  6 - ambient Exotic 7       -0.56796 0.5563 1129.9  -1.021 1.0000
##  ambient  6 - warmed Both 6         -0.90014 0.5469 1120.8  -1.646 1.0000
##  ambient  6 - ambient Both 6        -0.82581 0.5427 1136.1  -1.522 1.0000
##  ambient  6 - warmed Exotic 6       -1.21806 0.5406 1122.6  -2.253 0.9943
##  ambient  6 - ambient Exotic 6      -1.14374 0.5372 1136.1  -2.129 0.9983
##  ambient  6 - warmed Native 7       -1.48500 0.5577 1119.6  -2.663 0.9091
##  ambient  6 - ambient Native 7      -1.41067 0.5543 1136.0  -2.545 0.9515
##  ambient  6 - warmed  7              0.42712 0.1420  412.9   3.008 0.6769
##  ambient  6 - ambient  7             0.50145 0.1277 1123.2   3.927 0.0782
##  ambient  6 - warmed Both 7         -0.39869 0.5622 1120.2  -0.709 1.0000
##  ambient  6 - ambient Both 7        -0.32436 0.5582 1135.9  -0.581 1.0000
##  ambient  6 - warmed Exotic 7       -0.71662 0.5555 1122.1  -1.290 1.0000
##  ambient  6 - ambient Exotic 7      -0.64229 0.5523 1136.1  -1.163 1.0000
##  warmed Both 6 - ambient Both 6      0.07433 0.0629   21.8   1.181 1.0000
##  warmed Both 6 - warmed Exotic 6    -0.31793 0.1006 1136.1  -3.159 0.5454
##  warmed Both 6 - ambient Exotic 6   -0.24360 0.1227  254.3  -1.985 0.9995
##  warmed Both 6 - warmed Native 7    -0.58486 0.1660 1128.2  -3.524 0.2551
##  warmed Both 6 - ambient Native 7   -0.51053 0.1799  712.3  -2.838 0.8092
##  warmed Both 6 - warmed  7           1.32726 0.5568 1135.9   2.384 0.9834
##  warmed Both 6 - ambient  7          1.40159 0.5611 1126.6   2.498 0.9635
##  warmed Both 6 - warmed Both 7       0.50145 0.1277 1123.2   3.927 0.0782
##  warmed Both 6 - ambient Both 7      0.57578 0.1427  430.1   4.034 0.0579
##  warmed Both 6 - warmed Exotic 7     0.18352 0.1608 1129.5   1.141 1.0000
##  warmed Both 6 - ambient Exotic 7    0.25785 0.1758  671.2   1.467 1.0000
##  ambient Both 6 - warmed Exotic 6   -0.39226 0.1145  199.5  -3.426 0.3359
##  ambient Both 6 - ambient Exotic 6  -0.31793 0.1006 1136.1  -3.159 0.5454
##  ambient Both 6 - warmed Native 7   -0.65919 0.1750  645.2  -3.766 0.1330
##  ambient Both 6 - ambient Native 7  -0.58486 0.1660 1128.2  -3.524 0.2551
##  ambient Both 6 - warmed  7          1.25293 0.5597 1132.0   2.239 0.9950
##  ambient Both 6 - ambient  7         1.32726 0.5568 1135.9   2.384 0.9834
##  ambient Both 6 - warmed Both 7      0.42712 0.1420  412.9   3.008 0.6769
##  ambient Both 6 - ambient Both 7     0.50145 0.1277 1123.2   3.927 0.0782
##  ambient Both 6 - warmed Exotic 7    0.10919 0.1695  611.5   0.644 1.0000
##  ambient Both 6 - ambient Exotic 7   0.18352 0.1608 1129.5   1.141 1.0000
##  warmed Exotic 6 - ambient Exotic 6  0.07433 0.0629   21.8   1.181 1.0000
##  warmed Exotic 6 - warmed Native 7  -0.26693 0.1450 1129.4  -1.841 1.0000
##  warmed Exotic 6 - ambient Native 7 -0.19260 0.1577  547.2  -1.221 1.0000
##  warmed Exotic 6 - warmed  7         1.64518 0.5520 1135.5   2.980 0.7018
##  warmed Exotic 6 - ambient  7        1.71951 0.5554 1128.0   3.096 0.6020
##  warmed Exotic 6 - warmed Both 7     0.81937 0.1643 1132.7   4.986 0.0010
##  warmed Exotic 6 - ambient Both 7    0.89370 0.1735  638.9   5.152 0.0005
##  warmed Exotic 6 - warmed Exotic 7   0.50145 0.1277 1123.2   3.927 0.0782
##  warmed Exotic 6 - ambient Exotic 7  0.57578 0.1427  430.1   4.034 0.0579
##  ambient Exotic 6 - warmed Native 7 -0.34126 0.1585  521.7  -2.153 0.9976
##  ambient Exotic 6 - ambient Native 7 -0.26693 0.1450 1129.4  -1.841 1.0000
##  ambient Exotic 6 - warmed  7        1.57085 0.5558 1133.1   2.826 0.8181
##  ambient Exotic 6 - ambient  7       1.64518 0.5520 1135.5   2.980 0.7018
##  ambient Exotic 6 - warmed Both 7    0.74504 0.1784  665.1   4.175 0.0336
##  ambient Exotic 6 - ambient Both 7   0.81937 0.1643 1132.7   4.986 0.0010
##  ambient Exotic 6 - warmed Exotic 7  0.42712 0.1420  412.9   3.008 0.6769
##  ambient Exotic 6 - ambient Exotic 7 0.50145 0.1277 1123.2   3.927 0.0782
```

```
##  warmed Native 7 - ambient Native 7   0.07433 0.0629   21.8   1.181 1.0000
##  warmed Native 7 - warmed  7          1.91211 0.5401 1136.1   3.540 0.2449
##  warmed Native 7 - ambient  7         1.98644 0.5437 1120.1   3.654 0.1809
##  warmed Native 7 - warmed Both 7      1.08630 0.1129 1135.0   9.622 <.0001
##  warmed Native 7 - ambient Both 7     1.16063 0.1263  272.6   9.188 <.0001
##  warmed Native 7 - warmed Exotic 7    0.76838 0.0752 1136.1  10.211 <.0001
##  warmed Native 7 - ambient Exotic 7   0.84271 0.0993  119.7   8.491 <.0001
##  ambient Native 7 - warmed  7         1.83778 0.5438 1129.0   3.379 0.3584
##  ambient Native 7 - ambient  7        1.91211 0.5401 1136.1   3.540 0.2449
##  ambient Native 7 - warmed Both 7     1.01197 0.1321  332.1   7.659 <.0001
##  ambient Native 7 - ambient Both 7    1.08630 0.1129 1135.0   9.622 <.0001
##  ambient Native 7 - warmed Exotic 7   0.69405 0.0969  116.6   7.161 <.0001
##  ambient Native 7 - ambient Exotic 7  0.76838 0.0752 1136.1  10.211 <.0001
##  warmed  7 - ambient  7               0.07433 0.0629   21.8   1.181 1.0000
##  warmed  7 - warmed Both 7           -0.82581 0.5427 1136.1  -1.522 1.0000
##  warmed  7 - ambient Both 7          -0.75148 0.5457 1128.5  -1.377 1.0000
##  warmed  7 - warmed Exotic 7         -1.14374 0.5372 1136.1  -2.129 0.9983
##  warmed  7 - ambient Exotic 7        -1.06941 0.5412 1130.2  -1.976 0.9997
##  ambient  7 - warmed Both 7          -0.90014 0.5469 1120.8  -1.646 1.0000
##  ambient  7 - ambient Both 7         -0.82581 0.5427 1136.1  -1.522 1.0000
##  ambient  7 - warmed Exotic 7        -1.21806 0.5406 1122.6  -2.253 0.9943
##  ambient  7 - ambient Exotic 7       -1.14374 0.5372 1136.1  -2.129 0.9983
##  warmed Both 7 - ambient Both 7       0.07433 0.0629   21.8   1.181 1.0000
##  warmed Both 7 - warmed Exotic 7     -0.31793 0.1006 1136.1  -3.159 0.5454
##  warmed Both 7 - ambient Exotic 7    -0.24360 0.1227  254.3  -1.985 0.9995
##  ambient Both 7 - warmed Exotic 7    -0.39226 0.1145  199.5  -3.426 0.3359
##  ambient Both 7 - ambient Exotic 7   -0.31793 0.1006 1136.1  -3.159 0.5454
##  warmed Exotic 7 - ambient Exotic 7   0.07433 0.0629   21.8   1.181 1.0000
##
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## P value adjustment: tukey method for comparing a family of 56 estimates
```

```
emmeans(mod9a, list(pairwise ~ origin), adjust = "tukey")
```

```
## boundary (singular) fit: see ?isSingular
```

```
## $`emmeans of origin`
##  origin emmean     SE     df lower.CL upper.CL
##  Native   3.01 0.0651  322.6    2.886     3.14
##           1.10 0.5339 1135.6    0.054     2.15
##  Both     1.93 0.0933  689.5    1.744     2.11
##  Exotic   2.25 0.0406   56.8    2.164     2.33
##
## Results are averaged over the levels of: state, year_factor
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
## $`pairwise differences of origin`
##  1               estimate     SE   df t.ratio p.value
##  Native -           1.912 0.5401 1136  3.540  0.0023
##  Native - Both      1.086 0.1129 1135  9.622  <.0001
```

```
##  Native - Exotic    0.768 0.0752 1136 10.211  <.0001
##   - Both           -0.826 0.5427 1136 -1.522  0.4247
##   - Exotic         -1.144 0.5372 1136 -2.129  0.1445
##  Both - Exotic     -0.318 0.1006 1136 -3.159  0.0088
##
## Results are averaged over the levels of: state, year_factor
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## P value adjustment: tukey method for comparing a family of 4 estimates
```

```
emmeans(mod9a, list(pairwise ~ year_factor), adjust = "tukey")
```

```
## boundary (singular) fit: see ?isSingular
```

```
## $`emmeans of year_factor`
##  year_factor emmean    SE   df lower.CL upper.CL
##            1   0.97 0.159 1090    0.658     1.28
##            2   2.50 0.152 1047    2.200     2.79
##            3   2.55 0.156 1062    2.249     2.86
##            4   2.63 0.156 1062    2.325     2.94
##            5   2.07 0.158 1072    1.764     2.38
##            6   2.14 0.160 1060    1.824     2.45
##            7   1.64 0.166 1082    1.311     1.96
##
## Results are averaged over the levels of: state, origin
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
## $`pairwise differences of year_factor`
##  1     estimate    SE   df t.ratio p.value
##  1 - 2  -1.5269 0.138 1132 -11.025 <.0001
##  1 - 3  -1.5841 0.143 1133 -11.076 <.0001
##  1 - 4  -1.6608 0.142 1134 -11.696 <.0001
##  1 - 5  -1.1039 0.145 1129  -7.619 <.0001
##  1 - 6  -1.1681 0.147 1133  -7.927 <.0001
##  1 - 7  -0.6666 0.154 1132  -4.334 0.0003
##  2 - 3  -0.0572 0.104 1126  -0.550 0.9980
##  2 - 4  -0.1339 0.103 1124  -1.306 0.8492
##  2 - 5   0.4229 0.106 1130   3.975 0.0015
##  2 - 6   0.3588 0.110 1131   3.265 0.0193
##  2 - 7   0.8602 0.118 1134   7.269 <.0001
##  3 - 4  -0.0767 0.108 1120  -0.708 0.9921
##  3 - 5   0.4802 0.112 1130   4.285 0.0004
##  3 - 6   0.4160 0.115 1135   3.604 0.0060
##  3 - 7   0.9175 0.123 1136   7.430 <.0001
##  4 - 5   0.5568 0.110 1127   5.057 <.0001
##  4 - 6   0.4927 0.114 1133   4.337 0.0003
##  4 - 7   0.9941 0.122 1135   8.167 <.0001
##  5 - 6  -0.0642 0.117 1126  -0.548 0.9981
##  5 - 7   0.4373 0.125 1127   3.507 0.0085
##  6 - 7   0.5014 0.128 1123   3.927 0.0018
##
```

```
## Results are averaged over the levels of: state, origin
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## P value adjustment: tukey method for comparing a family of 7 estimates
```

```
# including growth form - first with interaction term
kbs_flwr_spp <- within(kbs_flwr_spp, growth_habit <- relevel(factor(growth_habit),
    ref = "Forb"))  # releveling so forb is the reference
mod10 <- lmer(log(flwr_duration_scaled) ~ state * growth_habit + (1 + factor(year_factor) |
    plot), kbs_flwr_spp, REML = FALSE)
```

```
## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
## boundary (singular) fit: see ?isSingular
```

```
mod11 <- lmer(log(flwr_duration_scaled) ~ state + growth_habit + (1 + factor(year_factor) |
    plot), kbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod11a <- lmer(log(flwr_duration_scaled) ~ state + growth_habit + factor(year_factor) +
    (1 | plot), kbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
anova(mod10, mod11)  # model 11 is a better fit to data
```

```
## Data: kbs_flwr_spp
## Models:
## mod11: log(flwr_duration_scaled) ~ state + growth_habit + (1 + factor(year_factor) |
## mod11:     plot)
## mod10: log(flwr_duration_scaled) ~ state * growth_habit + (1 + factor(year_factor) |
## mod10:     plot)
##       npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## mod11   34 3460.0 3630.9 -1696.0   3392.0
## mod10   36 3462.3 3643.2 -1695.1   3390.3 1.7175  2     0.4237
```

```
anova(mod11, mod11a)  # model 11a is still a better fit to data
```

```
## Data: kbs_flwr_spp
## Models:
## mod11a: log(flwr_duration_scaled) ~ state + growth_habit + factor(year_factor) +
## mod11a:     (1 | plot)
## mod11: log(flwr_duration_scaled) ~ state + growth_habit + (1 + factor(year_factor) |
## mod11:     plot)
##        npar  AIC    BIC logLik deviance Chisq Df Pr(>Chisq)
## mod11a   13 3368 3433.3  -1671     3342
## mod11    34 3460 3630.9  -1696     3392     0 21          1
```

```
summary(mod11a)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula:
## log(flwr_duration_scaled) ~ state + growth_habit + factor(year_factor) +
##     (1 | plot)
##    Data: kbs_flwr_spp
##
##      AIC      BIC   logLik deviance df.resid
##   3368.0   3433.3  -1671.0   3342.0     1112
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.0791 -0.4005  0.2601  0.6315  2.4887
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  plot     (Intercept) 0.000    0.000
##  Residual             1.142    1.069
## Number of obs: 1125, groups:  plot, 24
##
## Fixed effects:
##                          Estimate Std. Error         df t value Pr(>|t|)
## (Intercept)               1.44014    0.12652 1125.00000  11.383  < 2e-16 ***
## stateambient             -0.10780    0.06432 1125.00000  -1.676    0.094 .
## growth_habit             -0.62455    0.10854 1125.00000  -5.754 1.12e-08 ***
## growth_habitForb/herb    -2.41091    1.07424 1125.00000  -2.244    0.025 *
## growth_habitGraminoid    -0.49957    0.06900 1125.00000  -7.240 8.28e-13 ***
## factor(year_factor)2      1.69267    0.13918 1125.00000  12.162  < 2e-16 ***
## factor(year_factor)3      1.71160    0.14384 1125.00000  11.899  < 2e-16 ***
## factor(year_factor)4      1.85033    0.14355 1125.00000  12.890  < 2e-16 ***
## factor(year_factor)5      1.34643    0.14663 1125.00000   9.183  < 2e-16 ***
## factor(year_factor)6      1.43330    0.14968 1125.00000   9.575  < 2e-16 ***
## factor(year_factor)7      0.97077    0.15558 1125.00000   6.240 6.19e-10 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) sttmbn grwth_ grw_F/ grwt_G fc(_)2 fc(_)3 fc(_)4 fc(_)5
## stateambint -0.245
## growth_habt -0.176 -0.040
## grwth_hbtF/ -0.014  0.031  0.013
## grwth_hbtGr -0.185  0.075  0.293  0.036
## fctr(yr_f)2 -0.791 -0.036 -0.018 -0.003 -0.068
## fctr(yr_f)3 -0.774 -0.038  0.029 -0.002 -0.046  0.717
## fctr(yr_f)4 -0.764 -0.048  0.034 -0.005 -0.123  0.724  0.701
## fctr(yr_f)5 -0.747 -0.054  0.038 -0.005 -0.120  0.709  0.687  0.700
## fctr(yr_f)6 -0.732 -0.024  0.012 -0.005 -0.148  0.696  0.673  0.687  0.673
## fctr(yr_f)7 -0.717 -0.016  0.050 -0.060 -0.100  0.666  0.646  0.658  0.644
##             fc(_)6
## stateambint
## growth_habt
```

```
## grwth_hbtF/
## grwth_hbtGr
## fctr(yr_f)2
## fctr(yr_f)3
## fctr(yr_f)4
## fctr(yr_f)5
## fctr(yr_f)6
## fctr(yr_f)7  0.633
## optimizer (nloptwrap) convergence code: 0 (OK)
## boundary (singular) fit: see ?isSingular
```

```
anova(mod11a)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##                      Sum Sq Mean Sq NumDF DenDF F value    Pr(>F)
## state                 3.208   3.208     1  1125  2.8093   0.09399 .
## growth_habit         80.775  26.925     3  1125 23.5773 8.396e-15 ***
## factor(year_factor) 252.838  42.140     6  1125 36.9005 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
emmeans(mod11a, list(pairwise ~ factor(year_factor)), adjust = "tukey")
```

```
## boundary (singular) fit: see ?isSingular
```

```
## $`emmeans of year_factor`
##  year_factor emmean    SE   df lower.CL upper.CL
##            1  0.502 0.296 1130  -0.0787     1.08
##            2  2.195 0.279 1129   1.6469     2.74
##            3  2.214 0.282 1123   1.6603     2.77
##            4  2.353 0.282 1127   1.8003     2.91
##            5  1.849 0.283 1128   1.2933     2.40
##            6  1.936 0.285 1130   1.3774     2.49
##            7  1.473 0.280 1126   0.9242     2.02
##
## Results are averaged over the levels of: state, growth_habit
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
## $`pairwise differences of year_factor`
##  1     estimate    SE   df t.ratio p.value
##  1 - 2  -1.6927 0.140 1130 -12.092 <.0001
##  1 - 3  -1.7116 0.145 1132 -11.830 <.0001
##  1 - 4  -1.8503 0.144 1133 -12.813 <.0001
##  1 - 5  -1.3464 0.147 1129  -9.130 <.0001
##  1 - 6  -1.4333 0.151 1132  -9.518 <.0001
##  1 - 7  -0.9708 0.157 1133  -6.203 <.0001
##  2 - 3  -0.0189 0.107 1126  -0.177 1.0000
##  2 - 4  -0.1577 0.106 1124  -1.492 0.7496
##  2 - 5   0.3462 0.110 1130   3.152 0.0277
##  2 - 6   0.2594 0.114 1132   2.280 0.2546
```

```
##  2 - 7   0.7219 0.122 1134   5.914 <.0001
##  3 - 4  -0.1387 0.112 1121  -1.243 0.8773
##  3 - 5   0.3652 0.116 1131   3.158 0.0271
##  3 - 6   0.2783 0.120 1135   2.326 0.2323
##  3 - 7   0.7408 0.127 1136   5.823 <.0001
##  4 - 5   0.5039 0.113 1127   4.456 0.0002
##  4 - 6   0.4170 0.117 1133   3.570 0.0068
##  4 - 7   0.8796 0.125 1135   7.035 <.0001
##  5 - 6  -0.0869 0.121 1126  -0.721 0.9914
##  5 - 7   0.3757 0.128 1127   2.925 0.0542
##  6 - 7   0.4625 0.132 1122   3.514 0.0083
##
## Results are averaged over the levels of: state, growth_habit
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## P value adjustment: tukey method for comparing a family of 7 estimates
```

```
emmeans(mod11a, list(pairwise ~ growth_habit), adjust = "tukey")
```

```
## boundary (singular) fit: see ?isSingular

## $`emmeans of growth_habit`
##  growth_habit emmean     SE   df lower.CL upper.CL
##  Forb          2.673 0.0493  105     2.57     2.77
##                2.048 0.0992  732     1.85     2.24
##  Forb/herb     0.262 1.0800 1136    -1.86     2.38
##  Graminoid     2.173 0.0504  118     2.07     2.27
##
## Results are averaged over the levels of: state, year_factor
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
## $`pairwise differences of growth_habit`
##  1                       estimate     SE   df t.ratio p.value
##  Forb -                     0.625 0.1092 1135  5.719  <.0001
##  Forb - (Forb/herb)         2.411 1.0815 1136  2.229  0.1160
##  Forb - Graminoid           0.500 0.0695 1134  7.188  <.0001
##   - (Forb/herb)             1.786 1.0855 1136  1.646  0.3534
##   - Graminoid              -0.125 0.1110 1135 -1.126  0.6734
##  (Forb/herb) - Graminoid   -1.911 1.0811 1136 -1.768  0.2894
##
## Results are averaged over the levels of: state, year_factor
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## P value adjustment: tukey method for comparing a family of 4 estimates
```

```
# New version of our model incorporating interaction term and species within year
# so that there is a separate intercept and slope for each species. The issue
# here is that there are some species that are not found each year. Easiest to
# remove those from another version of this dataframe before running below.
# Otherwise, it's not a balanced design.  updated mod4
mod12 <- lmer(log(flwr_duration_scaled) ~ state * factor(year_factor) + (1 + factor(year_factor) |
    species), kbs_flwr_spp)
```

```
## boundary (singular) fit: see ?isSingular
```

```
# So another version of this model would include the interaction but not include
# the nesting (and thus would assume that species aren't observed ea yr) updated
# mod5
mod13 <- lmer(log(flwr_duration_scaled) ~ state * factor(year_factor) + (1 | species),
    kbs_flwr_spp)

# All the models ran:
mod1 <- lmer(log(flwr_duration_scaled) ~ state * year_factor + insecticide * year_factor +
    (1 | species) + (1 | plot), kbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod2 <- lmer(log(flwr_duration_scaled) ~ state * year_factor + insecticide * year_factor +
    (1 | species), kbs_flwr_spp, REML = FALSE)
mod3 <- lmer(log(flwr_duration_scaled) ~ state * year_factor + (1 | species), kbs_flwr_spp,
    REML = FALSE)
mod4 <- lmer(log(flwr_duration_scaled) ~ state * year_factor + insecticide + (1 |
    species) + (1 | plot), kbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod5 <- lmer(log(flwr_duration_scaled) ~ state + year_factor + (1 | species), kbs_flwr_spp,
    REML = FALSE)
mod6 <- lmer(log(flwr_duration_scaled) ~ state + year_factor + (1 | species) + (1 +
    year | plot), kbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod7 <- lmer(log(flwr_duration_scaled) ~ state + species + (1 + factor(year_factor) |
    plot), kbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod7a <- lmer(log(flwr_duration_scaled) ~ state + species + factor(year_factor) +
    (1 | plot), kbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod7b <- lmer(log(flwr_duration_scaled) ~ state * factor(year_factor) + species +
    (1 | plot), kbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod7c <- lmer(log(flwr_duration_scaled) ~ state + species + factor(year_factor) +
    insecticide + (1 | plot), kbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod8 <- lmer(log(flwr_duration_scaled) ~ state * origin + (1 + factor(year_factor) |
    plot), kbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod9 <- lmer(log(flwr_duration_scaled) ~ state + origin + (1 + factor(year_factor) |
    plot), kbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod9a <- lmer(log(flwr_duration_scaled) ~ state + origin + factor(year_factor) +
    (1 | plot), kbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod10 <- lmer(log(flwr_duration_scaled) ~ state * growth_habit + (1 + factor(year_factor) |
    plot), kbs_flwr_spp, REML = FALSE)
```

```
## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
## boundary (singular) fit: see ?isSingular
```

```
mod11 <- lmer(log(flwr_duration_scaled) ~ state + growth_habit + (1 + factor(year_factor) |
    plot), kbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod11a <- lmer(log(flwr_duration_scaled) ~ state + growth_habit + factor(year_factor) +
    (1 | plot), kbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod12 <- lmer(log(flwr_duration_scaled) ~ state * factor(year_factor) + (1 + factor(year_factor) |
    species), kbs_flwr_spp, REML = FALSE)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, :
## Model failed to converge with max|grad| = 0.00608627 (tol = 0.002, component 1)
```

```
# mod13 <- lmer(log(flwr_duration_scaled) ~ state * factor(year_factor) +
# (1|species), kbs_flwr_spp, REML=FALSE)
AICctab(mod1, mod2, mod3, mod5, mod7, mod7a, mod7b, mod7c, mod8, mod9, mod9a, mod10,
    mod11, mod11a, mod12, mod13, weights = T)  # mod7a is the best fitting model (took out mod12 bc it
```

```
## Error in ICtab(..., mnames = mnames, type = "AICc"): nobs different: must have identical data for al
```

```
# not sure why the above code wont work - all the data looks identical to me
# despite what error says??
summary(mod7a)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: log(flwr_duration_scaled) ~ state + species + factor(year_factor) +
##     (1 | plot)
##    Data: kbs_flwr_spp
##
##      AIC      BIC   logLik deviance df.resid
##   3199.6   3411.6  -1557.8   3115.6     1109
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.6381 -0.3669  0.1663  0.5936  2.8919
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  plot     (Intercept) 0.0000   0.0000
##  Residual             0.8772   0.9366
## Number of obs: 1151, groups:  plot, 24
##
## Fixed effects:
##                       Estimate Std. Error         df t value Pr(>|t|)
## (Intercept)            1.37159    0.16646 1151.00000   8.240 4.65e-16 ***
## stateambient          -0.02860    0.05754 1151.00000  -0.497 0.619258
## speciesArel           -0.92604    0.16877 1151.00000  -5.487 5.03e-08 ***
## speciesAspi           -1.37385    0.40594 1151.00000  -3.384 0.000737 ***
## speciesAssp           -2.39186    0.33958 1151.00000  -7.044 3.22e-12 ***
## speciesBavu           -0.56878    0.30029 1151.00000  -1.894 0.058463 .
## speciesCahi           -1.11291    0.24634 1151.00000  -4.518 6.89e-06 ***
## speciesCest            0.11516    0.16872 1151.00000   0.683 0.495036
## speciesDaca           -0.14226    0.23258 1151.00000  -0.612 0.540895
## speciesDagl           -0.81921    0.17977 1151.00000  -4.557 5.74e-06 ***
## speciesDlre           -3.43605    0.94731 1151.00000  -3.627 0.000299 ***
## speciesElre           -0.58567    0.16696 1151.00000  -3.508 0.000469 ***
## speciesEugr            0.02179    0.18744 1151.00000   0.116 0.907472
## speciesHisp           -1.17902    0.16935 1151.00000  -6.962 5.63e-12 ***
## speciesHype           -0.05845    0.20898 1151.00000  -0.280 0.779767
## speciesLapu           -2.51215    0.95033 1151.00000  -2.643 0.008318 **
## speciesLesp           -1.24721    0.94810 1151.00000  -1.315 0.188611
## speciesPhpr           -0.68003    0.15614 1151.00000  -4.355 1.45e-05 ***
## speciesPoco           -0.91746    0.18682 1151.00000  -4.911 1.04e-06 ***
## speciesPopr           -0.52308    0.15310 1151.00000  -3.417 0.000656 ***
## speciesPore           -1.02770    0.18212 1151.00000  -5.643 2.10e-08 ***
## speciesPosp           -1.35729    0.49611 1151.00000  -2.736 0.006317 **
## speciesRusp           -1.12566    0.25520 1151.00000  -4.411 1.13e-05 ***
## speciesSila            0.22187    0.94706 1151.00000   0.234 0.814814
## speciesSoca            0.37146    0.15097 1151.00000   2.461 0.014019 *
## speciesSoga           -3.53550    0.67748 1151.00000  -5.219 2.14e-07 ***
## speciesSogr           -0.27801    0.32506 1151.00000  -0.855 0.392575
## speciesSora           -0.50070    0.37997 1151.00000  -1.318 0.187849
## speciesSyla           -2.48355    0.94999 1151.00000  -2.614 0.009058 **
## speciesSypi           -1.08779    0.25955 1151.00000  -4.191 2.99e-05 ***
## speciesSyur            0.46089    0.94999 1151.00000   0.485 0.627662
## speciesTaof           -2.03824    0.28063 1151.00000  -7.263 6.96e-13 ***
## speciesTrsp            0.11860    0.21049 1151.00000   0.563 0.573252
```

```
## speciesVear            -3.47862    0.67519 1151.00000  -5.152 3.03e-07 ***
## factor(year_factor)2    1.87227    0.13083 1151.00000  14.311  < 2e-16 ***
## factor(year_factor)3    2.06446    0.13882 1151.00000  14.872  < 2e-16 ***
## factor(year_factor)4    2.17821    0.13884 1151.00000  15.689  < 2e-16 ***
## factor(year_factor)5    1.59855    0.14194 1151.00000  11.262  < 2e-16 ***
## factor(year_factor)6    1.62751    0.14448 1151.00000  11.265  < 2e-16 ***
## factor(year_factor)7    1.14056    0.15036 1151.00000   7.586 6.79e-14 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 40 > 12.
## Use print(x, correlation=TRUE)  or
##     vcov(x)        if you need it

## optimizer (nloptwrap) convergence code: 0 (OK)
## boundary (singular) fit: see ?isSingular
```

```
anova(mod7a)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##                      Sum Sq Mean Sq NumDF DenDF F value Pr(>F)
## state                  0.22   0.217     1  1151   0.247 0.6193
## species              396.26  12.383    32  1151  14.117 <2e-16 ***
## factor(year_factor) 292.34  48.723     6  1151  55.543 <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

KBS Plot-level Mixed Effects Models:

```
mod1p <- lmer(flwr_duration_scaled ~ state + (1 | plot), kbs_flwr_plot, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod2p <- lmer(flwr_duration_scaled ~ insecticide + (1 | plot), kbs_flwr_plot, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod3p <- lmer(flwr_duration_scaled ~ insecticide + state + (1 | plot), kbs_flwr_plot,
    REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod4p <- lmer(flwr_duration_scaled ~ insecticide * state + (1 | plot), kbs_flwr_plot,
    REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod5p <- lmer(flwr_duration_scaled ~ state + year_factor + (1 | plot), kbs_flwr_plot,
    REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod6p <- lmer(flwr_duration_scaled ~ state + year_factor + insecticide + (1 | plot),
    kbs_flwr_plot, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod7p <- lmer(flwr_duration_scaled ~ state * year_factor + (1 | plot), kbs_flwr_plot,
    REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod8p <- lmer(flwr_duration_scaled ~ state * year_factor + insecticide + (1 | plot),
    kbs_flwr_plot, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod9p <- lmer(flwr_duration_scaled ~ state * insecticide + year_factor + (1 | plot),
    kbs_flwr_plot, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod10p <- lmer(flwr_duration_scaled ~ state + insecticide * year_factor + (1 | plot),
    kbs_flwr_plot, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod11p <- lmer(flwr_duration_scaled ~ state * year_factor * insecticide + (1 | plot),
    kbs_flwr_plot, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
AICctab(mod1p, mod2p, mod3p, mod4p, mod5p, mod6p, mod7p, mod8p, mod9p, mod10p, mod11p,
    weights = T)  # model 5p and 7p are the top models
```

```
##        dAICc df weight
## mod1p   0.0  4  0.2797
## mod2p   0.1  4  0.2613
## mod3p   1.5  5  0.1324
## mod5p   1.8  5  0.1114
## mod4p   3.3  6  0.0532
## mod6p   3.4  6  0.0524
## mod7p   3.7  6  0.0450
## mod8p   5.2  7  0.0210
## mod10p  5.2  7  0.0209
## mod9p   5.2  7  0.0207
## mod11p  9.8  10 0.0021
```

```r
anova(mod1p, mod2p)  # go with 1p
```

```
## Data: kbs_flwr_plot
## Models:
## mod1p: flwr_duration_scaled ~ state + (1 | plot)
## mod2p: flwr_duration_scaled ~ insecticide + (1 | plot)
##       npar    AIC    BIC  logLik deviance Chisq Df Pr(>Chisq)
## mod1p    4 1156.4 1168.9 -574.22   1148.4
## mod2p    4 1156.6 1169.0 -574.29   1148.6     0  0
```

```r
AICctab(mod1p, mod2p, weights = T)
```

```
##       dAICc df weight
## mod1p 0.0   4  0.52
## mod2p 0.1   4  0.48
```

```r
summ(mod1p)
```

Observations	166
Dependent variable	flwr_duration_scaled
Type	Mixed effects linear regression

AIC	1156.44
BIC	1168.89
Pseudo-R^2 (fixed effects)	0.00
Pseudo-R^2 (total)	0.00

Fixed Effects

	Est.	S.E.	t val.	d.f.	p
(Intercept)	19.41	0.84	23.12	166.00	0.00
stateambient	-1.03	1.19	-0.87	166.00	0.39

p values calculated using Satterthwaite d.f.

Random Effects

Group	Parameter	Std. Dev.
plot	(Intercept)	0.00
Residual		7.69

Grouping Variables

Group	# groups	ICC
plot	24	0.00

```
summary(mod1p)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: flwr_duration_scaled ~ state + (1 | plot)
##    Data: kbs_flwr_plot
##
##      AIC      BIC   logLik deviance df.resid
##   1156.4   1168.9   -574.2   1148.4      162
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.3931 -0.6294 -0.0344  0.6491  3.5003
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  plot     (Intercept)  0.00    0.000
##  Residual             59.17    7.692
## Number of obs: 166, groups:  plot, 24
##
## Fixed effects:
##              Estimate Std. Error       df t value Pr(>|t|)
## (Intercept)   19.4082     0.8393 166.0000  23.124   <2e-16 ***
## stateambient  -1.0335     1.1942 166.0000  -0.865    0.388
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr)
## stateambint -0.703
## optimizer (nloptwrap) convergence code: 0 (OK)
## boundary (singular) fit: see ?isSingular
```

```
emmeans(mod1p, list(pairwise ~ state), adjust = "tukey")
```

```
## boundary (singular) fit: see ?isSingular

## $`emmeans of state`
##  state   emmean    SE   df lower.CL upper.CL
##  warmed    19.4 0.844 22.1     17.7     21.2
##  ambient   18.4 0.855 22.9     16.6     20.1
##
## Degrees-of-freedom method: kenward-roger
## Confidence level used: 0.95
##
## $`pairwise differences of state`
##  1                estimate  SE   df t.ratio p.value
##  warmed - ambient     1.03 1.2 22.5 0.860   0.3989
##
## Degrees-of-freedom method: kenward-roger
```

```
# including native vs. exotic
kbs_flwr_plot_origin <- within(kbs_flwr_plot_origin, origin <- relevel(factor(origin),
    ref = "Native"))  # releveling so native is the reference
mod12p <- lmer(log(flwr_duration_scaled) ~ state * origin + (1 + year_factor | plot),
    kbs_flwr_plot_origin, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod13p <- lmer(log(flwr_duration_scaled) ~ state + origin + (1 + year_factor | plot),
    kbs_flwr_plot_origin, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod14p <- lmer(log(flwr_duration_scaled) ~ state + origin + year_factor + (1 | plot),
    kbs_flwr_plot_origin, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
anova(mod12p, mod13p)  # go with model 13p
```

```
## Data: kbs_flwr_plot_origin
## Models:
## mod13p: log(flwr_duration_scaled) ~ state + origin + (1 + year_factor |
## mod13p:     plot)
## mod12p: log(flwr_duration_scaled) ~ state * origin + (1 + year_factor |
## mod12p:     plot)
##        npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## mod13p    9 1117.5 1153.8 -549.76   1099.5
## mod12p   12 1122.1 1170.6 -549.07   1098.1 1.3693  3     0.7127
```

```
anova(mod13p, mod14p)
```

```
## Data: kbs_flwr_plot_origin
## Models:
## mod14p: log(flwr_duration_scaled) ~ state + origin + year_factor + (1 |
## mod14p:     plot)
## mod13p: log(flwr_duration_scaled) ~ state + origin + (1 + year_factor |
## mod13p:     plot)
##        npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## mod14p    8 1119.0 1151.3 -551.49   1103.0
## mod13p    9 1117.5 1153.8 -549.76   1099.5 3.4706  1    0.06247 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
AICctab(mod12p, mod13p, mod14p, weights = T)  #model 13p
```

```
##        dAICc df weight
## mod13p  0.0  9  0.631
## mod14p  1.4  8  0.316
## mod12p  5.0  12 0.053
```

```
summary(mod13p)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: log(flwr_duration_scaled) ~ state + origin + (1 + year_factor |
##     plot)
##    Data: kbs_flwr_plot_origin
##
##      AIC      BIC   logLik deviance df.resid
##   1117.5   1153.8   -549.8   1099.5      409
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.7485 -0.2247  0.2478  0.5773  1.6953
##
## Random effects:
##  Groups   Name        Variance Std.Dev. Corr
##  plot     (Intercept) 0.154078 0.39253
##           year_factor 0.006986 0.08358  -1.00
##  Residual             0.789002 0.88826
## Number of obs: 418, groups:  plot, 24
##
## Fixed effects:
##               Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)    3.22579    0.08556 313.11578  37.701  < 2e-16 ***
## statewarmed    0.06766    0.08999 157.86035   0.752    0.453
## origin        -3.18654    0.46589 397.11655  -6.840 3.01e-11 ***
## originBoth    -1.14030    0.11709 407.95495  -9.738  < 2e-16 ***
## originExotic  -0.73756    0.09965 396.96556  -7.402 8.11e-13 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) sttwrm origin orgnBt
## statewarmed -0.540
## origin      -0.128  0.007
## originBoth  -0.551  0.083  0.105
## originExotc -0.604  0.008  0.116  0.443
## optimizer (nloptwrap) convergence code: 0 (OK)
## boundary (singular) fit: see ?isSingular
```

```
summ(mod13p)
```

```
## Warning in summ.merMod(mod13p): Could not calculate r-squared. Try removing missing data
## before fitting the model.
```

Observations	418
Dependent variable	log(flwr_duration_scaled)
Type	Mixed effects linear regression

AIC	1117.51
BIC	1153.83

Fixed Effects					
	Est.	S.E.	t val.	d.f.	p
(Intercept)	3.23	0.09	37.70	313.12	0.00
statewarmed	0.07	0.09	0.75	157.86	0.45
origin	-3.19	0.47	-6.84	397.12	0.00
originBoth	-1.14	0.12	-9.74	407.95	0.00
originExotic	-0.74	0.10	-7.40	396.97	0.00

p values calculated using Satterthwaite d.f.

Random Effects		
Group	Parameter	Std. Dev.
plot	(Intercept)	0.39
plot	year_factor	0.08
Residual		0.89

Grouping Variables		
Group	# groups	ICC
plot	24	0.16

```
anova(mod13p)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##         Sum Sq Mean Sq NumDF  DenDF F value Pr(>F)
## state    0.446   0.446     1 157.86  0.5653 0.4533
## origin 108.918  36.306     3 400.53 46.0149 <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
emmeans(mod13p, list(pairwise ~ state), adjust = "tukey")
```

```
## boundary (singular) fit: see ?isSingular
```

```
## $`emmeans of state`
##  state   emmean    SE  df lower.CL upper.CL
##  ambient   1.96 0.132 201     1.70     2.22
##  warmed    2.03 0.134 213     1.76     2.29
##
## Results are averaged over the levels of: origin
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
## $`pairwise differences of state`
##  1               estimate     SE   df t.ratio p.value
```

```
##  ambient - warmed  -0.0677 0.0954 22.8 -0.710  0.4852
##
## Results are averaged over the levels of: origin
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
```

```
emmeans(mod13p, list(pairwise ~ origin), adjust = "tukey")
```

```
## boundary (singular) fit: see ?isSingular
```

```
## $`emmeans of origin`
##  origin emmean     SE  df lower.CL upper.CL
##  Native 3.2596 0.0739 129    3.113    3.406
##         0.0731 0.4704 375   -0.852    0.998
##  Both   2.1193 0.0960 216    1.930    2.309
##  Exotic 2.5221 0.0717 119    2.380    2.664
##
## Results are averaged over the levels of: state
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
## $`pairwise differences of origin`
##  1               estimate    SE  df t.ratio p.value
##  Native -           3.187 0.475 386  6.704  <.0001
##  Native - Both      1.140 0.119 408  9.618  <.0001
##  Native - Exotic    0.738 0.100 380  7.354  <.0001
##   - Both           -2.046 0.478 390 -4.284  0.0001
##   - Exotic         -2.449 0.474 388 -5.164  <.0001
##  Both - Exotic     -0.403 0.117 405 -3.451  0.0034
##
## Results are averaged over the levels of: state
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## P value adjustment: tukey method for comparing a family of 4 estimates
```

```
# including growth form - first with interaction term
kbs_flwr_plot_growthhabit <- within(kbs_flwr_plot_growthhabit, growth_habit <- relevel(factor(growth_hal
    ref = "Forb"))  # releveling so forb is the reference
mod15p <- lmer(log(flwr_duration_scaled) ~ state * growth_habit + (1 + year_factor |
    plot), kbs_flwr_plot_growthhabit, REML = FALSE)
```

```
## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
## boundary (singular) fit: see ?isSingular
```

```
mod16p <- lmer(log(flwr_duration_scaled) ~ state + growth_habit + (1 + year_factor |
    plot), kbs_flwr_plot_growthhabit, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod17p <- lmer(log(flwr_duration_scaled) ~ state + growth_habit + year_factor + (1 |
    plot), kbs_flwr_plot_growthhabit, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
anova(mod15p, mod16p)  # go with model 16p
```

```
## Data: kbs_flwr_plot_growthhabit
## Models:
## mod16p: log(flwr_duration_scaled) ~ state + growth_habit + (1 + year_factor |
## mod16p:     plot)
## mod15p: log(flwr_duration_scaled) ~ state * growth_habit + (1 + year_factor |
## mod15p:     plot)
##        npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## mod16p    9 1166.1 1202.4 -574.07   1148.1
## mod15p   11 1168.6 1212.9 -573.28   1146.6 1.5788  2     0.4541
```

```
anova(mod16p, mod17p)  # mod 17p
```

```
## Data: kbs_flwr_plot_growthhabit
## Models:
## mod17p: log(flwr_duration_scaled) ~ state + growth_habit + year_factor +
## mod17p:     (1 | plot)
## mod16p: log(flwr_duration_scaled) ~ state + growth_habit + (1 + year_factor |
## mod16p:     plot)
##        npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## mod17p    8 1164.8 1197.1 -574.42   1148.8
## mod16p    9 1166.1 1202.4 -574.07   1148.1 0.6978  1     0.4035
```

```
AICctab(mod15p, mod16p, mod17p, weights = T)
```

```
##        dAICc df weight
## mod17p  0.0  8  0.613
## mod16p  1.4  9  0.305
## mod15p  4.0  11 0.082
```

```
summary(mod17p)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: log(flwr_duration_scaled) ~ state + growth_habit + year_factor +
##     (1 | plot)
##    Data: kbs_flwr_plot_growthhabit
##
##      AIC      BIC   logLik deviance df.resid
##   1164.8   1197.1   -574.4   1148.8      409
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.1473 -0.2722  0.1793  0.6320  1.8000
```

```
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  plot     (Intercept) 0.0000   0.0000
##  Residual             0.9205   0.9594
## Number of obs: 417, groups:  plot, 24
##
## Fixed effects:
##                          Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)               2.90589    0.13165 417.00000  22.073  < 2e-16 ***
## statewarmed               0.07858    0.09452 417.00000   0.831 0.406251
## growth_habit             -0.90964    0.12455 417.00000  -7.303 1.44e-12 ***
## growth_habitForb/herb    -3.23045    0.96627 417.00000  -3.343 0.000903 ***
## growth_habitGraminoid    -0.72659    0.10722 417.00000  -6.776 4.22e-11 ***
## year_factor               0.03514    0.02449 417.00000   1.435 0.152077
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) sttwrm grwth_ grw_F/ grwt_G
## statewarmed -0.358
## growth_habt -0.441  0.078
## grwth_hbtF/  0.030 -0.048  0.035
## grwth_hbtGr -0.365 -0.003  0.414  0.057
## year_factor -0.740 -0.005  0.099 -0.076 -0.039
## optimizer (nloptwrap) convergence code: 0 (OK)
## boundary (singular) fit: see ?isSingular
```

```
summ(mod17p)
```

Observations	417
Dependent variable	log(flwr_duration_scaled)
Type	Mixed effects linear regression

AIC	1164.84
BIC	1197.11
Pseudo-R^2 (fixed effects)	0.17
Pseudo-R^2 (total)	0.17

Fixed Effects					
	Est.	S.E.	t val.	d.f.	p
(Intercept)	2.91	0.13	22.07	417.00	0.00
statewarmed	0.08	0.09	0.83	417.00	0.41
growth_habit	-0.91	0.12	-7.30	417.00	0.00
growth_habitForb/herb	-3.23	0.97	-3.34	417.00	0.00
growth_habitGraminoid	-0.73	0.11	-6.78	417.00	0.00
year_factor	0.04	0.02	1.43	417.00	0.15

p values calculated using Satterthwaite d.f.

Random Effects		
Group	Parameter	Std. Dev.
plot	(Intercept)	0.00
Residual		0.96

Grouping Variables		
Group	# groups	ICC
plot	24	0.00

```
anova(mod17p)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##              Sum Sq Mean Sq NumDF DenDF F value    Pr(>F)
## state         0.636  0.6362     1   417  0.6911    0.4063
## growth_habit 72.498 24.1659     3   417 26.2537 1.422e-15 ***
## year_factor   1.895  1.8951     1   417  2.0588    0.1521
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
emmeans(mod17p, list(pairwise ~ state + growth_habit), adjust = "tukey")
```

```
## boundary (singular) fit: see ?isSingular
```

```
## $`emmeans of state, growth_habit`
##  state   growth_habit emmean     SE    df lower.CL upper.CL
##  ambient Forb          3.045 0.0892  67.6     2.87     3.22
##  warmed  Forb          3.123 0.0889  67.6     2.95     3.30
##  ambient               2.135 0.1071 114.0     1.92     2.35
##  warmed                2.213 0.1154 136.8     1.99     2.44
##  ambient Forb/herb    -0.186 0.9787 423.0    -2.11     1.74
##  warmed  Forb/herb    -0.107 0.9741 422.9    -2.02     1.81
##  ambient Graminoid     2.318 0.0914  73.3     2.14     2.50
##  warmed  Graminoid     2.397 0.0907  72.7     2.22     2.58
##
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
## $`pairwise differences of state, growth_habit`
##  1                                        estimate     SE    df t.ratio p.value
##  ambient Forb - warmed Forb               -0.0786 0.0953  22.7 -0.825  0.9897
##  ambient Forb - ambient                    0.9096 0.1258 418.3  7.231  <.0001
##  ambient Forb - warmed                     0.8311 0.1637 145.4  5.077  <.0001
##  ambient Forb - (ambient Forb/herb)        3.2304 0.9780 423.1  3.303  0.0229
##  ambient Forb - (warmed Forb/herb)         3.1519 0.9781 422.5  3.222  0.0295
##  ambient Forb - ambient Graminoid          0.7266 0.1080 401.6  6.727  <.0001
##  ambient Forb - warmed Graminoid           0.6480 0.1438 107.8  4.505  0.0004
##  warmed Forb - ambient                     0.9882 0.1517 122.4  6.514  <.0001
##  warmed Forb - warmed                      0.9096 0.1258 418.3  7.231  <.0001
```

```
##  warmed Forb - (ambient Forb/herb)          3.3090 0.9872 422.7  3.352  0.0196
##  warmed Forb - (warmed Forb/herb)           3.2304 0.9780 423.1  3.303  0.0229
##  warmed Forb - ambient Graminoid            0.8052 0.1442 108.4  5.582  <.0001
##  warmed Forb - warmed Graminoid             0.7266 0.1080 401.6  6.727  <.0001
##  ambient  - warmed                         -0.0786 0.0953  22.7 -0.825  0.9897
##  ambient  - (ambient Forb/herb)             2.3208 0.9818 423.1  2.364  0.2621
##  ambient  - (warmed Forb/herb)              2.2422 0.9809 422.4  2.286  0.3038
##  ambient  - ambient Graminoid              -0.1831 0.1276 419.0 -1.434  0.8409
##  ambient  - warmed Graminoid               -0.2616 0.1530 125.2 -1.710  0.6810
##  warmed  - (ambient Forb/herb)              2.3994 0.9919 422.6  2.419  0.2348
##  warmed  - (warmed Forb/herb)               2.3208 0.9818 423.1  2.364  0.2621
##  warmed  - ambient Graminoid               -0.1045 0.1653 148.5 -0.632  0.9984
##  warmed  - warmed Graminoid                -0.1831 0.1276 419.0 -1.434  0.8409
##  (ambient Forb/herb) - (warmed Forb/herb)  -0.0786 0.0953  22.7 -0.825  0.9897
##  (ambient Forb/herb) - ambient Graminoid   -2.5039 0.9779 423.1 -2.561  0.1736
##  (ambient Forb/herb) - warmed Graminoid    -2.5824 0.9870 422.7 -2.616  0.1528
##  (warmed Forb/herb) - ambient Graminoid    -2.4253 0.9780 422.5 -2.480  0.2069
##  (warmed Forb/herb) - warmed Graminoid     -2.5039 0.9779 423.1 -2.561  0.1736
##  ambient Graminoid - warmed Graminoid      -0.0786 0.0953  22.7 -0.825  0.9897
##
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## P value adjustment: tukey method for comparing a family of 8 estimates
```

```
emmeans(mod17p, list(pairwise ~ growth_habit), adjust = "tukey")
```

```
## boundary (singular) fit: see ?isSingular
```

```
## $`emmeans of growth_habit`
##  growth_habit emmean     SE  df lower.CL upper.CL
##  Forb          3.084 0.0753 127     2.93     3.23
##                2.174 0.1006 225     1.98     2.37
##  Forb/herb    -0.147 0.9752 423    -2.06     1.77
##  Graminoid     2.357 0.0776 139     2.20     2.51
##
## Results are averaged over the levels of: state
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
## $`pairwise differences of growth_habit`
##  1                      estimate    SE  df t.ratio p.value
##  Forb -                    0.910 0.126 418  7.231  <.0001
##  Forb - (Forb/herb)        3.230 0.978 423  3.303  0.0057
##  Forb - Graminoid          0.727 0.108 402  6.727  <.0001
##   - (Forb/herb)            2.321 0.982 423  2.364  0.0858
##   - Graminoid             -0.183 0.128 419 -1.434  0.4786
##  (Forb/herb) - Graminoid  -2.504 0.978 423 -2.561  0.0525
##
## Results are averaged over the levels of: state
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## P value adjustment: tukey method for comparing a family of 4 estimates
```

```
emmeans(mod17p, list(pairwise ~ growth_habit + year_factor), adjust = "tukey")
```

```
## boundary (singular) fit: see ?isSingular
```

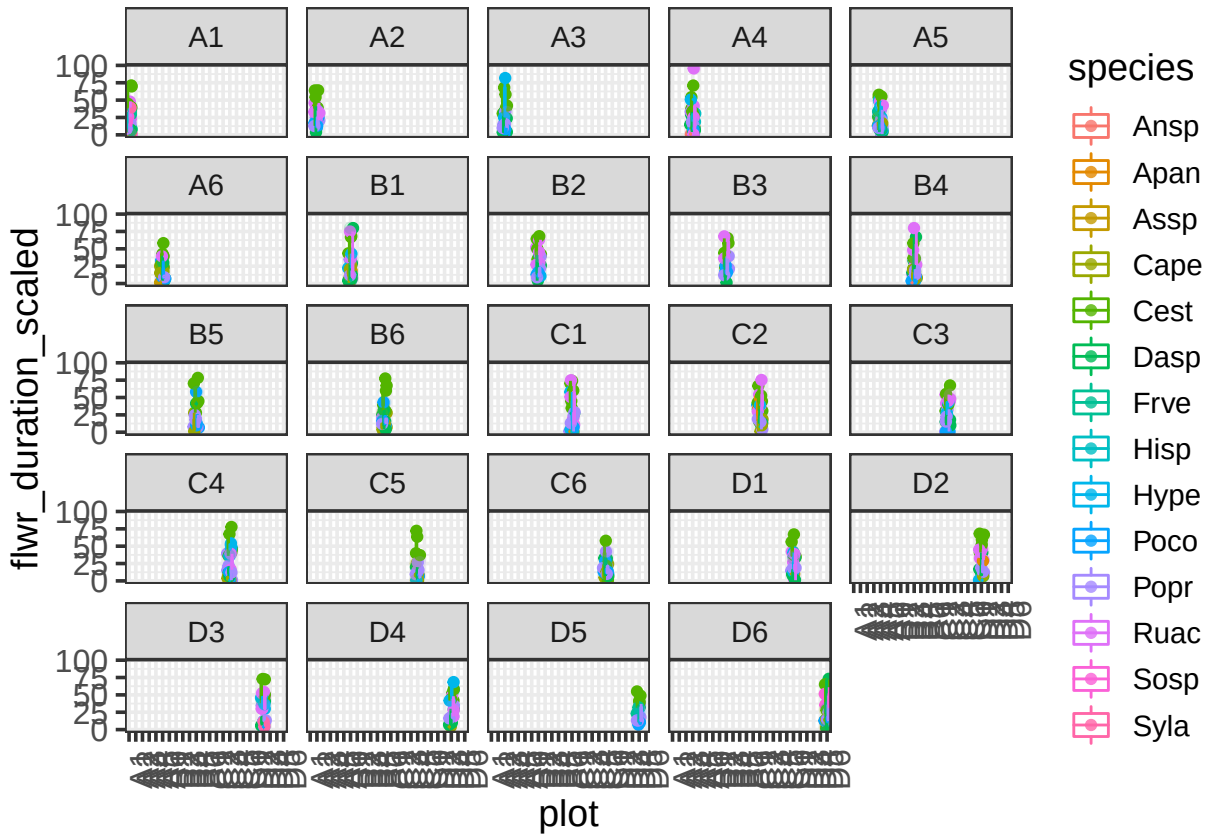
```
## $`emmeans of growth_habit, year_factor`
##  growth_habit year_factor emmean     SE  df lower.CL upper.CL
##  Forb                3.94  3.084 0.0753 127     2.93     3.23
##                      3.94  2.174 0.1006 225     1.98     2.37
##  Forb/herb           3.94 -0.147 0.9752 423    -2.06     1.77
##  Graminoid           3.94  2.357 0.0776 139     2.20     2.51
##
## Results are averaged over the levels of: state
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
## $`pairwise differences of growth_habit, year_factor`
##  1                                                          estimate    SE  df
##  Forb 3.94484412470024 -  3.94484412470024                     0.910 0.126 418
##  Forb 3.94484412470024 - (Forb/herb 3.94484412470024)          3.230 0.978 423
##  Forb 3.94484412470024 - Graminoid 3.94484412470024            0.727 0.108 402
##   3.94484412470024 - (Forb/herb 3.94484412470024)              2.321 0.982 423
##   3.94484412470024 - Graminoid 3.94484412470024               -0.183 0.128 419
##  (Forb/herb 3.94484412470024) - Graminoid 3.94484412470024    -2.504 0.978 423
##  t.ratio p.value
##   7.231  <.0001
##   3.303  0.0057
##   6.727  <.0001
##   2.364  0.0858
##  -1.434  0.4786
##  -2.561  0.0525
##
## Results are averaged over the levels of: state
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## P value adjustment: tukey method for comparing a family of 4 estimates
```

UMBS

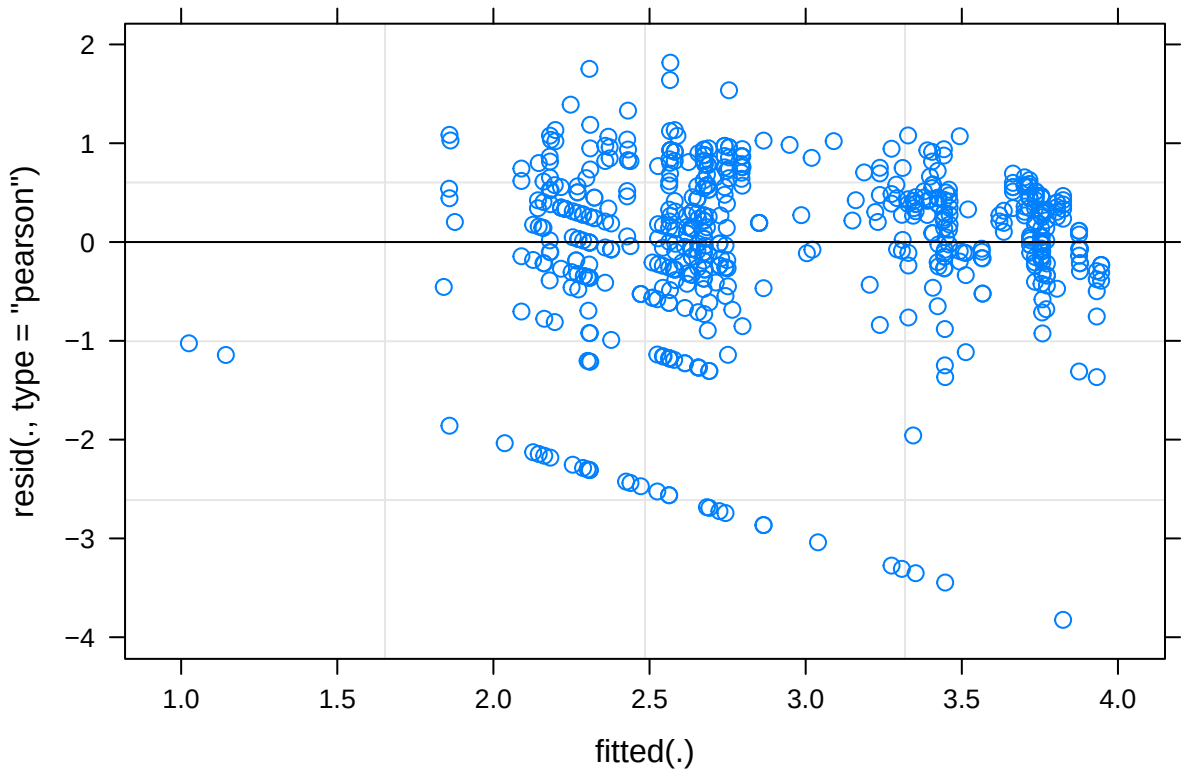
```
# UMBS SPECIES LEVEL - Looking at DURATION of flowering
mod1u <- lmer(log(flwr_duration_scaled) ~ state * year_factor + insecticide * year_factor +
    (1 | species) + (1 | plot), umbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
ggplot(umbs_flwr_spp, aes(x = plot, y = flwr_duration_scaled, col = species)) + geom_jitter() +
    geom_boxplot(alpha = 0.2) + facet_wrap(~plot)
```




```
# Check Assumptions: (1) Linearity: if covariates are not categorical (year
# isn't) (2) Homogeneity: Need to Check by plotting residuals vs predicted
# values.
par(mfrow = c(1, 2))
plot(mod1u)  # the zeros in the data are making this look weird
```




```
# Homogeneity of variance is ok here (increasing variance in resids is not
# increasing with fitted values) Check for homogeneity of variances (true if
# p>0.05). If the result is not significant, the assumption of equal variances
# (homoscedasticity) is met (no significant difference between the group
# variances).  *****Levene's Test - tests whether or not the variance among two
# or more groups is equal - If the p-value is less than our chosen significance
# level, we can reject the null hypothesis and conclude that we have enough
# evidence to state that the variance among the groups is not equal (which we
# want).

leveneTest(residuals(mod1u) ~ umbs_flwr_spp$state)
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##        Df F value Pr(>F)
## group   1  0.0028 0.9579
##       570
```

```
# Assumption not met
leveneTest(residuals(mod1u) ~ umbs_flwr_spp$species)
```

```
## Warning in leveneTest.default(y = y, group = group, ...): group coerced to
## factor.

## Levene's Test for Homogeneity of Variance (center = median)
##        Df F value    Pr(>F)
## group  13  2.7969 0.0006918 ***
##       558
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# Assumption met
leveneTest(residuals(mod1u) ~ umbs_flwr_spp$insecticide)
```

```
## Warning in leveneTest.default(y = y, group = group, ...): group coerced to
## factor.
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##        Df F value Pr(>F)
## group   1  0.0419 0.8378
##       570
```

```
# Assumption not met
leveneTest(residuals(mod1u) ~ umbs_flwr_spp$plot)
```

```
## Warning in leveneTest.default(y = y, group = group, ...): group coerced to
## factor.
```

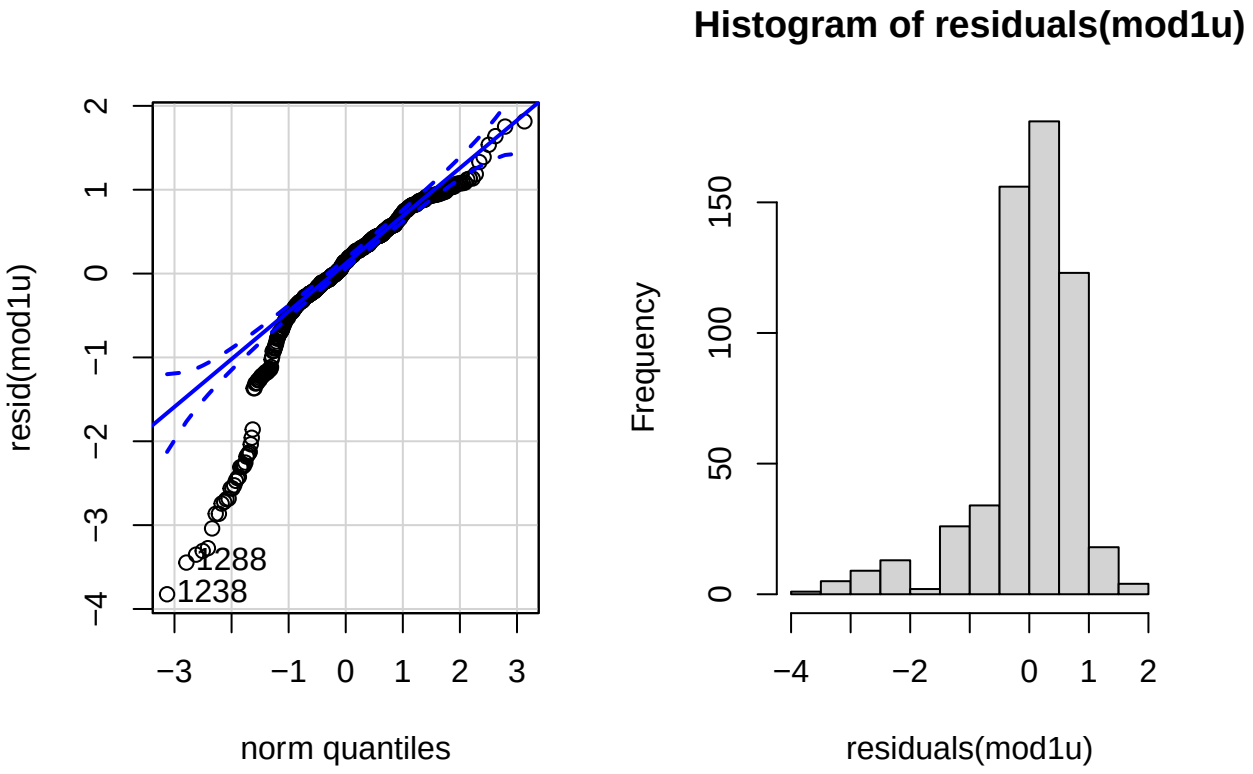
```
## Levene's Test for Homogeneity of Variance (center = median)
##        Df F value Pr(>F)
## group  23  0.9697 0.5036
##       548
```

```
# Assumption not met

# (3) Normality of error term: need to check by histogram, QQplot of residuals,
# could do Kolmogorov-Smirnov test.  Check for normal residuals
qqPlot(resid(mod1u))
```

```
## 1238 1288
##  426  442
```

```
hist(residuals(mod1u))
```



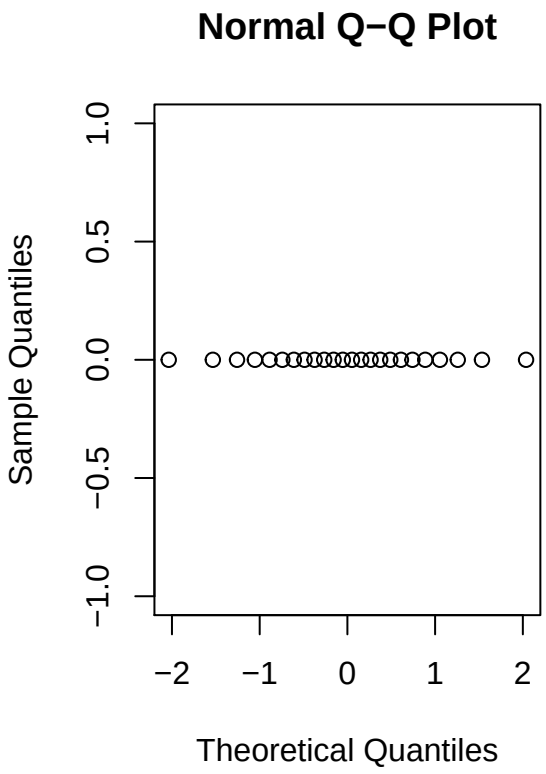

```
shapiro.test(resid(mod1u))  # not normally distributed resids bc p<0.05
```

```
##
##  Shapiro-Wilk normality test
##
## data:  resid(mod1u)
## W = 0.87031, p-value < 2.2e-16
```

```
outlierTest(mod1u)  # outliers
```

```
##       rstudent unadjusted p-value Bonferroni p
## 1238 -4.589346         5.4888e-06    0.0031396
## 1288 -4.177723         3.4132e-05    0.0195240
## 310  -4.049665         5.8496e-05    0.0334600
## 1375 -4.010389         6.8809e-05    0.0393590
## 1201 -3.983660         7.6790e-05    0.0439240
```

```
# (4) Normality of random effect: Get the estimate of random effect (e.g., random
# intercepts), and check them as you would check the residual.
require(lme4)
r_int <- ranef(mod1u)$plot$`(Intercept)`
qqnorm(r_int)
# qqline(r_int) doesn't work shapiro.test(r_int) # this doesnt work
```




```
# Do we need to include plot as a random effect with the KBS models?
mod1u <- lmer(log(flwr_duration_scaled) ~ state * year_factor + insecticide * year_factor +
    (1 | species) + (1 | plot), umbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod2u <- lmer(log(flwr_duration_scaled) ~ state * year_factor + insecticide * year_factor +
    (1 | species), umbs_flwr_spp, REML = FALSE)
# Run analysis of variance on each model (see this for more explanation on how
# anova on a linear mixed effects model is similar to an anove on a regular
# linear model: https://m-clark.github.io/docs/mixedModels/anovamixed.html)
anova(mod1u)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##                           Sum Sq Mean Sq NumDF  DenDF F value Pr(>F)
## state                    1.12313 1.12313     1 554.87  1.5974 0.2068
## year_factor              1.35249 1.35249     1 559.84  1.9235 0.1660
## insecticide              0.03213 0.03213     1 556.11  0.0457 0.8308
## state:year_factor        0.77321 0.77321     1 554.43  1.0997 0.2948
## year_factor:insecticide 0.07685 0.07685     1 556.10  0.1093 0.7411
```

```
anova(mod2u)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##                           Sum Sq Mean Sq NumDF  DenDF F value Pr(>F)
## state                    1.12313 1.12313     1 554.87  1.5974 0.2068
## year_factor              1.35249 1.35249     1 559.84  1.9235 0.1660
```

```
## insecticide             0.03213 0.03213     1 556.11  0.0457 0.8308
## state:year_factor       0.77321 0.77321     1 554.43  1.0997 0.2948
## year_factor:insecticide 0.07685 0.07685     1 556.10  0.1093 0.7411
```

```
anova(mod1u, mod2u)  # Go with model 2 since pvalue >0.05, aka more complex model does not have somethi
```

```
## Data: umbs_flwr_spp
## Models:
## mod2u: log(flwr_duration_scaled) ~ state * year_factor + insecticide *
## mod2u:     year_factor + (1 | species)
## mod1u: log(flwr_duration_scaled) ~ state * year_factor + insecticide *
## mod1u:     year_factor + (1 | species) + (1 | plot)
##       npar    AIC    BIC  logLik deviance Chisq Df Pr(>Chisq)
## mod2u    8 1478.1 1512.9 -731.06   1462.1
## mod1u    9 1480.1 1519.3 -731.06   1462.1     0  1          1
```

```
summ(mod1u)
```

Observations	572
Dependent variable	log(flwr_duration_scaled)
Type	Mixed effects linear regression

AIC	1480.11
BIC	1519.26
Pseudo-R^2 (fixed effects)	0.00
Pseudo-R^2 (total)	0.43

Fixed Effects					
	Est.	S.E.	t val.	d.f.	p
(Intercept)	2.93	0.28	10.33	37.72	0.00
stateambient	-0.28	0.22	-1.26	554.87	0.21
year_factor	-0.05	0.05	-1.18	555.34	0.24
insecticideno_insects	0.05	0.22	0.21	556.11	0.83
stateambient:year_factor	0.05	0.05	1.05	554.43	0.29
year_factor:insecticideno_insects	-0.02	0.05	-0.33	556.10	0.74

p values calculated using Satterthwaite d.f.

Random Effects		
Group	Parameter	Std. Dev.
plot	(Intercept)	0.00
species	(Intercept)	0.73
Residual		0.84

```
summ(mod2u)
```

Grouping Variables		
Group	# groups	ICC
plot	24	0.00
species	14	0.43

Observations	572
Dependent variable	log(flwr_duration_scaled)
Type	Mixed effects linear regression

AIC	1478.11
BIC	1512.91
Pseudo-R^2 (fixed effects)	0.00
Pseudo-R^2 (total)	0.43

Fixed Effects					
	Est.	S.E.	t val.	d.f.	p
(Intercept)	2.93	0.28	10.33	37.72	0.00
stateambient	-0.28	0.22	-1.26	554.87	0.21
year_factor	-0.05	0.05	-1.18	555.34	0.24
insecticideno_insects	0.05	0.22	0.21	556.11	0.83
stateambient:year_factor	0.05	0.05	1.05	554.43	0.29
year_factor:insecticideno_insects	-0.02	0.05	-0.33	556.10	0.74

p values calculated using Satterthwaite d.f.

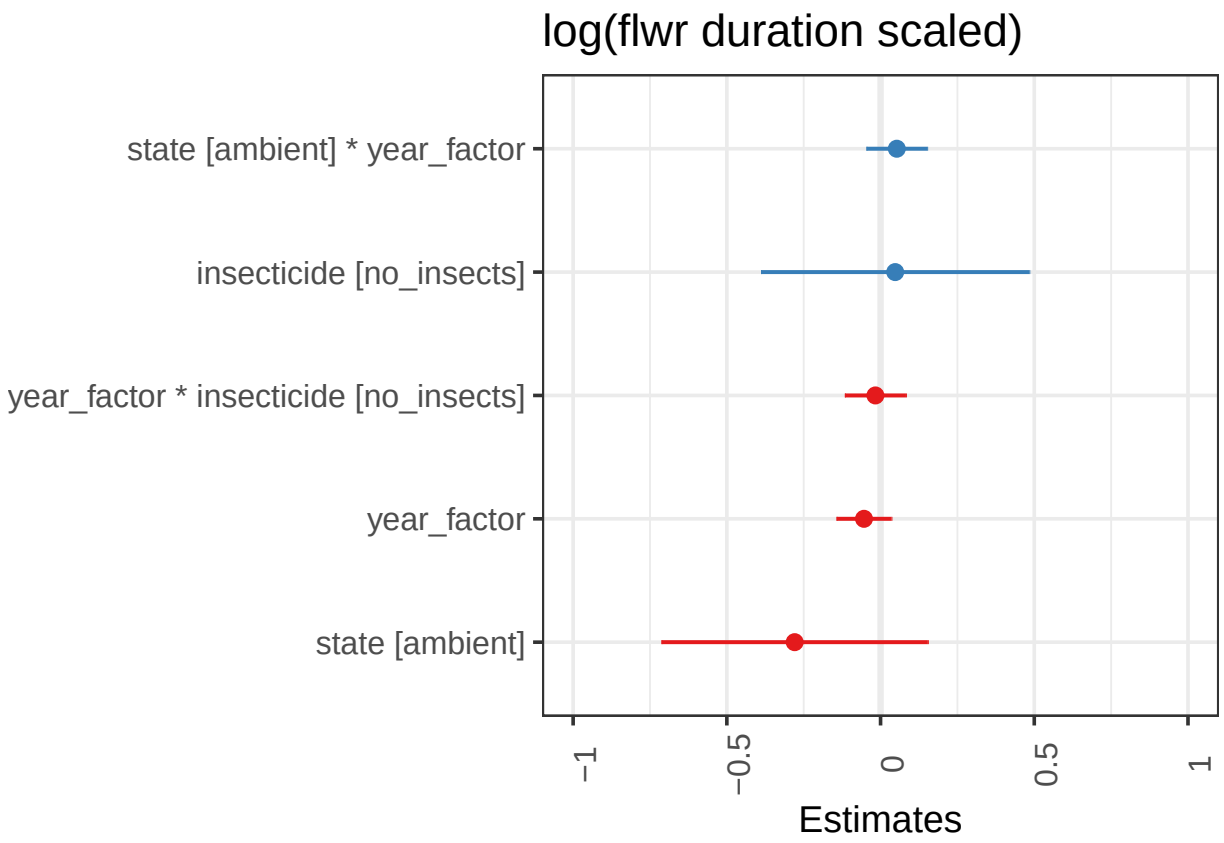
Random Effects		
Group	Parameter	Std. Dev.
species	(Intercept)	0.73
Residual		0.84

Grouping Variables		
Group	# groups	ICC
species	14	0.43

```
AICctab(mod1u, mod2u, weights = T)
```

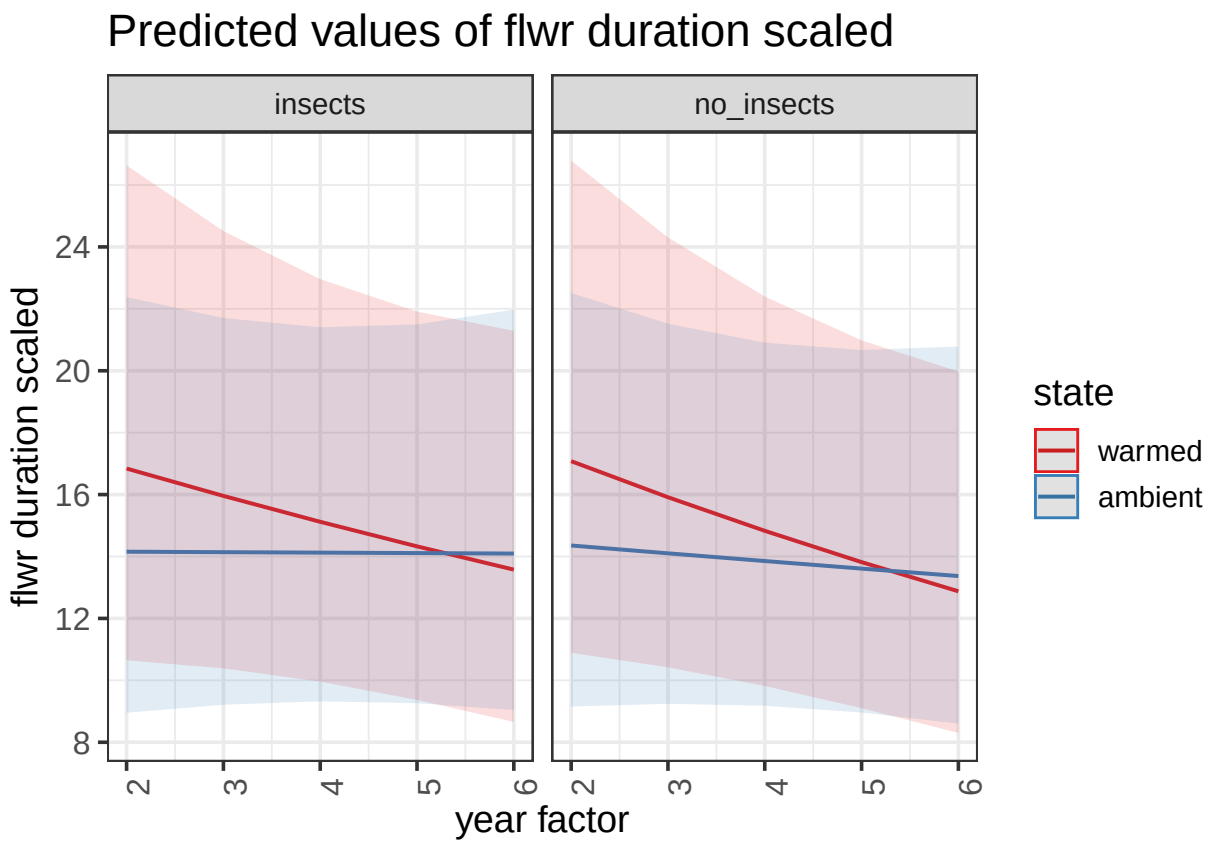
```
##       dAICc df weight
## mod2u 0.0   8  0.74
## mod1u 2.1   9  0.26
```

```
# Plot the fixed effects estimates for different models these are the fixed
# effects estimates from summary(mod1)
plot_model(mod2u, sort.est = TRUE)
```

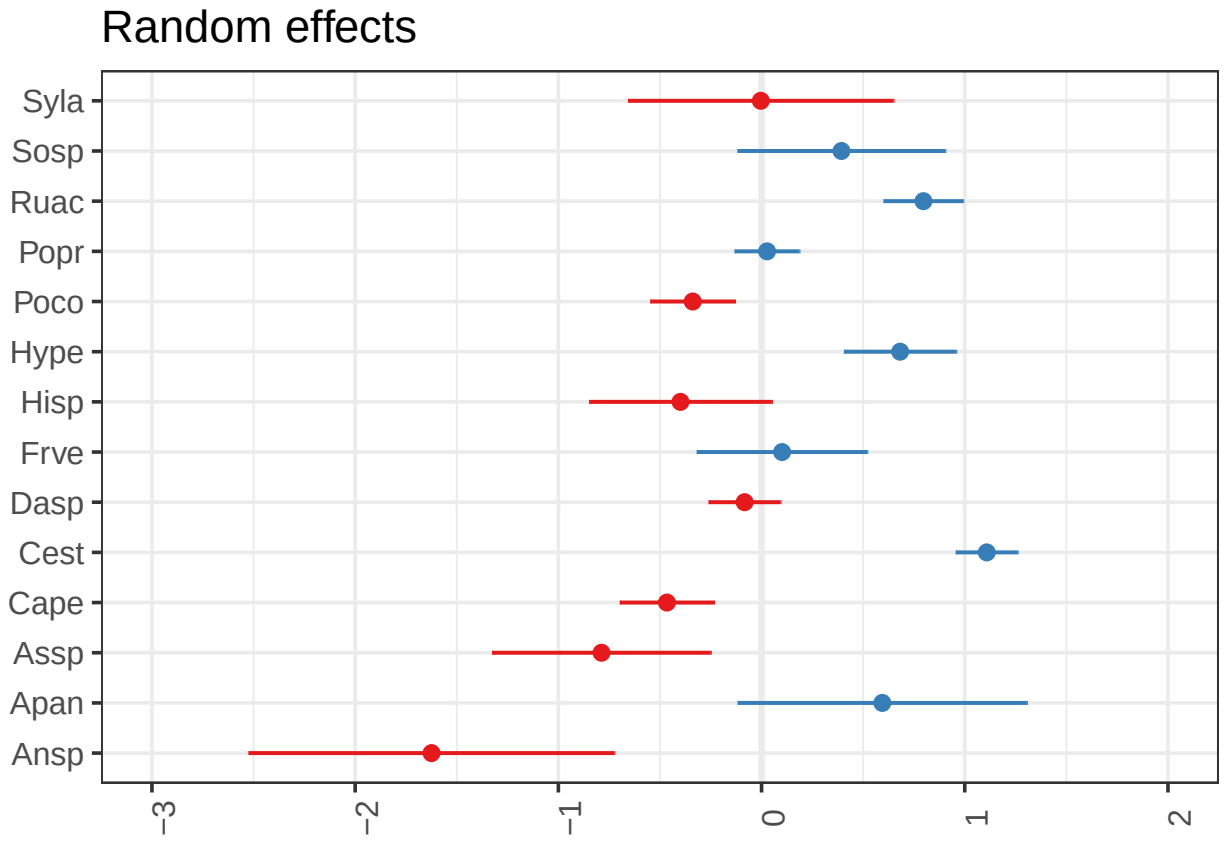



```
# these are the fixed predicted values:
plot_model(mod2u, type = "pred", terms = c("year_factor", "state", "insecticide"))
```

```
## Model has log-transformed response. Back-transforming predictions to original response scale. Standa
```




```
# these are the random effects estimates
plot_model(mod2u, type = "re", terms = c("species"))
```




```
# Do we need to include insecticide? (dropping insecticide from the model) mod2
# <- lmer(log(relabun) ~ state*year_factor + insecticide*year_factor +
# (1|species), comp_kbs_spp, REML=FALSE)
mod3u <- lmer(log(flwr_duration_scaled) ~ state * year_factor + (1 | species), umbs_flwr_spp,
    REML = FALSE)
anova(mod2u, mod3u)
```

```
## Data: umbs_flwr_spp
## Models:
## mod3u: log(flwr_duration_scaled) ~ state * year_factor + (1 | species)
## mod2u: log(flwr_duration_scaled) ~ state * year_factor + insecticide *
## mod2u:     year_factor + (1 | species)
##       npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## mod3u    6 1474.3 1500.4 -731.16   1462.3
## mod2u    8 1478.1 1512.9 -731.06   1462.1 0.2032  2     0.9034
```

```
AICctab(mod2u, mod3u, weights = T)  # go with model 3u
```

```
##       dAICc df weight
## mod3u 0.0   6  0.88
## mod2u 3.9   8  0.12
```

```
# Looks like no, pvalue > 0.05, so insecticide does not improve model fit so we
# will go with mod 3
```

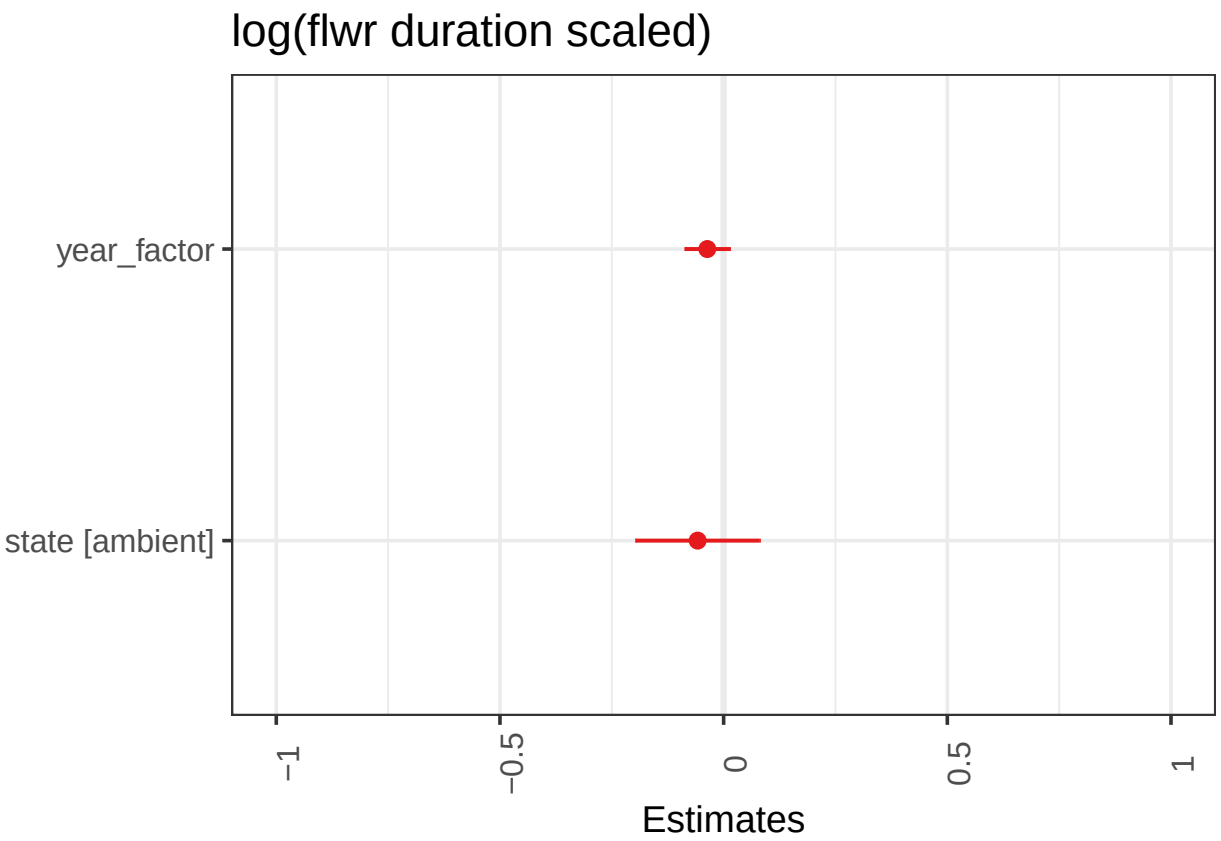
```r
# Does year need to be interactive with insecticide? - already removed
# insecticide mod4 <- lmer(log(julian_median) ~ state*year_factor + insecticide +
# (1|species) + (1|plot), umbs_flwr_spp, REML=FALSE)

# Does year need to be interactive with state?
mod5u <- lmer(log(flwr_duration_scaled) ~ state + year_factor + (1 | species), umbs_flwr_spp,
    REML = FALSE)
anova(mod3u, mod5u)
```

```
## Data: umbs_flwr_spp
## Models:
## mod5u: log(flwr_duration_scaled) ~ state + year_factor + (1 | species)
## mod3u: log(flwr_duration_scaled) ~ state * year_factor + (1 | species)
##       npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## mod5u    5 1473.5 1495.2 -731.73   1463.5
## mod3u    6 1474.3 1500.4 -731.16   1462.3 1.1468  1     0.2842
```

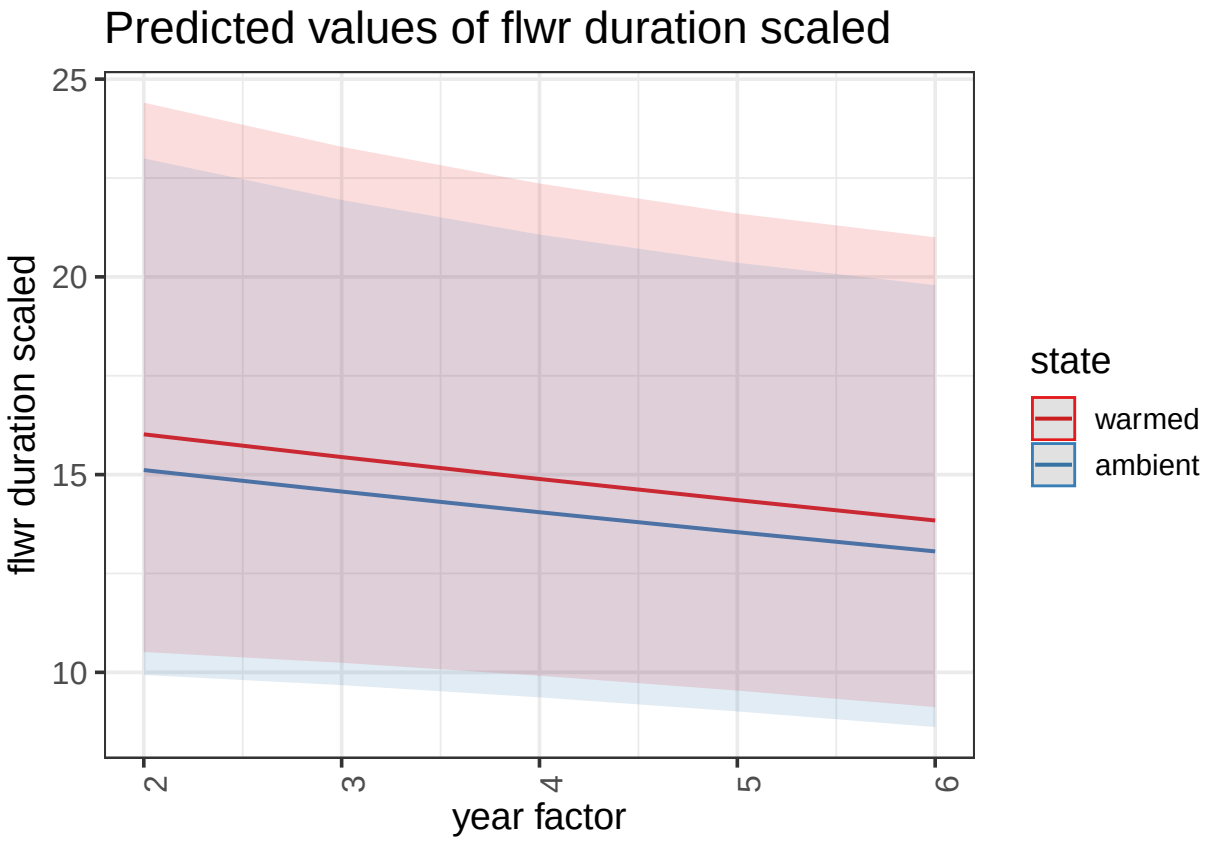
```r
# No, P>0.05 so state*year_factor doesn't strongly improve model fit so we will
# shift to mod5, but AIC values are super close!!

# Plot the fixed effects estimates for different models these are the fixed
# effects estimates from summary(mod5)
plot_model(mod5u, sort.est = TRUE)
```

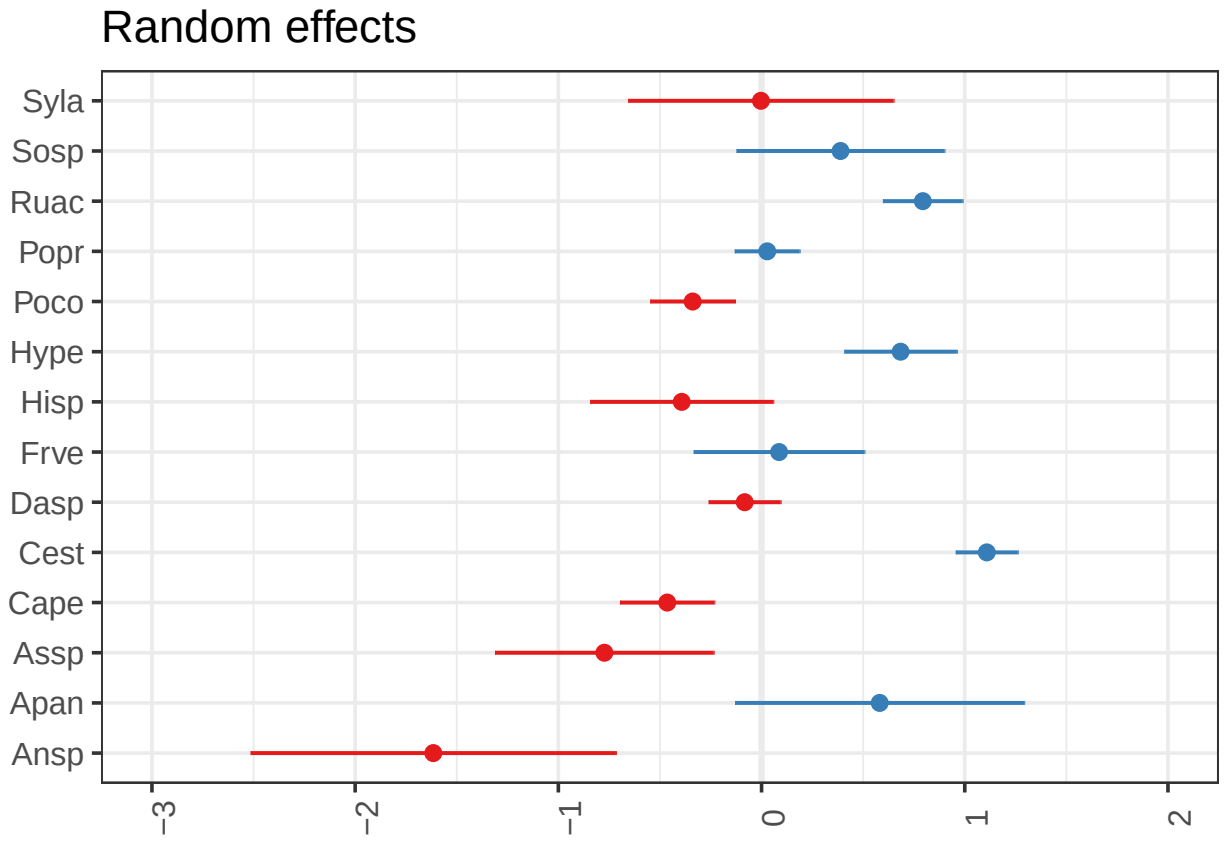


```
# these are the fixed predicted values:
plot_model(mod5u, type = "pred", terms = c("year_factor", "state"))
```

```
## Model has log-transformed response. Back-transforming predictions to original response scale. Standa
```




```
# these are the random effects estimates
plot_model(mod5u, type = "re", terms = c("species"))
```




```
# If we wanted to include plots nested within year it would look like this:
mod6u <- lmer(log(flwr_duration_scaled) ~ state + year_factor + (1 | species) + (1 +
    year_factor | plot), umbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
# Model failed to converge with 1 negative eigenvalue: -1.9e+00
anova(mod5u, mod6u)
```

```
## Data: umbs_flwr_spp
## Models:
## mod5u: log(flwr_duration_scaled) ~ state + year_factor + (1 | species)
## mod6u: log(flwr_duration_scaled) ~ state + year_factor + (1 | species) +
## mod6u:     (1 + year_factor | plot)
##       npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## mod5u    5 1473.5 1495.2 -731.73   1463.5
## mod6u    8 1479.5 1514.2 -731.73   1463.5 0.0102  3     0.9997
```

```
anova(mod5u)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##              Sum Sq Mean Sq NumDF  DenDF F value Pr(>F)
## state       0.47321 0.47321     1 557.11  0.6712 0.4130
## year_factor 1.41450 1.41450     1 560.22  2.0064 0.1572
```

```
# mod4 (and mod5) are pretty complex in terms of interpretation (they actually
# don't have many parameters though). We could consider an alternative model
# that's simpler to understand and also one that provides more insight about the
# species. That would be something like this:
mod7u <- lmer(log(flwr_duration_scaled) ~ state + species + (1 + factor(year_factor) |
    plot), umbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
## Warning: Model failed to converge with 1 negative eigenvalue: -1.7e+00
```

```
mod7au <- lmer(log(flwr_duration_scaled) ~ state + species + factor(year_factor) +
    (1 | plot), umbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod7bu <- lmer(log(flwr_duration_scaled) ~ state * factor(year_factor) + species +
    (1 | plot), umbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod7cu <- lmer(log(flwr_duration_scaled) ~ state + species + factor(year_factor) +
    insecticide + (1 | plot), umbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
anova(mod5u, mod7u)  # model 7 is a better fit to data
```

```
## Data: umbs_flwr_spp
## Models:
## mod5u: log(flwr_duration_scaled) ~ state + year_factor + (1 | species)
## mod7u: log(flwr_duration_scaled) ~ state + species + (1 + factor(year_factor) |
## mod7u:     plot)
##       npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## mod5u    5 1473.5 1495.2 -731.73   1463.5
## mod7u   31 1468.6 1603.4 -703.29   1406.6 56.881 26  0.0004339 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
anova(mod7u, mod7au)  #mod 7a
```

```
## Data: umbs_flwr_spp
## Models:
## mod7au: log(flwr_duration_scaled) ~ state + species + factor(year_factor) +
## mod7au:     (1 | plot)
## mod7u: log(flwr_duration_scaled) ~ state + species + (1 + factor(year_factor) |
## mod7u:     plot)
##        npar    AIC    BIC  logLik deviance Chisq Df Pr(>Chisq)
## mod7au   21 1437.3 1528.7 -697.66   1395.3
## mod7u    31 1468.6 1603.4 -703.29   1406.6     0 10          1
```

```
anova(mod7au, mod7bu)  #mod 7a - interaction between state and year does not improve model go with simp
```

```
## Data: umbs_flwr_spp
## Models:
## mod7au: log(flwr_duration_scaled) ~ state + species + factor(year_factor) +
## mod7au:     (1 | plot)
## mod7bu: log(flwr_duration_scaled) ~ state * factor(year_factor) + species +
## mod7bu:     (1 | plot)
##        npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## mod7au   21 1437.3 1528.7 -697.66   1395.3
## mod7bu   25 1443.2 1551.9 -696.58   1393.2 2.1686  4     0.7048
```

```
anova(mod7au, mod7cu)  #models are not different than one another, go with simpler model = mod7a
```

```
## Data: umbs_flwr_spp
## Models:
## mod7au: log(flwr_duration_scaled) ~ state + species + factor(year_factor) +
## mod7au:     (1 | plot)
## mod7cu: log(flwr_duration_scaled) ~ state + species + factor(year_factor) +
## mod7cu:     insecticide + (1 | plot)
##        npar    AIC    BIC  logLik deviance Chisq Df Pr(>Chisq)
## mod7au   21 1437.3 1528.7 -697.66   1395.3
## mod7cu   22 1439.1 1534.8 -697.54   1395.1 0.243  1      0.622
```

```
summary(mod7au)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: log(flwr_duration_scaled) ~ state + species + factor(year_factor) +
##     (1 | plot)
##    Data: umbs_flwr_spp
##
##      AIC      BIC   logLik deviance df.resid
##   1437.3   1528.7   -697.7   1395.3      551
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.4052 -0.3296  0.2038  0.6211  2.1411
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  plot     (Intercept) 0.0000   0.0000
##  Residual             0.6713   0.8193
## Number of obs: 572, groups:  plot, 24
##
## Fixed effects:
##                       Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)           -0.07144    0.59218 572.00000  -0.121 0.904014
## stateambient          -0.05779    0.06933 572.00000  -0.833 0.404922
## speciesApan            3.66307    0.71570 572.00000   5.118 4.22e-07 ***
## speciesAssp            1.96170    0.65466 572.00000   2.997 0.002849 **
```

```
## speciesCape            2.38247    0.59569 572.00000   4.000 7.18e-05 ***
## speciesCest            3.97830    0.58865 572.00000   6.758 3.45e-11 ***
## speciesDasp            2.75697    0.59039 572.00000   4.670 3.76e-06 ***
## speciesFrve            2.96020    0.62433 572.00000   4.741 2.68e-06 ***
## speciesHisp            2.40897    0.63036 572.00000   3.822 0.000147 ***
## speciesHype            3.57575    0.60204 572.00000   5.939 4.97e-09 ***
## speciesPoco            2.50251    0.59277 572.00000   4.222 2.82e-05 ***
## speciesPopr            2.88350    0.58902 572.00000   4.895 1.28e-06 ***
## speciesRuac            3.66212    0.59206 572.00000   6.185 1.18e-09 ***
## speciesSosp            3.30338    0.64422 572.00000   5.128 4.02e-07 ***
## speciesSyla            2.91794    0.69165 572.00000   4.219 2.86e-05 ***
## factor(year_factor)3   0.10034    0.11770 572.00000   0.852 0.394315
## factor(year_factor)4  -0.29751    0.11744 572.00000  -2.533 0.011564 *
## factor(year_factor)5  -0.10010    0.11426 572.00000  -0.876 0.381353
## factor(year_factor)6  -0.11873    0.11439 572.00000  -1.038 0.299731
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 19 > 12.
## Use print(x, correlation=TRUE)  or
##     vcov(x)        if you need it

## optimizer (nloptwrap) convergence code: 0 (OK)
## boundary (singular) fit: see ?isSingular
```

```
anova(mod7au)  # investigates whether at least one of the levels within each factor is significantly di
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##                       Sum Sq Mean Sq NumDF DenDF F value    Pr(>F)
## state                  0.466  0.4664     1   572  0.6947  0.404922
## species              216.667 16.6667    13   572 24.8264 < 2.2e-16 ***
## factor(year_factor)    9.361  2.3403     4   572  3.4861  0.007958 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# Yes, at least one of the species is different (they do not all have the same
# relative abundances).
emmeans(mod7au, list(pairwise ~ state + year_factor), adjust = "tukey")
```

```
## boundary (singular) fit: see ?isSingular

## $`emmeans of state, year_factor`
##  state   year_factor emmean    SE  df lower.CL upper.CL
##  warmed            2   2.71 0.115 313     2.48     2.94
##  ambient           2   2.65 0.114 273     2.43     2.88
##  warmed            3   2.81 0.109 255     2.60     3.03
##  ambient           3   2.75 0.107 219     2.54     2.96
##  warmed            4   2.41 0.109 246     2.20     2.63
##  ambient           4   2.36 0.107 210     2.14     2.57
##  warmed            5   2.61 0.105 240     2.40     2.82
##  ambient           5   2.55 0.104 213     2.35     2.76
```

```
##  warmed            6   2.59 0.104 227     2.39     2.80
##  ambient           6   2.53 0.103 192     2.33     2.74
##
## Results are averaged over the levels of: species
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
## $`pairwise differences of state, year_factor`
##  1                     estimate     SE    df t.ratio p.value
##  warmed 2 - ambient 2    0.0578 0.0709  21.2  0.815  0.9975
##  warmed 2 - warmed 3    -0.1003 0.1198 574.5 -0.838  0.9980
##  warmed 2 - ambient 3   -0.0426 0.1388 242.1 -0.307  1.0000
##  warmed 2 - warmed 4     0.2975 0.1196 579.1  2.489  0.2768
##  warmed 2 - ambient 4    0.3553 0.1388 235.1  2.559  0.2432
##  warmed 2 - warmed 5     0.1001 0.1163 577.9  0.861  0.9975
##  warmed 2 - ambient 5    0.1579 0.1362 229.9  1.160  0.9775
##  warmed 2 - warmed 6     0.1187 0.1164 578.9  1.020  0.9910
##  warmed 2 - ambient 6    0.1765 0.1362 224.6  1.296  0.9538
##  ambient 2 - warmed 3   -0.1581 0.1395 239.6 -1.133  0.9808
##  ambient 2 - ambient 3  -0.1003 0.1198 574.5 -0.838  0.9980
##  ambient 2 - warmed 4    0.2397 0.1392 235.5  1.723  0.7816
##  ambient 2 - ambient 4   0.2975 0.1196 579.1  2.489  0.2768
##  ambient 2 - warmed 5    0.0423 0.1362 217.9  0.311  1.0000
##  ambient 2 - ambient 5   0.1001 0.1163 577.9  0.861  0.9975
##  ambient 2 - warmed 6    0.0609 0.1364 222.3  0.447  1.0000
##  ambient 2 - ambient 6   0.1187 0.1164 578.9  1.020  0.9910
##  warmed 3 - ambient 3    0.0578 0.0709  21.2  0.815  0.9975
##  warmed 3 - warmed 4     0.3978 0.1133 572.8  3.511  0.0172
##  warmed 3 - ambient 4    0.4556 0.1339 215.0  3.404  0.0268
##  warmed 3 - warmed 5     0.2004 0.1101 572.0  1.820  0.7222
##  warmed 3 - ambient 5    0.2582 0.1313 209.2  1.966  0.6234
##  warmed 3 - warmed 6     0.2191 0.1097 572.5  1.996  0.6022
##  warmed 3 - ambient 6    0.2769 0.1310 202.7  2.114  0.5199
##  ambient 3 - warmed 4    0.3401 0.1334 217.7  2.548  0.2492
##  ambient 3 - ambient 4   0.3978 0.1133 572.8  3.511  0.0172
##  ambient 3 - warmed 5    0.1427 0.1306 199.6  1.092  0.9850
##  ambient 3 - ambient 5   0.2004 0.1101 572.0  1.820  0.7222
##  ambient 3 - warmed 6    0.1613 0.1304 202.5  1.237  0.9654
##  ambient 3 - ambient 6   0.2191 0.1097 572.5  1.996  0.6022
##  warmed 4 - ambient 4    0.0578 0.0709  21.2  0.815  0.9975
##  warmed 4 - warmed 5    -0.1974 0.1087 573.7 -1.816  0.7249
##  warmed 4 - ambient 5   -0.1396 0.1299 203.7 -1.075  0.9866
##  warmed 4 - warmed 6    -0.1788 0.1080 575.5 -1.655  0.8200
##  warmed 4 - ambient 6   -0.1210 0.1293 195.2 -0.936  0.9951
##  ambient 4 - warmed 5   -0.2552 0.1296 191.8 -1.968  0.6221
##  ambient 4 - ambient 5  -0.1974 0.1087 573.7 -1.816  0.7249
##  ambient 4 - warmed 6   -0.2366 0.1291 192.5 -1.832  0.7139
##  ambient 4 - ambient 6  -0.1788 0.1080 575.5 -1.655  0.8200
##  warmed 5 - ambient 5    0.0578 0.0709  21.2  0.815  0.9975
##  warmed 5 - warmed 6     0.0186 0.1043 572.3  0.179  1.0000
##  warmed 5 - ambient 6    0.0764 0.1260 177.5  0.606  0.9998
##  ambient 5 - warmed 6   -0.0392 0.1261 186.4 -0.310  1.0000
##  ambient 5 - ambient 6   0.0186 0.1043 572.3  0.179  1.0000
```

```
##  warmed 6 - ambient 6    0.0578 0.0709  21.2  0.815  0.9975
##
## Results are averaged over the levels of: species
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## P value adjustment: tukey method for comparing a family of 10 estimates
```

```
emmeans(mod7au, list(pairwise ~ year_factor), adjust = "tukey")
```

```
## boundary (singular) fit: see ?isSingular
```

```
## $`emmeans of year_factor`
##  year_factor emmean     SE  df lower.CL upper.CL
##            2   2.68 0.1093 446     2.47     2.90
##            3   2.78 0.1019 380     2.58     2.98
##            4   2.38 0.1019 364     2.18     2.59
##            5   2.58 0.0987 373     2.39     2.78
##            6   2.56 0.0972 346     2.37     2.75
##
## Results are averaged over the levels of: state, species
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
## $`pairwise differences of year_factor`
##  1     estimate    SE  df t.ratio p.value
##  2 - 3  -0.1003 0.120 575 -0.838  0.9188
##  2 - 4   0.2975 0.120 579  2.489  0.0946
##  2 - 5   0.1001 0.116 578  0.861  0.9110
##  2 - 6   0.1187 0.116 579  1.020  0.8463
##  3 - 4   0.3978 0.113 573  3.511  0.0044
##  3 - 5   0.2004 0.110 572  1.820  0.3628
##  3 - 6   0.2191 0.110 573  1.996  0.2692
##  4 - 5  -0.1974 0.109 574 -1.816  0.3653
##  4 - 6  -0.1788 0.108 575 -1.655  0.4628
##  5 - 6   0.0186 0.104 572  0.179  0.9998
##
## Results are averaged over the levels of: state, species
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## P value adjustment: tukey method for comparing a family of 5 estimates
```

```
emmeans(mod7au, list(pairwise ~ species), adjust = "tukey")
```

```
## boundary (singular) fit: see ?isSingular
```

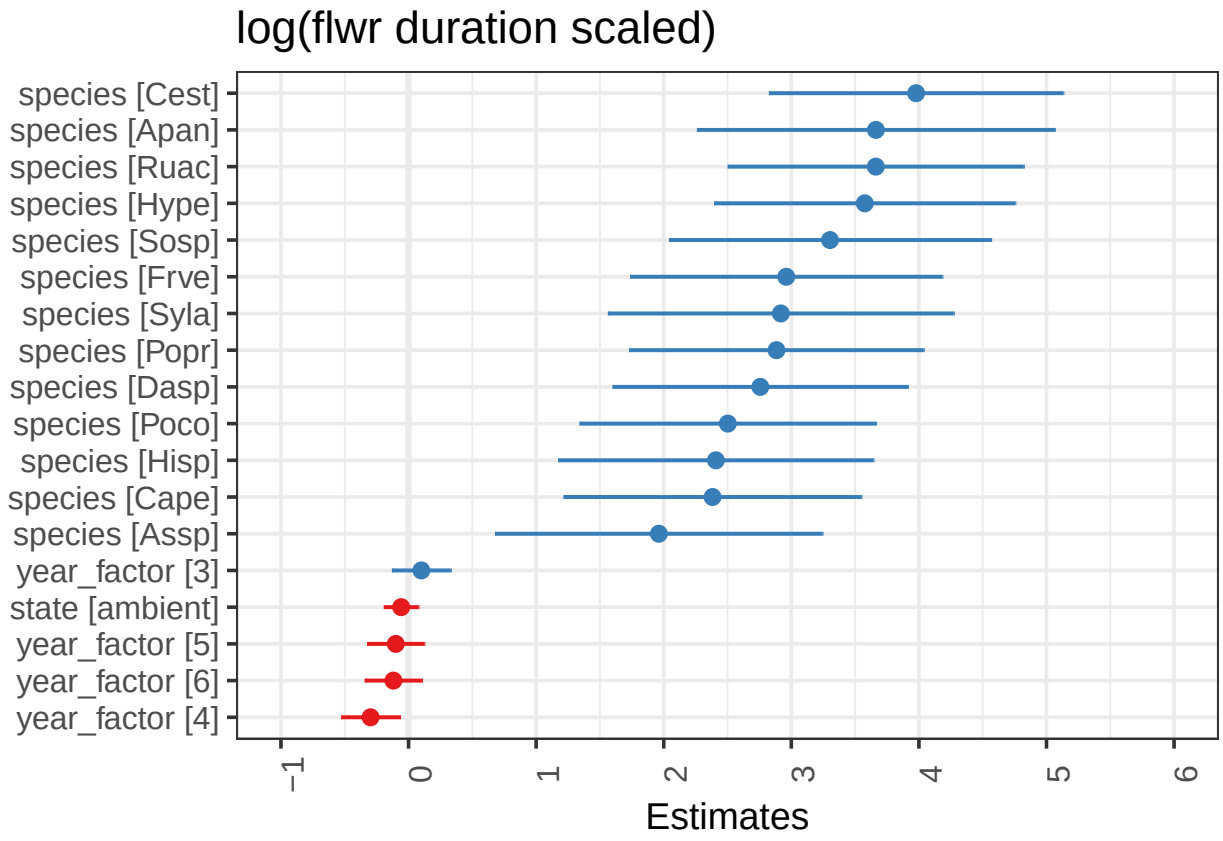
```
## $`emmeans of species`
##  species emmean     SE  df lower.CL upper.CL
##  Ansp    -0.184 0.5959 591    -1.35    0.987
##  Apan     3.480 0.4222 530     2.65    4.309
##  Assp     1.778 0.2988 573     1.19    2.365
##  Cape     2.199 0.1201 400     1.96    2.435
```

```
##  Cest     3.795 0.0778 336     3.64    3.948
##  Dasp     2.573 0.0910 398     2.39    2.752
##  Frve     2.777 0.2270 399     2.33    3.223
##  Hisp     2.225 0.2454 527     1.74    2.708
##  Hype     3.392 0.1452 485     3.11    3.677
##  Poco     2.319 0.1090 451     2.10    2.533
##  Popr     2.700 0.0816 360     2.54    2.860
##  Ruac     3.479 0.1010 363     3.28    3.677
##  Sosp     3.120 0.2831 357     2.56    3.677
##  Syla     2.734 0.3782 520     1.99    3.477
##
## Results are averaged over the levels of: state, year_factor
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
## $`pairwise differences of species`
##  1           estimate    SE  df t.ratio p.value
##  Ansp - Apan -3.66307 0.732 583  -5.002 0.0001
##  Ansp - Assp -1.96170 0.669 590  -2.932 0.1672
##  Ansp - Cape -2.38247 0.608 592  -3.917 0.0075
##  Ansp - Cest -3.97830 0.601 592  -6.620 <.0001
##  Ansp - Dasp -2.75697 0.603 592  -4.574 0.0005
##  Ansp - Frve -2.96021 0.639 585  -4.634 0.0004
##  Ansp - Hisp -2.40897 0.643 591  -3.744 0.0143
##  Ansp - Hype -3.57575 0.615 591  -5.814 <.0001
##  Ansp - Poco -2.50251 0.605 592  -4.135 0.0032
##  Ansp - Popr -2.88350 0.601 592  -4.795 0.0002
##  Ansp - Ruac -3.66212 0.604 592  -6.060 <.0001
##  Ansp - Sosp -3.30338 0.660 576  -5.005 0.0001
##  Ansp - Syla -2.91794 0.708 583  -4.121 0.0034
##  Apan - Assp  1.70136 0.517 537   3.288 0.0639
##  Apan - Cape  1.28059 0.438 548   2.922 0.1715
##  Apan - Cest -0.31523 0.429 547  -0.735 1.0000
##  Apan - Dasp  0.90610 0.433 545   2.095 0.7047
##  Apan - Frve  0.70286 0.479 495   1.467 0.9728
##  Apan - Hisp  1.25409 0.490 556   2.558 0.3703
##  Apan - Hype  0.08732 0.445 551   0.196 1.0000
##  Apan - Poco  1.16056 0.436 528   2.664 0.3031
##  Apan - Popr  0.77957 0.430 545   1.814 0.8692
##  Apan - Ruac  0.00095 0.433 558   0.002 1.0000
##  Apan - Sosp  0.35968 0.509 479   0.707 1.0000
##  Apan - Syla  0.74513 0.566 526   1.317 0.9894
##  Assp - Cape -0.42077 0.322 583  -1.306 0.9902
##  Assp - Cest -2.01659 0.309 588  -6.529 <.0001
##  Assp - Dasp -0.79526 0.312 590  -2.550 0.3752
##  Assp - Frve -0.99850 0.373 577  -2.681 0.2929
##  Assp - Hisp -0.44727 0.386 590  -1.158 0.9969
##  Assp - Hype -1.61404 0.332 583  -4.859 0.0001
##  Assp - Poco -0.54080 0.320 580  -1.691 0.9186
##  Assp - Popr -0.92180 0.310 586  -2.972 0.1515
##  Assp - Ruac -1.70041 0.315 590  -5.395 <.0001
##  Assp - Sosp -1.34168 0.411 552  -3.264 0.0686
##  Assp - Syla -0.95623 0.482 577  -1.984 0.7772
```

```
##  Cape - Cest -1.59582 0.143 580 -11.155 <.0001
##  Cape - Dasp -0.37449 0.151 588  -2.481 0.4232
##  Cape - Frve -0.57773 0.257 463  -2.249 0.5935
##  Cape - Hisp -0.02650 0.274 562  -0.097 1.0000
##  Cape - Hype -1.19328 0.188 552  -6.354 <.0001
##  Cape - Poco -0.12004 0.161 588  -0.744 1.0000
##  Cape - Popr -0.50103 0.145 580  -3.455 0.0381
##  Cape - Ruac -1.27964 0.157 498  -8.138 <.0001
##  Cape - Sosp -0.92091 0.307 446  -2.999 0.1426
##  Cape - Syla -0.53547 0.397 515  -1.349 0.9868
##  Cest - Dasp  1.22133 0.120 583  10.184 <.0001
##  Cest - Frve  1.01809 0.240 481   4.244 0.0021
##  Cest - Hisp  1.56932 0.258 570   6.089 <.0001
##  Cest - Hype  0.40255 0.164 588   2.447 0.4471
##  Cest - Poco  1.47579 0.134 590  11.052 <.0001
##  Cest - Popr  1.09479 0.113 575   9.724 <.0001
##  Cest - Ruac  0.31618 0.127 592   2.483 0.4218
##  Cest - Sosp  0.67491 0.294 407   2.299 0.5567
##  Cest - Syla  1.06036 0.386 543   2.747 0.2552
##  Dasp - Frve -0.20324 0.245 485  -0.831 0.9999
##  Dasp - Hisp  0.34799 0.260 579   1.336 0.9879
##  Dasp - Hype -0.81878 0.172 590  -4.767 0.0002
##  Dasp - Poco  0.25446 0.143 592   1.779 0.8850
##  Dasp - Popr -0.12654 0.123 587  -1.032 0.9990
##  Dasp - Ruac -0.90515 0.136 591  -6.649 <.0001
##  Dasp - Sosp -0.54642 0.297 422  -1.837 0.8581
##  Dasp - Syla -0.16097 0.390 548  -0.413 1.0000
##  Frve - Hisp  0.55123 0.333 588   1.658 0.9295
##  Frve - Hype -0.61554 0.269 479  -2.284 0.5673
##  Frve - Poco  0.45770 0.252 518   1.817 0.8680
##  Frve - Popr  0.07670 0.241 491   0.318 1.0000
##  Frve - Ruac -0.70191 0.248 463  -2.825 0.2158
##  Frve - Sosp -0.34318 0.361 514  -0.951 0.9996
##  Frve - Syla  0.04227 0.440 563   0.096 1.0000
##  Hisp - Hype -1.16677 0.286 577  -4.074 0.0041
##  Hisp - Poco -0.09353 0.270 565  -0.346 1.0000
##  Hisp - Popr -0.47453 0.259 570  -1.831 0.8614
##  Hisp - Ruac -1.25314 0.266 577  -4.718 0.0003
##  Hisp - Sosp -0.89441 0.374 524  -2.393 0.4867
##  Hisp - Syla -0.50897 0.451 566  -1.128 0.9976
##  Hype - Poco  1.07324 0.181 559   5.938 <.0001
##  Hype - Popr  0.69225 0.166 588   4.167 0.0028
##  Hype - Ruac -0.08637 0.176 590  -0.490 1.0000
##  Hype - Sosp  0.27236 0.319 384   0.854 0.9999
##  Hype - Syla  0.65781 0.404 557   1.629 0.9378
##  Poco - Popr -0.38099 0.135 589  -2.817 0.2189
##  Poco - Ruac -1.15961 0.148 556  -7.817 <.0001
##  Poco - Sosp -0.80088 0.302 444  -2.648 0.3131
##  Poco - Syla -0.41543 0.393 534  -1.058 0.9988
##  Popr - Ruac -0.77862 0.130 591  -6.006 <.0001
##  Popr - Sosp -0.41988 0.294 421  -1.427 0.9784
##  Popr - Syla -0.03444 0.387 542  -0.089 1.0000
##  Ruac - Sosp  0.35873 0.300 399   1.194 0.9957
##  Ruac - Syla  0.74418 0.391 557   1.905 0.8235
```

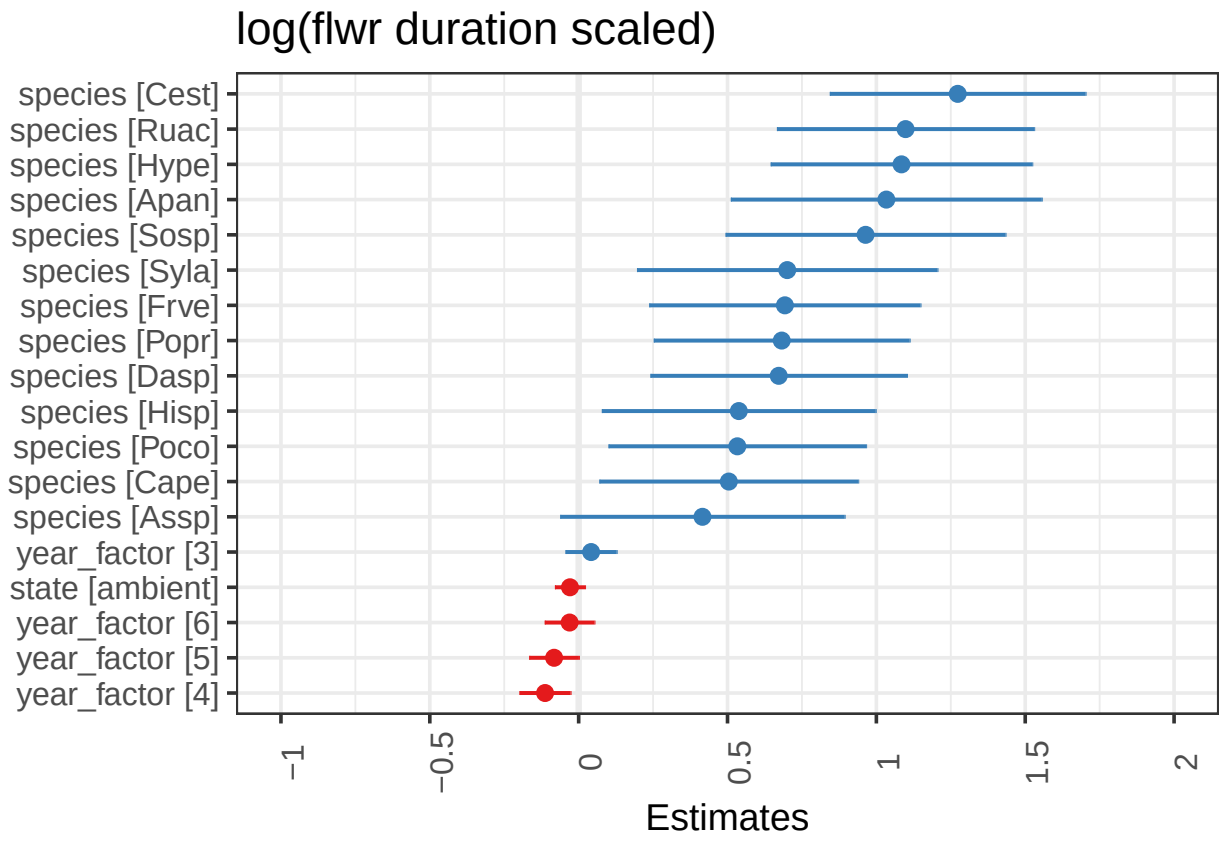
```
##  Sosp - Syla  0.38545 0.470 550   0.821 0.9999
##
## Results are averaged over the levels of: state, year_factor
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## P value adjustment: tukey method for comparing a family of 14 estimates
```

```
# Take a look at the estimates for each fixed effect. These are the estimates
# from summary(mod7a). You'll see that species vary a lot - and many of them are
# different from zero (meaning their half cover date is significantly different
# from zero).
plot_model(mod7au, sort.est = TRUE)
```



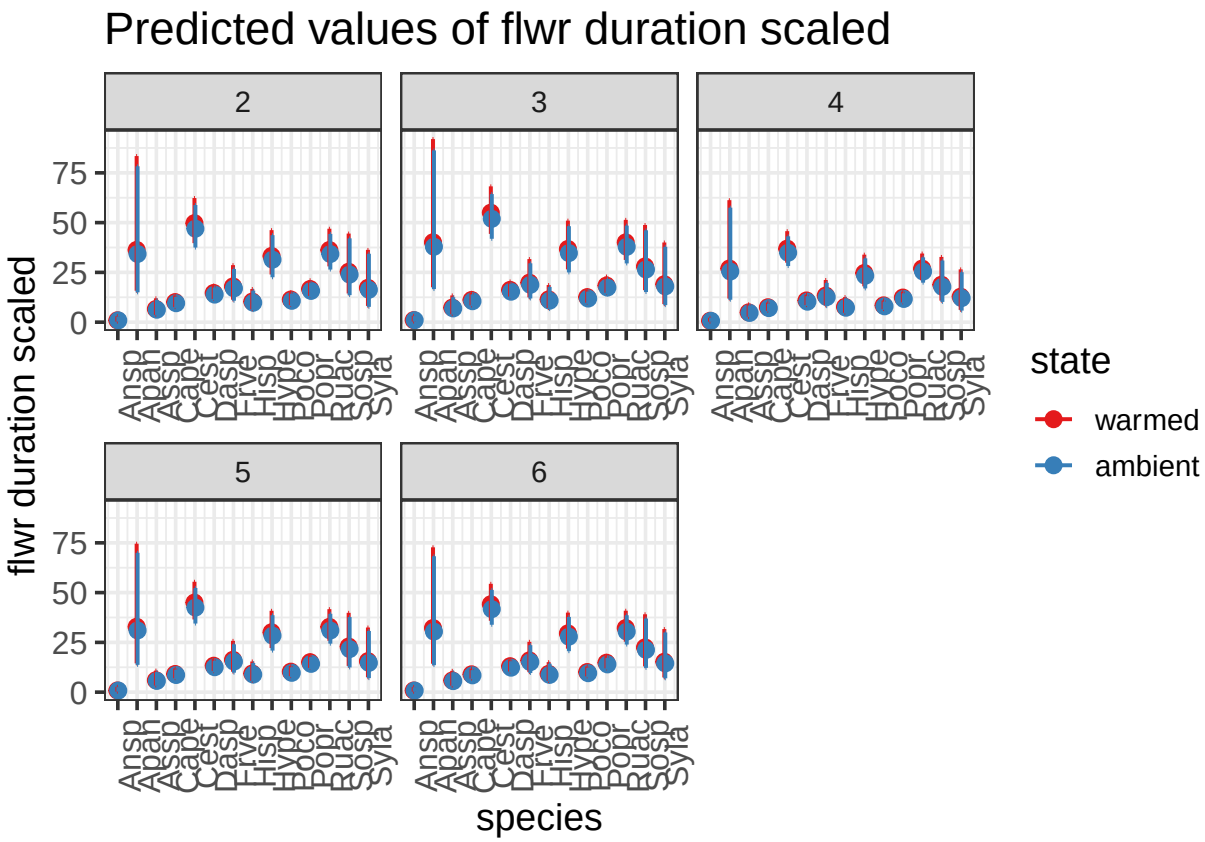

```
# if you want to standardize the estimates:
plot_model(mod7au, sort.est = TRUE, type = "std")
```

```
## Formula contains log- or sqrt-terms. See help("standardize") for how such terms are standardized.
## boundary (singular) fit: see ?isSingular
```

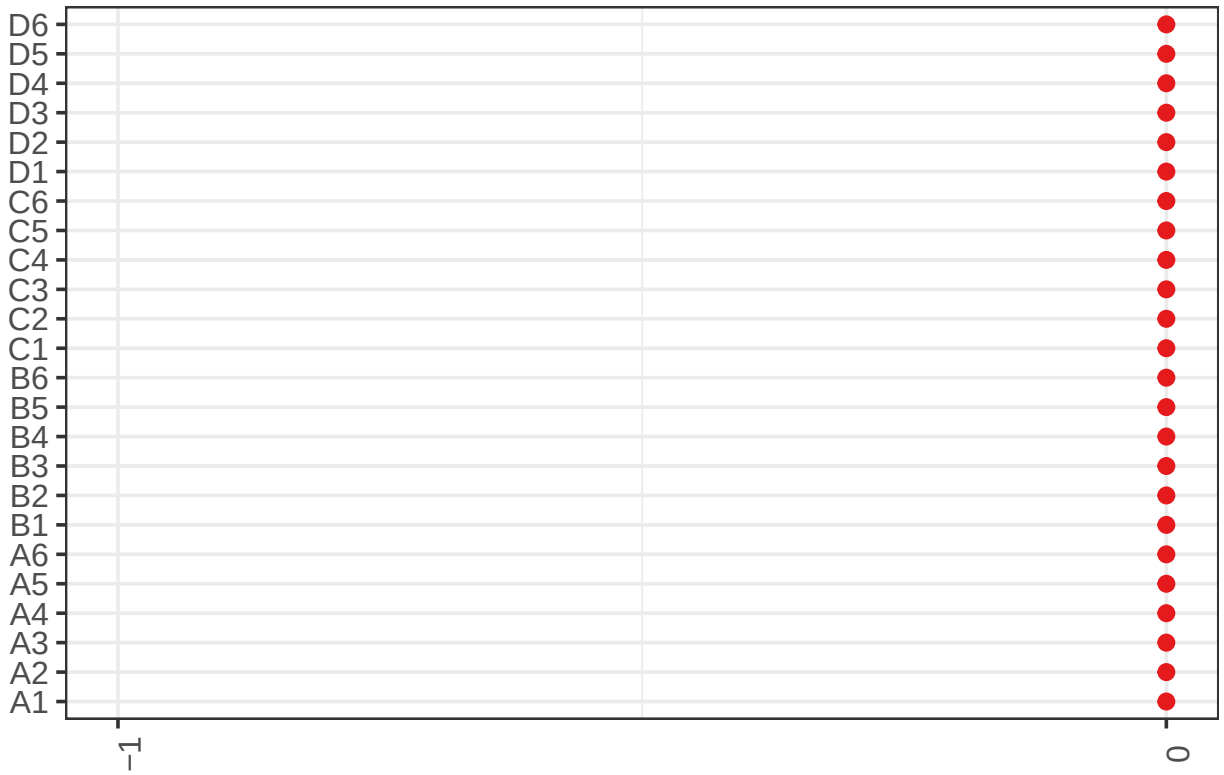



```
# these are the fixed predicted values: - note this is a new plot
plot_model(mod7au, type = "pred", terms = c("species", "state", "year_factor"))
```

```
## Model has log-transformed response. Back-transforming predictions to original response scale. Standa
```




```
# these are the random effects estimates
plot_model(mod7au, type = "re")
```




```
# including native vs. exotic
umbs_flwr_spp <- within(umbs_flwr_spp, origin <- relevel(factor(origin), ref = "Native"))  # releveling
mod8u <- lmer(log(flwr_duration_scaled) ~ state * origin + (1 + factor(year_factor) |
    plot), umbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod9u <- lmer(log(flwr_duration_scaled) ~ state + origin + (1 + factor(year_factor) |
    plot), umbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod9au <- lmer(log(flwr_duration_scaled) ~ state + origin + factor(year_factor) +
    (1 | plot), umbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
anova(mod8u, mod9u)  # model 9 is a better fit to data
```

```
## Data: umbs_flwr_spp
## Models:
## mod9u: log(flwr_duration_scaled) ~ state + origin + (1 + factor(year_factor) |
## mod9u:     plot)
## mod8u: log(flwr_duration_scaled) ~ state * origin + (1 + factor(year_factor) |
```

```
## mod8u:     plot)
##       npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## mod9u   20 1631.2 1718.2 -795.63   1591.2
## mod8u   22 1634.4 1730.1 -795.21   1590.4 0.8376  2     0.6578
```

```
anova(mod9u, mod9au)  # mod 9a
```

```
## Data: umbs_flwr_spp
## Models:
## mod9au: log(flwr_duration_scaled) ~ state + origin + factor(year_factor) +
## mod9au:     (1 | plot)
## mod9u: log(flwr_duration_scaled) ~ state + origin + (1 + factor(year_factor) |
## mod9u:     plot)
##        npar    AIC    BIC  logLik deviance Chisq Df Pr(>Chisq)
## mod9au   10 1601.0 1644.5 -790.50   1581.0
## mod9u    20 1631.2 1718.2 -795.63   1591.2     0 10          1
```

```
summary(mod9au)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: log(flwr_duration_scaled) ~ state + origin + factor(year_factor) +
##     (1 | plot)
##    Data: umbs_flwr_spp
##
##      AIC      BIC   logLik deviance df.resid
##   1601.0   1644.5   -790.5   1581.0      562
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.5185 -0.5281  0.2371  0.6719  1.8794
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  plot     (Intercept) 0.0000   0.0000
##  Residual             0.9288   0.9637
## Number of obs: 572, groups:  plot, 24
##
## Fixed effects:
##                       Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)            2.71513    0.12195 572.00000  22.265  < 2e-16 ***
## stateambient          -0.02624    0.08064 572.00000  -0.325  0.74499
## originBoth            -0.49302    0.22959 572.00000  -2.147  0.03218 *
## originExotic           0.67577    0.08961 572.00000   7.541 1.84e-13 ***
## factor(year_factor)3  -0.09745    0.13654 572.00000  -0.714  0.47568
## factor(year_factor)4  -0.41544    0.13641 572.00000  -3.046  0.00243 **
## factor(year_factor)5  -0.23516    0.13249 572.00000  -1.775  0.07644 .
## factor(year_factor)6  -0.25103    0.13221 572.00000  -1.899  0.05811 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) sttmbn orgnBt orgnEx fc(_)3 fc(_)4 fc(_)5
```

```
## stateambint -0.338
## originBoth  -0.276 -0.013
## originExotc -0.445  0.025  0.257
## fctr(yr_f)3 -0.583  0.001  0.090 -0.069
## fctr(yr_f)4 -0.577 -0.002  0.087 -0.082  0.549
## fctr(yr_f)5 -0.598 -0.002  0.097 -0.077  0.565  0.567
## fctr(yr_f)6 -0.598  0.000  0.108 -0.088  0.568  0.570  0.587
## optimizer (nloptwrap) convergence code: 0 (OK)
## boundary (singular) fit: see ?isSingular
```

```
anova(mod9au)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##                     Sum Sq Mean Sq NumDF DenDF F value    Pr(>F)
## state                0.098   0.098     1   572  0.1059   0.74499
## origin              69.416  34.708     2   572 37.3705 5.577e-16 ***
## factor(year_factor) 10.356   2.589     4   572  2.7877   0.02587 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
emmeans(mod9au, list(pairwise ~ state + origin), adjust = "tukey")
```

```
## boundary (singular) fit: see ?isSingular

## $`emmeans of state, origin`
##  state   origin emmean     SE    df lower.CL upper.CL
##  warmed  Native   2.52 0.0863  82.3     2.34     2.69
##  ambient Native   2.49 0.0855  75.7     2.32     2.66
##  warmed  Both     2.02 0.2254 438.5     1.58     2.47
##  ambient Both     2.00 0.2243 409.1     1.56     2.44
##  warmed  Exotic   3.19 0.0640  32.6     3.06     3.32
##  ambient Exotic   3.16 0.0656  35.4     3.03     3.30
##
## Results are averaged over the levels of: year_factor
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
## $`pairwise differences of state, origin`
##  1                              estimate     SE    df t.ratio p.value
##  warmed Native - ambient Native   0.0262 0.0817  21.0  0.321  0.9995
##  warmed Native - warmed Both      0.4930 0.2327 571.6  2.119  0.2791
##  warmed Native - ambient Both     0.5193 0.2459 377.8  2.112  0.2833
##  warmed Native - warmed Exotic   -0.6758 0.0909 561.4 -7.437  <.0001
##  warmed Native - ambient Exotic  -0.6495 0.1235  90.4 -5.257  <.0001
##  ambient Native - warmed Both     0.4668 0.2474 418.7  1.887  0.4116
##  ambient Native - ambient Both    0.4930 0.2327 571.6  2.119  0.2791
##  ambient Native - warmed Exotic  -0.7020 0.1208  80.0 -5.812  <.0001
##  ambient Native - ambient Exotic -0.6758 0.0909 561.4 -7.437  <.0001
##  warmed Both - ambient Both       0.0262 0.0817  21.0  0.321  0.9995
##  warmed Both - warmed Exotic     -1.1688 0.2276 550.8 -5.134  <.0001
##  warmed Both - ambient Exotic    -1.1425 0.2433 379.4 -4.696  0.0001
```

```
##  ambient Both - warmed Exotic     -1.1950 0.2404 330.5 -4.971  <.0001
##  ambient Both - ambient Exotic    -1.1688 0.2276 550.8 -5.134  <.0001
##  warmed Exotic - ambient Exotic    0.0262 0.0817  21.0  0.321  0.9995
##
## Results are averaged over the levels of: year_factor
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## P value adjustment: tukey method for comparing a family of 6 estimates
```

```
emmeans(mod9au, list(pairwise ~ origin), adjust = "tukey")
```

```
## boundary (singular) fit: see ?isSingular
```

```
## $`emmeans of origin`
##  origin emmean     SE    df lower.CL upper.CL
##  Native   2.50 0.0756 143.6     2.35     2.65
##  Both     2.01 0.2211 482.4     1.57     2.44
##  Exotic   3.18 0.0503  50.1     3.08     3.28
##
## Results are averaged over the levels of: state, year_factor
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
## $`pairwise differences of origin`
##  1               estimate     SE  df t.ratio p.value
##  Native - Both      0.493 0.2327 572  2.119  0.0870
##  Native - Exotic   -0.676 0.0909 561 -7.437  <.0001
##  Both - Exotic     -1.169 0.2276 551 -5.134  <.0001
##
## Results are averaged over the levels of: state, year_factor
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## P value adjustment: tukey method for comparing a family of 3 estimates
```

```
emmeans(mod9au, list(pairwise ~ factor(year_factor)), adjust = "tukey")
```

```
## boundary (singular) fit: see ?isSingular
```

```
## $`emmeans of year_factor`
##  year_factor emmean    SE  df lower.CL upper.CL
##            2   2.76 0.114 396     2.54     2.99
##            3   2.67 0.117 378     2.44     2.89
##            4   2.35 0.117 364     2.12     2.58
##            5   2.53 0.112 358     2.31     2.75
##            6   2.51 0.113 335     2.29     2.73
##
## Results are averaged over the levels of: state, origin
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
```

```
## $`pairwise differences of year_factor`
##  1     estimate    SE  df t.ratio p.value
##  2 - 3   0.0975 0.138 565  0.708  0.9546
##  2 - 4   0.4154 0.138 568  3.021  0.0220
##  2 - 5   0.2352 0.133 565  1.762  0.3973
##  2 - 6   0.2510 0.133 566  1.884  0.3271
##  3 - 4   0.3180 0.131 564  2.434  0.1079
##  3 - 5   0.1377 0.126 564  1.089  0.8124
##  3 - 6   0.1536 0.126 563  1.220  0.7395
##  4 - 5  -0.1803 0.126 565 -1.429  0.6094
##  4 - 6  -0.1644 0.126 565 -1.310  0.6853
##  5 - 6   0.0159 0.121 561  0.131  0.9999
##
## Results are averaged over the levels of: state, origin
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## P value adjustment: tukey method for comparing a family of 5 estimates
```

```
# including growth form - first with interaction term
umbs_flwr_spp <- within(umbs_flwr_spp, growth_habit <- relevel(factor(growth_habit),
    ref = "Forb"))  # releveling so forb is the reference
mod10u <- lmer(log(flwr_duration_scaled) ~ state * growth_habit + (1 + factor(year_factor) |
    plot), umbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
## Warning: Model failed to converge with 1 negative eigenvalue: -7.5e+00
```

```
mod11u <- lmer(log(flwr_duration_scaled) ~ state + growth_habit + (1 + factor(year_factor) |
    plot), umbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod11au <- lmer(log(flwr_duration_scaled) ~ state + growth_habit + factor(year_factor) +
    (1 | plot), umbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
anova(mod10u, mod11u)  # model 11 is a better fit to data
```

```
## Data: umbs_flwr_spp
## Models:
## mod11u: log(flwr_duration_scaled) ~ state + growth_habit + (1 + factor(year_factor) |
## mod11u:     plot)
## mod10u: log(flwr_duration_scaled) ~ state * growth_habit + (1 + factor(year_factor) |
## mod10u:     plot)
##        npar    AIC    BIC  logLik deviance Chisq Df Pr(>Chisq)
## mod11u   20 1556.8 1643.8 -758.39   1516.8
## mod10u   22 1560.8 1656.5 -758.43   1516.8     0  2          1
```

```r
anova(mod11u, mod11au)  # model 11a
```

```
## Data: umbs_flwr_spp
## Models:
## mod11au: log(flwr_duration_scaled) ~ state + growth_habit + factor(year_factor) +
## mod11au:     (1 | plot)
## mod11u: log(flwr_duration_scaled) ~ state + growth_habit + (1 + factor(year_factor) |
## mod11u:     plot)
##         npar    AIC    BIC  logLik deviance Chisq Df Pr(>Chisq)
## mod11au   10 1527.5 1571.0 -753.73   1507.5
## mod11u    20 1556.8 1643.8 -758.39   1516.8     0 10          1
```

```r
summary(mod11au)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula:
## log(flwr_duration_scaled) ~ state + growth_habit + factor(year_factor) +
##     (1 | plot)
##    Data: umbs_flwr_spp
##
##      AIC      BIC   logLik deviance df.resid
##   1527.5   1571.0   -753.7   1507.5      562
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.0778 -0.2429  0.1705  0.6324  2.0229
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  plot     (Intercept) 0.0000   0.0000
##  Residual             0.8167   0.9037
## Number of obs: 572, groups:  plot, 24
##
## Fixed effects:
##                         Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)              3.61421    0.11061 572.00000  32.675  < 2e-16 ***
## stateambient            -0.10167    0.07575 572.00000  -1.342   0.1801
## growth_habit            -1.25297    0.27019 572.00000  -4.637 4.38e-06 ***
## growth_habitGraminoid   -0.95868    0.07676 572.00000 -12.490  < 2e-16 ***
## factor(year_factor)3     0.07104    0.12741 572.00000   0.558   0.5774
## factor(year_factor)4    -0.30074    0.12727 572.00000  -2.363   0.0185 *
## factor(year_factor)5    -0.13446    0.12414 572.00000  -1.083   0.2792
## factor(year_factor)6    -0.13339    0.12328 572.00000  -1.082   0.2797
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) sttmbn grwth_ grwt_G fc(_)3 fc(_)4 fc(_)5
## stateambint -0.366
## growth_habt -0.227  0.055
## grwth_hbtGr -0.379  0.046  0.155
```

```
## fctr(yr_f)3 -0.617  0.007  0.070 -0.038
## fctr(yr_f)4 -0.635  0.007  0.095  0.001  0.543
## fctr(yr_f)5 -0.656  0.009  0.135 -0.002  0.560  0.563
## fctr(yr_f)6 -0.661  0.011  0.121  0.003  0.562  0.566  0.584
## optimizer (nloptwrap) convergence code: 0 (OK)
## boundary (singular) fit: see ?isSingular
```

```
anova(mod11au)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##                       Sum Sq Mean Sq NumDF DenDF F value Pr(>F)
## state                  1.471   1.471     1   572  1.8015 0.1801
## growth_habit         133.493  66.747     2   572 81.7238 <2e-16 ***
## factor(year_factor)    8.855   2.214     4   572  2.7106 0.0294 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
emmeans(mod11au, list(pairwise ~ factor(year_factor)), adjust = "tukey")
```

```
## boundary (singular) fit: see ?isSingular
```

```
## $`emmeans of year_factor`
##  year_factor emmean    SE  df lower.CL upper.CL
##            2   2.83 0.119 431     2.59     3.06
##            3   2.90 0.121 411     2.66     3.13
##            4   2.53 0.122 410     2.29     2.77
##            5   2.69 0.121 420     2.45     2.93
##            6   2.69 0.119 395     2.46     2.93
##
## Results are averaged over the levels of: state, growth_habit
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
## $`pairwise differences of year_factor`
##  1     estimate    SE  df t.ratio p.value
##  2 - 3 -0.07104 0.128 564 -0.553  0.9815
##  2 - 4  0.30074 0.128 567  2.345  0.1325
##  2 - 5  0.13446 0.125 564  1.075  0.8194
##  2 - 6  0.13339 0.124 564  1.074  0.8199
##  3 - 4  0.37177 0.123 563  3.032  0.0213
##  3 - 5  0.20549 0.119 563  1.728  0.4175
##  3 - 6  0.20443 0.118 563  1.730  0.4165
##  4 - 5 -0.16628 0.118 564 -1.404  0.6253
##  4 - 6 -0.16734 0.118 565 -1.421  0.6140
##  5 - 6 -0.00106 0.114 561 -0.009  1.0000
##
## Results are averaged over the levels of: state, growth_habit
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## P value adjustment: tukey method for comparing a family of 5 estimates
```

```
emmeans(mod11au, list(pairwise ~ growth_habit), adjust = "tukey")
```

```
## boundary (singular) fit: see ?isSingular

## $`emmeans of growth_habit`
##  growth_habit emmean     SE    df lower.CL upper.CL
##  Forb           3.46 0.0572  81.6     3.35     3.58
##                 2.21 0.2679 521.6     1.68     2.74
##  Graminoid      2.51 0.0530  73.0     2.40     2.61
##
## Results are averaged over the levels of: state, year_factor
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
## $`pairwise differences of growth_habit`
##  1                estimate     SE  df t.ratio p.value
##  Forb -              1.253 0.2741 570  4.571  <.0001
##  Forb - Graminoid    0.959 0.0778 564 12.328  <.0001
##   - Graminoid       -0.294 0.2734 557 -1.076  0.5292
##
## Results are averaged over the levels of: state, year_factor
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## P value adjustment: tukey method for comparing a family of 3 estimates
```

```
emmeans(mod11au, list(pairwise ~ state + growth_habit), adjust = "tukey")
```

```
## boundary (singular) fit: see ?isSingular

## $`emmeans of state, growth_habit`
##  state   growth_habit emmean     SE    df lower.CL upper.CL
##  warmed  Forb           3.51 0.0697  54.5     3.37     3.65
##  ambient Forb           3.41 0.0680  43.5     3.28     3.55
##  warmed                 2.26 0.2686 490.2     1.73     2.79
##  ambient                2.16 0.2725 487.4     1.62     2.70
##  warmed  Graminoid      2.56 0.0644  41.0     2.43     2.69
##  ambient Graminoid      2.45 0.0664  47.0     2.32     2.59
##
## Results are averaged over the levels of: year_factor
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
## $`pairwise differences of state, growth_habit`
##  1                                  estimate     SE    df t.ratio p.value
##  warmed Forb - ambient Forb            0.102 0.0767  21.1  1.325  0.7683
##  warmed Forb - warmed                  1.253 0.2741 569.8  4.571  0.0001
##  warmed Forb - ambient                 1.355 0.2887 467.2  4.692  0.0001
##  warmed Forb - warmed Graminoid        0.959 0.0778 564.3 12.328  <.0001
##  warmed Forb - ambient Graminoid       1.060 0.1115  85.0  9.513  <.0001
##  ambient Forb - warmed                 1.151 0.2805 460.9  4.105  0.0007
```

```
##  ambient Forb - ambient                  1.253 0.2741 569.8  4.571  0.0001
##  ambient Forb - warmed Graminoid         0.857 0.1070  63.5  8.012  <.0001
##  ambient Forb - ambient Graminoid        0.959 0.0778 564.3 12.328  <.0001
##  warmed  - ambient                       0.102 0.0767  21.1  1.325  0.7683
##  warmed  - warmed Graminoid             -0.294 0.2734 557.4 -1.076  0.8907
##  warmed  - ambient Graminoid            -0.193 0.2807 443.0 -0.686  0.9834
##  ambient  - warmed Graminoid            -0.396 0.2872 437.1 -1.379  0.7400
##  ambient  - ambient Graminoid           -0.294 0.2734 557.4 -1.076  0.8907
##  warmed Graminoid - ambient Graminoid    0.102 0.0767  21.1  1.325  0.7683
##
## Results are averaged over the levels of: year_factor
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## P value adjustment: tukey method for comparing a family of 6 estimates
```

```
# New version of our model incorporating interaction term and species within year
# so that there is a separate intercept and slope for each species. The issue
# here is that there are some species that are not found each year. Easiest to
# remove those from another version of this dataframe before running below.
# Otherwise, it's not a balanced design.  updated mod4
mod12u <- lmer(log(flwr_duration_scaled) ~ state * factor(year_factor) + (1 + factor(year_factor) |
    species), umbs_flwr_spp)
```

```
## boundary (singular) fit: see ?isSingular
```

```
# So another version of this model would include the interaction but not include
# the nesting (and thus would assume that species aren't observed ea yr) updated
# mod5
mod13u <- lmer(log(flwr_duration_scaled) ~ state * factor(year_factor) + (1 | species),
    umbs_flwr_spp)

# All the models ran:
mod1u <- lmer(log(flwr_duration_scaled) ~ state * year_factor + insecticide * year_factor +
    (1 | species) + (1 | plot), umbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod2u <- lmer(log(flwr_duration_scaled) ~ state * year_factor + insecticide * year_factor +
    (1 | species), umbs_flwr_spp, REML = FALSE)
mod3u <- lmer(log(flwr_duration_scaled) ~ state * year_factor + (1 | species), umbs_flwr_spp,
    REML = FALSE)
mod4u <- lmer(log(flwr_duration_scaled) ~ state * year_factor + insecticide + (1 |
    species) + (1 | plot), umbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod5u <- lmer(log(flwr_duration_scaled) ~ state + year_factor + (1 | species), umbs_flwr_spp,
    REML = FALSE)
mod6u <- lmer(log(flwr_duration_scaled) ~ state + year_factor + (1 | species) + (1 +
    year | plot), umbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
## Warning: Model failed to converge with 1 negative eigenvalue: -1.1e-01
```

```
mod7u <- lmer(log(flwr_duration_scaled) ~ state + species + (1 + factor(year_factor) |
    plot), umbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
## Warning: Model failed to converge with 1 negative eigenvalue: -1.7e+00
```

```
mod7au <- lmer(log(flwr_duration_scaled) ~ state + species + factor(year_factor) +
    (1 | plot), umbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod7bu <- lmer(log(flwr_duration_scaled) ~ state * factor(year_factor) + species +
    (1 | plot), umbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod7cu <- lmer(log(flwr_duration_scaled) ~ state + species + factor(year_factor) +
    insecticide + (1 | plot), umbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod8u <- lmer(log(flwr_duration_scaled) ~ state * origin + (1 + factor(year_factor) |
    plot), umbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod9u <- lmer(log(flwr_duration_scaled) ~ state + origin + (1 + factor(year_factor) |
    plot), umbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod9au <- lmer(log(flwr_duration_scaled) ~ state + origin + factor(year_factor) +
    (1 | plot), umbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod10u <- lmer(log(flwr_duration_scaled) ~ state * growth_habit + (1 + factor(year_factor) |
    plot), umbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
## Warning: Model failed to converge with 1 negative eigenvalue: -7.5e+00
```

```
mod11u <- lmer(log(flwr_duration_scaled) ~ state + growth_habit + (1 + factor(year_factor) |
    plot), umbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod11au <- lmer(log(flwr_duration_scaled) ~ state + growth_habit + factor(year_factor) +
    (1 | plot), umbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod12u <- lmer(log(flwr_duration_scaled) ~ state * factor(year_factor) + (1 + factor(year_factor) |
    species), umbs_flwr_spp, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod13u <- lmer(log(flwr_duration_scaled) ~ state * factor(year_factor) + (1 | species),
    umbs_flwr_spp, REML = FALSE)
AICctab(mod1u, mod2u, mod3u, mod5u, mod6u, mod7u, mod7au, mod7bu, mod7cu, mod8u,
    mod9u, mod9au, mod10u, mod11u, mod11au, mod12u, mod13u, weights = T)  # mod7a is the best fitting m
```

```
##         dAICc df weight
## mod12u    0.0 26 1
## mod7au   51.1 21 <0.001
## mod7cu   53.0 22 <0.001
## mod7bu   57.6 25 <0.001
## mod7u    84.3 31 <0.001
## mod5u    85.6 5  <0.001
## mod3u    86.5 6  <0.001
## mod13u   88.0 12 <0.001
## mod2u    90.4 8  <0.001
## mod1u    92.5 9  <0.001
## mod6u    94.1 8  <0.001
## mod11au 139.9 10 <0.001
## mod11u  170.4 20 <0.001
## mod10u  174.8 22 <0.001
## mod9au  213.4 10 <0.001
## mod9u   244.8 20 <0.001
## mod8u   248.3 22 <0.001
```

```
AICctab(mod12u, mod7au, weights = T)
```

```
##        dAICc df weight
## mod12u  0.0  26 1
## mod7au 51.1  21 <0.001
```

```
summary(mod12u)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
```

```
## Formula: log(flwr_duration_scaled) ~ state * factor(year_factor) + (1 +
##     factor(year_factor) | species)
##    Data: umbs_flwr_spp
##
##      AIC      BIC   logLik deviance df.resid
##   1385.4   1498.4   -666.7   1333.4      546
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -5.5538 -0.1904  0.1693  0.4779  2.3481
##
## Random effects:
##  Groups   Name                 Variance Std.Dev. Corr
##  species  (Intercept)          0.5267   0.7258
##           factor(year_factor)3 1.3610   1.1666   -0.66
##           factor(year_factor)4 0.6057   0.7783   -0.41  0.75
##           factor(year_factor)5 0.5907   0.7686   -0.73  0.89  0.87
##           factor(year_factor)6 0.8745   0.9351   -0.56  0.68  0.96  0.90
##  Residual                      0.5182   0.7198
## Number of obs: 572, groups:  species, 14
##
## Fixed effects:
##                                   Estimate Std. Error        df t value
## (Intercept)                        2.90380    0.25306  12.80663  11.475
## stateambient                      -0.13725    0.15134 525.07085  -0.907
## factor(year_factor)3              -0.17380    0.39042   7.71005  -0.445
## factor(year_factor)4              -0.29914    0.27931  13.70068  -1.071
## factor(year_factor)5              -0.18729    0.27991  11.04786  -0.669
## factor(year_factor)6              -0.04445    0.32111  14.68880  -0.138
## stateambient:factor(year_factor)3 -0.01392    0.20597 527.32347  -0.068
## stateambient:factor(year_factor)4  0.02707    0.20441 527.11601   0.132
## stateambient:factor(year_factor)5  0.22896    0.19866 527.88095   1.153
## stateambient:factor(year_factor)6  0.11038    0.19765 525.58936   0.558
##                                   Pr(>|t|)
## (Intercept)                       4.15e-08 ***
## stateambient                         0.365
## factor(year_factor)3                 0.668
## factor(year_factor)4                 0.303
## factor(year_factor)5                 0.517
## factor(year_factor)6                 0.892
## stateambient:factor(year_factor)3    0.946
## stateambient:factor(year_factor)4    0.895
## stateambient:factor(year_factor)5    0.250
## stateambient:factor(year_factor)6    0.577
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) sttmbn fc(_)3 fc(_)4 fc(_)5 fc(_)6 s:(_)3 s:(_)4 s:(_)5
## stateambint -0.303
## fctr(yr_f)3 -0.696  0.199
## fctr(yr_f)4 -0.554  0.273  0.698
## fctr(yr_f)5 -0.772  0.274  0.810  0.797
## fctr(yr_f)6 -0.654  0.239  0.647  0.865  0.828
```

```
## sttmbn:(_)3  0.223 -0.737 -0.262 -0.201 -0.202 -0.176
## sttmbn:(_)4  0.224 -0.739 -0.151 -0.375 -0.208 -0.183  0.545
## sttmbn:(_)5  0.231 -0.762 -0.159 -0.215 -0.362 -0.187  0.562  0.565
## sttmbn:(_)6  0.230 -0.766 -0.150 -0.210 -0.209 -0.309  0.565  0.567  0.585
## optimizer (nloptwrap) convergence code: 0 (OK)
## boundary (singular) fit: see ?isSingular
```

```
anova(mod12u)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##                            Sum Sq Mean Sq NumDF  DenDF F value Pr(>F)
## state                      0.6107 0.61067     1 527.32  1.1785 0.2782
## factor(year_factor)        3.7721 0.94304     4   6.97  1.8200 0.2300
## state:factor(year_factor) 1.1831 0.29576     4 526.91  0.5708 0.6839
```

UMBS Plot-level Mixed Effects Models:

```
mod1up <- lmer(flwr_duration_scaled ~ state + (1 | plot), umbs_flwr_plot, REML = FALSE)
mod2up <- lmer(flwr_duration_scaled ~ insecticide + (1 | plot), umbs_flwr_plot, REML = FALSE)
mod3up <- lmer(flwr_duration_scaled ~ insecticide + state + (1 | plot), umbs_flwr_plot,
    REML = FALSE)
mod4up <- lmer(flwr_duration_scaled ~ insecticide * state + (1 | plot), umbs_flwr_plot,
    REML = FALSE)
mod5up <- lmer(flwr_duration_scaled ~ state + year_factor + (1 | plot), umbs_flwr_plot,
    REML = FALSE)
mod6up <- lmer(flwr_duration_scaled ~ state + year_factor + insecticide + (1 | plot),
    umbs_flwr_plot, REML = FALSE)
mod7up <- lmer(flwr_duration_scaled ~ state * year_factor + (1 | plot), umbs_flwr_plot,
    REML = FALSE)
mod8up <- lmer(flwr_duration_scaled ~ state * year_factor + insecticide + (1 | plot),
    umbs_flwr_plot, REML = FALSE)
mod9up <- lmer(flwr_duration_scaled ~ state * insecticide + year_factor + (1 | plot),
    umbs_flwr_plot, REML = FALSE)
mod10up <- lmer(flwr_duration_scaled ~ state + insecticide * year_factor + (1 | plot),
    umbs_flwr_plot, REML = FALSE)
mod11up <- lmer(flwr_duration_scaled ~ state * year_factor * insecticide + (1 | plot),
    umbs_flwr_plot, REML = FALSE)
AICctab(mod1up, mod2up, mod3up, mod4up, mod5up, mod6up, mod7up, mod8up, mod9up, mod10up,
    mod11up, weights = T)
```

```
##         dAICc df weight
## mod1up   0.0  4  0.262
## mod2up   0.2  4  0.232
## mod3up   1.4  5  0.131
## mod5up   2.1  5  0.090
## mod7up   2.3  6  0.083
## mod4up   3.3  6  0.051
## mod6up   3.6  6  0.044
## mod8up   3.8  7  0.040
## mod10up  4.0  7  0.036
```

```
## mod9up   5.5  7  0.017
## mod11up  5.8  10 0.014
```

```
anova(mod1up, mod2up)  # go with simpler model 1up
```

```
## Data: umbs_flwr_plot
## Models:
## mod1up: flwr_duration_scaled ~ state + (1 | plot)
## mod2up: flwr_duration_scaled ~ insecticide + (1 | plot)
##        npar    AIC    BIC  logLik deviance Chisq Df Pr(>Chisq)
## mod1up    4 782.35 793.50 -387.17   774.35
## mod2up    4 782.59 793.74 -387.29   774.59     0  0
```

```
AICctab(mod1up, mod2up, weights = T)
```

```
##        dAICc df weight
## mod1up 0.0   4  0.53
## mod2up 0.2   4  0.47
```

```
summ(mod1up)
```

Observations	120
Dependent variable	flwr_duration_scaled
Type	Mixed effects linear regression

AIC	782.35
BIC	793.50
Pseudo-R^2 (fixed effects)	0.02
Pseudo-R^2 (total)	0.23

Fixed Effects					
	Est.	S.E.	t val.	d.f.	p
(Intercept)	28.52	1.12	25.43	24.00	0.00
stateambient	-1.60	1.59	-1.01	24.00	0.32

p values calculated using Satterthwaite d.f.

Random Effects		
Group	Parameter	Std. Dev.
plot	(Intercept)	2.98
Residual		5.58

Grouping Variables		
Group	# groups	ICC
plot	24	0.22

```r
summary(mod1up)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: flwr_duration_scaled ~ state + (1 | plot)
##    Data: umbs_flwr_plot
##
##      AIC      BIC   logLik deviance df.resid
##    782.3    793.5   -387.2    774.3      116
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.60901 -0.56153 -0.02106  0.59887  2.87040
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  plot     (Intercept)  8.872   2.979
##  Residual             31.119   5.578
## Number of obs: 120, groups:  plot, 24
##
## Fixed effects:
##              Estimate Std. Error     df t value Pr(>|t|)
## (Intercept)    28.517      1.122 24.000  25.425   <2e-16 ***
## stateambient   -1.601      1.586 24.000  -1.009    0.323
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr)
## stateambint -0.707
```

```r
emmeans(mod1up, list(pairwise ~ state), adjust = "tukey")
```

```
## $`emmeans of state`
##  state   emmean   SE   df lower.CL upper.CL
##  warmed    28.5 1.17 26.2     26.1     30.9
##  ambient   26.9 1.17 26.2     24.5     29.3
##
## Degrees-of-freedom method: kenward-roger
## Confidence level used: 0.95
##
## $`pairwise differences of state`
##  1                estimate   SE   df t.ratio p.value
##  warmed - ambient      1.6 1.66 26.2 0.966   0.3428
##
## Degrees-of-freedom method: kenward-roger
```

```r
# including native vs. exotic
umbs_flwr_plot_origin <- within(umbs_flwr_plot_origin, origin <- relevel(factor(origin),
    ref = "Native"))  # releveling so native is the reference
mod12up <- lmer(log(flwr_duration_scaled) ~ state * origin + (1 + year_factor | plot),
    umbs_flwr_plot_origin, REML = FALSE)
```

```
mod13up <- lmer(log(flwr_duration_scaled) ~ state + origin + (1 + year_factor | plot),
    umbs_flwr_plot_origin, REML = FALSE)
mod14up <- lmer(log(flwr_duration_scaled) ~ state + origin + year_factor + (1 | plot),
    umbs_flwr_plot_origin, REML = FALSE)
anova(mod12up, mod13up)  # go with model 13p
```

```
## Data: umbs_flwr_plot_origin
## Models:
## mod13up: log(flwr_duration_scaled) ~ state + origin + (1 + year_factor |
## mod13up:     plot)
## mod12up: log(flwr_duration_scaled) ~ state * origin + (1 + year_factor |
## mod12up:     plot)
##         npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## mod13up    8 523.92 551.80 -253.96   507.92
## mod12up   10 527.43 562.28 -253.72   507.43 0.4875  2     0.7837
```

```
anova(mod13up, mod14up)
```

```
## Data: umbs_flwr_plot_origin
## Models:
## mod14up: log(flwr_duration_scaled) ~ state + origin + year_factor + (1 |
## mod14up:     plot)
## mod13up: log(flwr_duration_scaled) ~ state + origin + (1 + year_factor |
## mod13up:     plot)
##         npar    AIC    BIC  logLik deviance Chisq Df Pr(>Chisq)
## mod14up    7 509.63 534.02 -247.81   495.63
## mod13up    8 523.92 551.80 -253.96   507.92     0  1          1
```

```
AICctab(mod12up, mod13up, mod14up, weights = T)  #model 13p
```

```
##         dAICc df weight
## mod14up  0.0  7  1
## mod13up 14.4  8  <0.001
## mod12up 18.3  10 <0.001
```

```
summary(mod14up)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: log(flwr_duration_scaled) ~ state + origin + year_factor + (1 |
##     plot)
##    Data: umbs_flwr_plot_origin
##
##      AIC      BIC   logLik deviance df.resid
##    509.6    534.0   -247.8    495.6      234
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.9203 -0.2956  0.1035  0.6606  2.0505
##
## Random effects:
```

```
##  Groups   Name        Variance Std.Dev.
##  plot     (Intercept) 0.01153  0.1074
##  Residual             0.44745  0.6689
## Number of obs: 241, groups:  plot, 24
##
## Fixed effects:
##               Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)    3.00948    0.14588 205.99827  20.629  < 2e-16 ***
## statewarmed    0.03647    0.09703  23.90743   0.376  0.71036
## originBoth    -0.47426    0.17817 240.86060  -2.662  0.00830 **
## originExotic   0.81801    0.08982 222.99232   9.107  < 2e-16 ***
## year_factor   -0.10871    0.03012 220.44328  -3.609  0.00038 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) sttwrm orgnBt orgnEx
## statewarmed -0.342
## originBoth  -0.238  0.003
## originExotc -0.302 -0.027  0.266
## year_factor -0.821  0.032  0.088 -0.025
```

```
summ(mod14up)
```

Observations	241
Dependent variable	log(flwr_duration_scaled)
Type	Mixed effects linear regression

AIC	509.63
BIC	534.02
Pseudo-R^2 (fixed effects)	0.33
Pseudo-R^2 (total)	0.35

Fixed Effects					
	Est.	S.E.	t val.	d.f.	p
(Intercept)	3.01	0.15	20.63	206.00	0.00
statewarmed	0.04	0.10	0.38	23.91	0.71
originBoth	-0.47	0.18	-2.66	240.86	0.01
originExotic	0.82	0.09	9.11	222.99	0.00
year_factor	-0.11	0.03	-3.61	220.44	0.00

p values calculated using Satterthwaite d.f.

Random Effects		
Group	Parameter	Std. Dev.
plot	(Intercept)	0.11
Residual		0.67

Grouping Variables		
Group	# groups	ICC
plot	24	0.03

```
anova(mod14up)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##             Sum Sq Mean Sq NumDF   DenDF F value    Pr(>F)
## state        0.063  0.0632     1  23.907  0.1412 0.7103579
## origin      49.568 24.7842     2 234.705 55.3898 < 2.2e-16 ***
## year_factor  5.828  5.8285     1 220.443 13.0259 0.0003802 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
emmeans(mod14up, list(pairwise ~ state), adjust = "tukey")
```

```
## $`emmeans of state`
##  state   emmean     SE   df lower.CL upper.CL
##  ambient   2.70 0.0849 44.4     2.53     2.87
##  warmed    2.73 0.0870 47.0     2.56     2.91
##
## Results are averaged over the levels of: origin
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
## $`pairwise differences of state`
##  1                estimate    SE   df t.ratio p.value
##  ambient - warmed  -0.0365 0.102 25.8 -0.358  0.7231
##
## Results are averaged over the levels of: origin
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
```

```
emmeans(mod14up, list(pairwise ~ origin), adjust = "tukey")
```

```
## $`emmeans of origin`
##  origin emmean     SE    df lower.CL upper.CL
##  Native   2.60 0.0714  92.2     2.46     2.74
##  Both     2.13 0.1717 223.6     1.79     2.46
##  Exotic   3.42 0.0668  78.8     3.29     3.55
##
## Results are averaged over the levels of: state
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
## $`pairwise differences of origin`
##  1               estimate     SE  df t.ratio p.value
```

```
##  Native - Both      0.474 0.1819 246  2.608  0.0261
##  Native - Exotic   -0.818 0.0906 226 -9.032  <.0001
##  Both - Exotic     -1.292 0.1807 246 -7.150  <.0001
##
## Results are averaged over the levels of: state
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## P value adjustment: tukey method for comparing a family of 3 estimates
```

```
# including growth form - first with interaction term
umbs_flwr_plot_growthhabit <- within(umbs_flwr_plot_growthhabit, growth_habit <- relevel(factor(growth_
    ref = "Forb"))  # releveling so forb is the reference
mod15up <- lmer(log(flwr_duration_scaled) ~ state * growth_habit + (1 + year_factor |
    plot), umbs_flwr_plot_growthhabit, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod16up <- lmer(log(flwr_duration_scaled) ~ state + growth_habit + (1 + year_factor |
    plot), umbs_flwr_plot_growthhabit, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
mod17up <- lmer(log(flwr_duration_scaled) ~ state + growth_habit + year_factor +
    (1 | plot), umbs_flwr_plot_growthhabit, REML = FALSE)
```

```
## boundary (singular) fit: see ?isSingular
```

```
anova(mod15up, mod16up)  # go with model 16p
```

```
## Data: umbs_flwr_plot_growthhabit
## Models:
## mod16up: log(flwr_duration_scaled) ~ state + growth_habit + (1 + year_factor |
## mod16up:     plot)
## mod15up: log(flwr_duration_scaled) ~ state * growth_habit + (1 + year_factor |
## mod15up:     plot)
##         npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## mod16up    8 468.53 496.67 -226.27   452.53
## mod15up   10 470.66 505.83 -225.33   450.66 1.8766  2     0.3913
```

```
anova(mod16up, mod17up)  # mod 17p
```

```
## Data: umbs_flwr_plot_growthhabit
## Models:
## mod17up: log(flwr_duration_scaled) ~ state + growth_habit + year_factor +
## mod17up:     (1 | plot)
## mod16up: log(flwr_duration_scaled) ~ state + growth_habit + (1 + year_factor |
## mod16up:     plot)
##         npar    AIC    BIC  logLik deviance Chisq Df Pr(>Chisq)
## mod17up    7 461.89 486.51 -223.94   447.89
## mod16up    8 468.53 496.67 -226.27   452.53     0  1          1
```

```
AICctab(mod15up, mod16up, mod17up, weights = T)
```

```
##         dAICc df weight
## mod17up  0.0  7  0.9583
## mod16up  6.8  8  0.0323
## mod15up  9.2  10 0.0095
```

```
summary(mod17up)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: log(flwr_duration_scaled) ~ state + growth_habit + year_factor +
##     (1 | plot)
##    Data: umbs_flwr_plot_growthhabit
##
##      AIC      BIC   logLik deviance df.resid
##    461.9    486.5   -223.9    447.9      242
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -6.1335 -0.4366  0.0581  0.6133  2.6088
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  plot     (Intercept) 0.0000   0.0000
##  Residual             0.3538   0.5948
## Number of obs: 249, groups:  plot, 24
##
## Fixed effects:
##                         Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)              3.84946    0.12739 249.00000  30.218  < 2e-16 ***
## statewarmed              0.03195    0.07559 249.00000   0.423   0.6729
## growth_habit            -1.41674    0.18329 249.00000  -7.729 2.66e-13 ***
## growth_habitGraminoid   -0.90244    0.07729 249.00000 -11.677  < 2e-16 ***
## year_factor             -0.05833    0.02693 249.00000  -2.166   0.0313 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) sttwrm grwth_ grwt_G
## statewarmed -0.288
## growth_habt -0.250 -0.072
## grwth_hbtGr -0.319 -0.004  0.216
## year_factor -0.853 -0.007  0.166  0.015
## optimizer (nloptwrap) convergence code: 0 (OK)
## boundary (singular) fit: see ?isSingular
```

```
summ(mod17up)
```

Observations	249
Dependent variable	log(flwr_duration_scaled)
Type	Mixed effects linear regression

AIC	461.89
BIC	486.51
Pseudo-R^2 (fixed effects)	0.40
Pseudo-R^2 (total)	0.40

Fixed Effects					
	Est.	S.E.	t val.	d.f.	p
(Intercept)	3.85	0.13	30.22	249.00	0.00
statewarmed	0.03	0.08	0.42	249.00	0.67
growth_habit	-1.42	0.18	-7.73	249.00	0.00
growth_habitGraminoid	-0.90	0.08	-11.68	249.00	0.00
year_factor	-0.06	0.03	-2.17	249.00	0.03

p values calculated using Satterthwaite d.f.

Random Effects		
Group	Parameter	Std. Dev.
plot	(Intercept)	0.00
Residual		0.59

Grouping Variables		
Group	# groups	ICC
plot	24	0.00

```
anova(mod17up)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##              Sum Sq Mean Sq NumDF DenDF F value  Pr(>F)
## state         0.063  0.0632     1   249  0.1786 0.67294
## growth_habit 58.287 29.1437     2   249 82.3823 < 2e-16 ***
## year_factor   1.660  1.6595     1   249  4.6910 0.03127 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
emmeans(mod17up, list(pairwise ~ state + growth_habit), adjust = "tukey")
```

```
## boundary (singular) fit: see ?isSingular
```

```
## $`emmeans of state, growth_habit`
##  state   growth_habit emmean     SE    df lower.CL upper.CL
##  ambient Forb           3.62 0.0673  52.9     3.48     3.75
##  warmed  Forb           3.65 0.0677  53.4     3.51     3.79
##  ambient               2.20 0.1862 188.6     1.83     2.57
```

```
##  warmed                2.23 0.1808 180.4     1.88     2.59
##  ambient Graminoid     2.72 0.0669  51.8     2.58     2.85
##  warmed  Graminoid     2.75 0.0669  51.8     2.61     2.88
##
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
## $`pairwise differences of state, growth_habit`
##  1                                  estimate     SE    df t.ratio p.value
##  ambient Forb - warmed Forb          -0.0319 0.0765  22.4 -0.418  0.9981
##  ambient Forb - ambient               1.4167 0.1882 237.8  7.528  <.0001
##  ambient Forb - warmed                1.3848 0.1980 164.6  6.992  <.0001
##  ambient Forb - ambient Graminoid     0.9024 0.0781 232.3 11.557  <.0001
##  ambient Forb - warmed Graminoid      0.8705 0.1090  84.5  7.983  <.0001
##  warmed Forb - ambient                1.4487 0.2081 178.7  6.961  <.0001
##  warmed Forb - warmed                 1.4167 0.1882 237.8  7.528  <.0001
##  warmed Forb - ambient Graminoid      0.9344 0.1095  84.9  8.531  <.0001
##  warmed Forb - warmed Graminoid       0.9024 0.0781 232.3 11.557  <.0001
##  ambient  - warmed                  -0.0319 0.0765  22.4 -0.418  0.9981
##  ambient  - ambient Graminoid        -0.5143 0.1878 236.8 -2.738  0.0716
##  ambient  - warmed Graminoid         -0.5462 0.2076 177.4 -2.631  0.0953
##  warmed  - ambient Graminoid         -0.4824 0.1978 163.1 -2.438  0.1493
##  warmed  - warmed Graminoid          -0.5143 0.1878 236.8 -2.738  0.0716
##  ambient Graminoid - warmed Graminoid -0.0319 0.0765  22.4 -0.418  0.9981
##
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## P value adjustment: tukey method for comparing a family of 6 estimates
```

```
emmeans(mod17up, list(pairwise ~ growth_habit), adjust = "tukey")
```

```
## boundary (singular) fit: see ?isSingular
```

```
## $`emmeans of growth_habit`
##  growth_habit emmean     SE    df lower.CL upper.CL
##  Forb           3.63 0.0556  90.4     3.52     3.74
##                 2.22 0.1795 204.7     1.86     2.57
##  Graminoid      2.73 0.0549  87.8     2.62     2.84
##
## Results are averaged over the levels of: state
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
## $`pairwise differences of growth_habit`
##  1                estimate     SE  df t.ratio p.value
##  Forb -              1.417 0.1882 238  7.528  <.0001
##  Forb - Graminoid    0.902 0.0781 232 11.557  <.0001
##   - Graminoid       -0.514 0.1878 237 -2.738  0.0182
##
## Results are averaged over the levels of: state
## Degrees-of-freedom method: kenward-roger
```

```
## Results are given on the log (not the response) scale.
## P value adjustment: tukey method for comparing a family of 3 estimates
```

```
emmeans(mod17up, list(pairwise ~ growth_habit + year_factor), adjust = "tukey")
```

```
## boundary (singular) fit: see ?isSingular
```

```
## $`emmeans of growth_habit, year_factor`
##  growth_habit year_factor emmean     SE    df lower.CL upper.CL
##  Forb                3.97   3.63 0.0556  90.4     3.52     3.74
##                      3.97   2.22 0.1795 204.7     1.86     2.57
##  Graminoid           3.97   2.73 0.0549  87.8     2.62     2.84
##
## Results are averaged over the levels of: state
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## Confidence level used: 0.95
##
## $`pairwise differences of growth_habit, year_factor`
##  1                                                 estimate     SE  df t.ratio
##  Forb 3.96787148594378 -  3.96787148594378            1.417 0.1882 238  7.528
##  Forb 3.96787148594378 - Graminoid 3.96787148594378    0.902 0.0781 232 11.557
##   3.96787148594378 - Graminoid 3.96787148594378       -0.514 0.1878 237 -2.738
##  p.value
##  <.0001
##  <.0001
##  0.0182
##
## Results are averaged over the levels of: state
## Degrees-of-freedom method: kenward-roger
## Results are given on the log (not the response) scale.
## P value adjustment: tukey method for comparing a family of 3 estimates
```