2A: East Bay Pond Water

Caitlin Nordheim-Maestas

# Load in data and libraries

## read in and clean data  
library(tidyverse) # for cleaning and viewing data  
library(gt) # pretty stats tables  
library(broom) # cleaning for gt  
library(here) # for importing data  
library(car) # stats tests like Levene's  
library(Hmisc) # autocalculate stat summaries in ggplot  
library(multcomp) # stats  
library(multcompView) # view cld  
library(nlme) # mixed effects models  
library(emmeans) # for pairwise comparisons, especially on mixed effects models and glms  
library(ggpubr) # for making ggqq plot  
library(patchwork) # for combining figures  
  
# load data  
fs\_pw\_bd <- read.csv(here("data", "fifteen-sites-PW-on-Bd - Sheet1.csv"))  
fig\_2b\_raw <- read.csv(here("data", "final\_NCOS\_2024\_reformatted\_for\_R.xlsx - Fig2B.csv"))  
  
# Colors: these are from Paul Tol's colorblind friendly palette  
with\_microbes\_40\_color <- "#999933"  
no\_microbes\_.22\_color <- "#88ccee"  
  
# set up custom theme  
myCustomTheme <- function() {  
 theme\_light() +  
 theme(axis.text = element\_text(size = 12, family = "Times", color = "black"),  
 axis.title.x = element\_text(margin = margin(t = 10), size = 14, face = "bold", family = "Times", color = "black"), # Add space between x-axis label and axis  
 axis.title.y = element\_text(margin = margin(r = 10), size = 14, face = "bold", family = "Times", color = "black"), # Add space between y-axis label and axis  
 title = element\_text(size = 12, face = "bold", family = "Times"),  
 plot.caption = element\_text(size = 10, face = "italic", family = "Times"),  
 legend.text = element\_text(size = 10, family = "Times"), # Increase legend text size  
 panel.grid.major.x = element\_blank(), # Remove major vertical grid lines  
 panel.grid.minor.x = element\_blank(), # Remove minor vertical grid lines  
 panel.grid.major.y = element\_blank(), # Remove major horizontal grid lines  
 panel.grid.minor.y = element\_blank(), # Remove minor horizontal grid lines  
 strip.text = element\_text(size = 12, face = "bold", family = "Times", color = "black"), # Set strip text style  
 strip.background = element\_rect(fill = "white", color = "grey"), # Set strip background to white, # color = "black"  
 axis.ticks = element\_blank() # Remove x and y axis ticks  
 )}

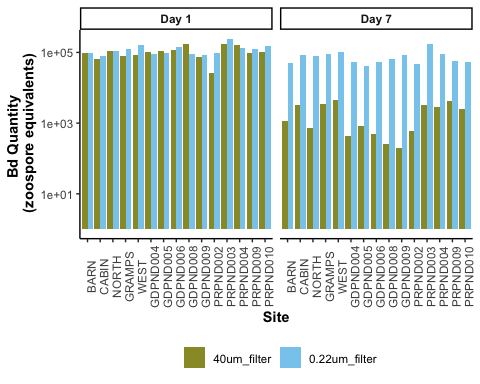
# 2A

## Data Wrangling

# remove controls  
eb\_pw <- fs\_pw\_bd %>% filter(site != "sterile MQ")  
  
# keep control for labeling plot  
eb\_pw\_controls <- fs\_pw\_bd %>%   
 filter(site =="sterile MQ") %>%   
 pivot\_wider(names\_from = bd\_location, values\_from = bd\_qty) %>%  
 mutate(combined\_bd = adherent + floating) %>%   
 mutate(day = case\_when(  
 day == 1 ~ "Day\_1",  
 day == 7 ~ "Day\_7"))  
  
# data type cleaning  
eb\_pw$bd\_location <- factor(eb\_pw$bd\_location, levels = c("floating", "adherent"))  
eb\_pw$filter <- factor(eb\_pw$filter,  
 levels = c("40um\_filter", "0.22um\_filter"))  
eb\_pw$day <- factor(eb\_pw$day, levels = c("1", "7"),  
 labels = c("Day\_1", "Day\_7"))  
eb\_pw$site <- factor(eb\_pw$site,  
 levels = c("BARN", "CABIN", "NORTH", "GRAMPS", "WEST", "GDPND004", "GDPND005", "GDPND006", "GDPND008", "GDPND009", "PRPND002", "PRPND003", "PRPND004", "PRPND009", "PRPND010", "sterile MQ"))  
  
# get the total difference across days by combining both locations of Bd then subtracting across days  
eb\_pw\_total\_diff <- eb\_pw %>%  
 # combine floating and adherent for total\_Bd  
 pivot\_wider(names\_from = bd\_location, values\_from = bd\_qty) %>%  
 mutate(combined\_bd = adherent + floating) %>%   
 subset(select = -c(adherent,floating)) %>%   
  
# different metrics of difference in Bd  
 pivot\_wider(names\_from = day, values\_from = combined\_bd) %>%  
  
 # calculate the rate loss by taking the log of each before subtracting  
 mutate(rate\_loss = log(Day\_1) - log(Day\_7))  
  
# Split into 2 data frames one for 40 and one for .22  
eb\_pw\_total\_diff\_40um <- eb\_pw\_total\_diff %>%   
 filter(filter =="40um\_filter")  
eb\_pw\_total\_diff.22um <- eb\_pw\_total\_diff%>%   
 filter(filter =="0.22um\_filter")

## EDA

# Renwei barplot remake  
eb\_pw %>%  
 # combine floating and adherent for total\_Bd  
 pivot\_wider(names\_from = bd\_location, values\_from = bd\_qty) %>%  
 mutate(combined\_bd = adherent + floating) %>%   
ggplot(aes(y= combined\_bd, x = site, fill = filter)) +   
 geom\_col(position = position\_dodge()) +  
 scale\_y\_log10() +  
 facet\_wrap(~day, labeller = labeller(day = c("Day\_1" = "Day 1",  
 "Day\_7" = "Day 7"))) +  
 scale\_fill\_manual(values = c("40um\_filter" = with\_microbes\_40\_color,   
 "0.22um\_filter" = no\_microbes\_.22\_color)) +  
 theme\_classic() +  
 theme(axis.text.x = element\_text(angle = 90),  
 legend.position = "bottom",  
 strip.text = element\_text(face="bold"),  
 axis.title = element\_text(face = "bold")) +   
 xlab("Site") +  
 ylab("Bd Quantity \n (zoospore equivalents)") +  
 guides(fill=guide\_legend(title=""))



Boxplot

# eb\_pw %>%  
# # combine floating and adherent for total\_Bd  
# pivot\_wider(names\_from = bd\_location, values\_from = bd\_qty) %>%  
# mutate(combined\_bd = adherent + floating) %>%   
#   
# # create the plot  
# ggplot(aes(y= combined\_bd, x = filter, fill = filter)) +   
# geom\_boxplot() +  
# geom\_jitter(width = 0.2, alpha = 0.3) +  
# scale\_y\_log10() +  
# facet\_wrap(~day, labeller = labeller(day = c("Day\_1" = "Day 1",  
# "Day\_7" = "Day 7")))+  
# scale\_fill\_manual(values = c("40um\_filter" = with\_microbes\_40\_color,   
# "0.22um\_filter" = no\_microbes\_.22\_color)) +  
# theme\_classic() +  
# theme(legend.position = "none",  
# strip.text = element\_text(face="bold"),  
# axis.title = element\_text(face = "bold")) +   
# scale\_x\_discrete (labels= c("40um\_filter" = "With Microbes", "0.22um\_filter" = "No Microbes")) +  
# xlab("Presence of Microbes in Pond Water") +  
# ylab("Bd Quantity \n (zoospore equivalents)") +  
#   
# # add controls ad x's  
# geom\_point(data = eb\_pw\_controls, aes(x = filter, y = combined\_bd), shape = 4, size = 2)

## Stats and assumption testing

**Statistical question**: Is there a difference in the **rate of gain or loss of Bd over 6 days** between the **filter sizes** looking at the **TOTAL BD**

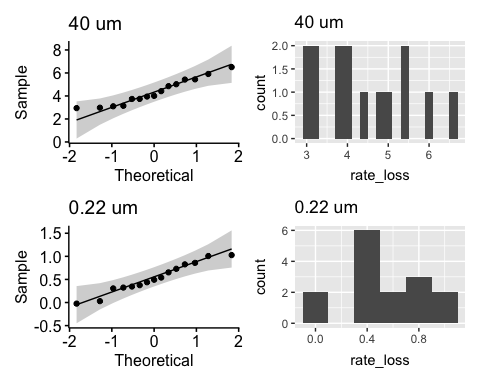
The samples are essentially paired by site, so a paired t-test is most appropriate

Assumptions:

Assumes that the observations from each group represent a random sample from the population. Assumes that the difference of the two observations follow a normal distribution.

Assumption testing:

# check normality of the differences across groups  
  
# numeric check  
eb\_pw\_40um\_shapiro.test <- shapiro.test(eb\_pw\_total\_diff\_40um$rate\_loss) # normal, yay!  
eb\_pw\_0.22um\_shapiro.test <- shapiro.test(eb\_pw\_total\_diff.22um$rate\_loss) # normal, yay!  
  
# visual check  
eb\_pw\_40um\_qq <- eb\_pw\_total\_diff\_40um %>%   
 ggqqplot("rate\_loss", title = "40 um")  
  
# Histogram using ggplot2  
eb\_pw\_40um\_hist <- eb\_pw\_total\_diff\_40um %>%   
 ggplot(aes(x = rate\_loss)) +  
 geom\_histogram(binwidth = 0.2) +  
 labs(title = "40 um")  
  
# visual check  
eb\_pw\_0.22um\_qq <- eb\_pw\_total\_diff.22um %>%   
 ggqqplot("rate\_loss", title = "0.22 um")  
  
# Histogram using ggplot2  
eb\_pw\_0.22um\_hist <- eb\_pw\_total\_diff.22um %>%   
 ggplot(aes(x = rate\_loss)) +  
 geom\_histogram(binwidth = 0.2) +  
 labs(title = "0.22 um")  
  
eb\_pw\_40um\_qq + eb\_pw\_40um\_hist + eb\_pw\_0.22um\_qq + eb\_pw\_0.22um\_hist



eb\_pw\_40um\_shapiro.test

Shapiro-Wilk normality test  
  
data: eb\_pw\_total\_diff\_40um$rate\_loss  
W = 0.93591, p-value = 0.3337

eb\_pw\_0.22um\_shapiro.test

Shapiro-Wilk normality test  
  
data: eb\_pw\_total\_diff.22um$rate\_loss  
W = 0.96119, p-value = 0.7131

The data for the 40um filter is normally distributed (Shapiro-Wilk test, W = 0.93591, p = 0.3337), and so is the data for the 0.22 filter (Shapiro-Wilk test, W = 0.96119, p = 0.7131).

# Run the paired t-test on the difference  
eb\_pw\_paired\_ttest\_result <- t.test(eb\_pw\_total\_diff\_40um$rate\_loss, eb\_pw\_total\_diff.22um$rate\_loss, paired = TRUE)  
  
eb\_pw\_paired\_ttest\_result

Paired t-test  
  
data: eb\_pw\_total\_diff\_40um$rate\_loss and eb\_pw\_total\_diff.22um$rate\_loss  
t = 12.449, df = 14, p-value = 5.83e-09  
alternative hypothesis: true mean difference is not equal to 0  
95 percent confidence interval:  
 3.159637 4.474996  
sample estimates:  
mean difference   
 3.817316

**There is a significant difference in the change in the total quantity of Bd from Day 1 to Day 7 across the filter types (t = 12.4488129, df = 14, p-value = 5.8299032^{-9})**

The t-value is positive, which shows that the first item entered (with microbes) has a larger loss of Bd than the second item entered (no microbes.) Df of 14 is expected, because it’s 15 sites.

# 2b

## Data wrangling

pw <- fig\_2b\_raw %>%   
# add column for microbes or no  
 mutate(microbes = case\_when(  
 str\_detect(sample\_ID, "\\+microorganism") ~ "y",  
 TRUE ~ "n"  
 )) %>%   
# add column for water\_treatment  
 mutate(water\_treatment = case\_when(  
 sample\_ID %in% c("1%TB", "MQ", "Added Bd") ~ "sterile-water",  
 sample\_ID %in% c("1%TB+PW+microorganism", "PW+microorganism") ~ "PW+MO",  
 sample\_ID %in% c("1%TB+PW-microorganism", "PW-microorganism") ~ "PW-MO"  
 )) %>%   
# add column for TB or no  
 mutate(TB = case\_when(  
 str\_detect(sample\_ID, "TB") ~ "y",  
 TRUE ~ "n"  
 ))  
  
pw\_summary <- pw %>%   
 group\_by(day, sample\_ID) %>%   
 reframe(mean = mean(adh\_plus\_sup), # calculate the mean  
 n = length(adh\_plus\_sup), # count the number of observations  
 df = n - 1, # calculate the degrees of freedom  
 sd = sd(adh\_plus\_sup), # calculate the standard deviation  
 se = sd/sqrt(n), # calculate the standard error  
 ) %>%   
 mutate(microbes = case\_when(  
 str\_detect(sample\_ID, "\\+microorganism") ~ "y",TRUE ~ "n")) %>%   
 # add column for TB or no  
 mutate(TB = case\_when(str\_detect(sample\_ID, "TB") ~ "y", TRUE ~ "n")) %>%   
 # add column for PW or no  
 mutate(water\_treatment = case\_when(  
 sample\_ID %in% c("1%TB", "MQ", "Added Bd") ~ "sterile-water",  
 sample\_ID %in% c("1%TB+PW+microorganism", "PW+microorganism") ~ "PW+MO",  
 sample\_ID %in% c("1%TB+PW-microorganism", "PW-microorganism") ~ "PW-MO"  
 ))  
  
# datafram of only controls  
pw\_control\_data <- pw %>%  
 filter(day == 0) %>%   
 dplyr::select(day, adh\_plus\_sup)  
  
# dataframe without controls  
pw\_noday0 <- pw %>%  
 filter(day != 0) %>%  
 mutate(log\_adh\_plus\_sup = log(adh\_plus\_sup)) # note: no zeroes so not log + 1  
  
# quick check: we want day as a FACTOR  
pw\_noday0 <- pw\_noday0 %>%   
 mutate(day = as.factor(day))  
  
# do we want it ordered? read the stats thing Tatum sent  
pw\_noday0 <- pw\_noday0 %>%   
mutate(day = factor(day,   
 levels = c("1", "3", "5", "7"), ordered = T))  
str(pw\_noday0$day)

Ord.factor w/ 4 levels "1"<"3"<"5"<"7": 1 2 3 4 1 2 3 4 1 2 ...

# set MQ as reference  
pw\_noday0$sample\_ID <- factor(pw\_noday0$sample\_ID)  
pw\_noday0$sample\_ID <- relevel(pw\_noday0$sample\_ID, ref = "MQ")  
  
# set sterile water as reference  
pw\_noday0$water\_treatment <- factor(pw\_noday0$water\_treatment)  
pw\_noday0$water\_treatment <- relevel(pw\_noday0$water\_treatment, ref = "sterile-water")  
  
# set no TB as reference  
pw\_noday0$TB <- factor(pw\_noday0$TB)  
pw\_noday0$TB <- relevel(pw\_noday0$TB, ref = "n")  
  
# set no microbes as reference  
pw\_noday0$microbes <- factor(pw\_noday0$microbes)  
pw\_noday0$microbes <- relevel(pw\_noday0$microbes, ref = "n")

Renwei’s figure

|  |
| --- |
|  |

Caitlin’s version

fig\_2b <- pw\_summary %>%   
 # reorder to match Renwei's plot  
 mutate(sample\_ID = factor(sample\_ID,   
 levels = c("1%TB", "MQ", "1%TB+PW+microorganism", "PW+microorganism", "1%TB+PW-microorganism", "PW-microorganism", "Added Bd"))) %>%   
  
 ggplot(aes(x = day,   
 y = mean,   
 color = sample\_ID)) +  
 geom\_point(size = 2) +  
 geom\_errorbar(aes(ymin = mean - se, # plot the standard error  
 ymax = mean + se),  
 width = 0.1) +  
 scale\_y\_log10(limits = c(1e3, 1e8),   
 breaks = c(1e3, 1e4, 1e5, 1e6, 1e7, 1e8)) +  
 # vibes  
 # vibes  
 labs(x = "Day",  
 y = "Bd Quantity per sample (ZE/well)",  
 color = "Medium", # Title for color legend  
 linetype = "Microbes Present" # Title for linetype legend  
 ) +  
 scale\_color\_manual(values = c("1%TB" = "#CCBB44",   
 "MQ" = "#228833",   
 "1%TB+PW+microorganism" = "#4477AA",   
 "PW+microorganism" = "#EE6677",   
 "1%TB+PW-microorganism" = "#66CCEE",  
 #"Added Bd" = "#BBBBBB" # removed bc not really a medium  
 "PW-microorganism" = "#AA3377"), # Assign specific colors to match RC's plot  
 labels = c("1%TB" = "TB",  
 "MQ" = "MQ",  
 "1%TB+PW+microorganism" = "TB + PW + MO",  
 "PW+microorganism" = "PW + MO",  
 "1%TB+PW-microorganism" = "TB + PW - MO",  
 "PW-microorganism" = "PW - MO",  
 "Added Bd" = "Initial Bd")) + # Custom labels for the color legend  
 geom\_line(aes(linetype = microbes)) +   
 scale\_linetype\_manual(values = c("n" = "dashed",   
 "y" = "solid"),  
 labels = c("n" = "N", "y" = "Y")) + # Change labels to uppercase N and Y  
 myCustomTheme()+  
 scale\_x\_continuous(breaks = c(0, 1, 3, 5, 7),  
 labels = c("Initial\nBd", "1", "3", "5", "7"))  
 theme(legend.position = "right") # Adjust the legend position to overlap with the plot

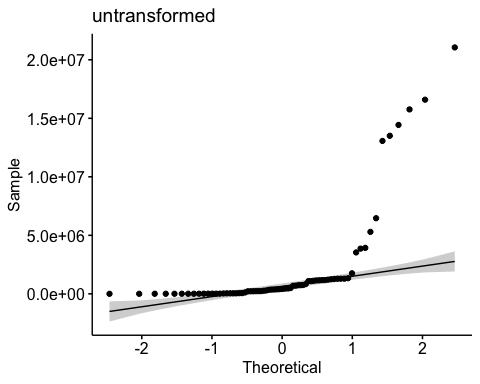
## 2b EDA

visualize y var: bd load

log transformed will get me closer to normal, note we only need to worry about the residuals normality though, so commented out the transformation of the data for space

TRY ARCSIN, TRY OTHER THINGS

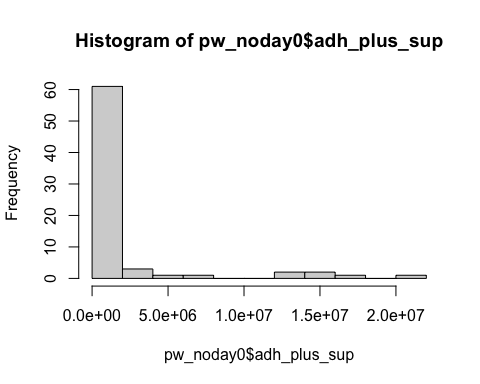
# untransformed  
ggqqplot(pw\_noday0, "adh\_plus\_sup", title = "untransformed")



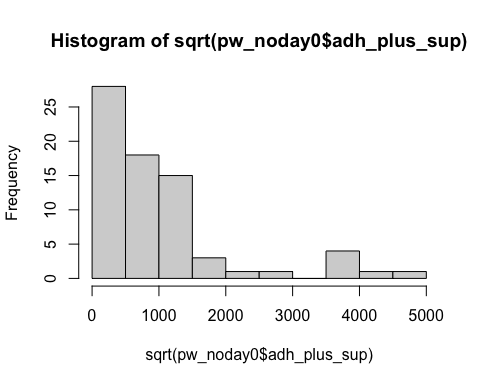
shapiro.test(pw\_noday0$adh\_plus\_sup) # nope

Shapiro-Wilk normality test  
  
data: pw\_noday0$adh\_plus\_sup  
W = 0.49498, p-value = 2.434e-14

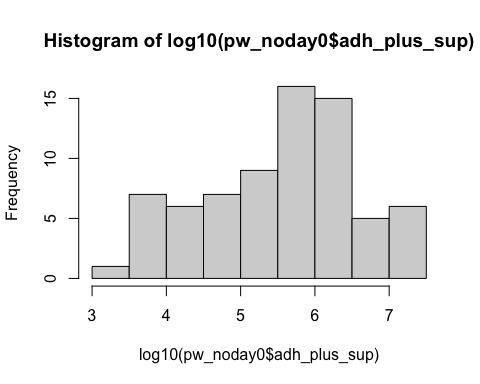
hist(pw\_noday0$adh\_plus\_sup) # note



# sqrt  
hist(sqrt(pw\_noday0$adh\_plus\_sup)) # nope



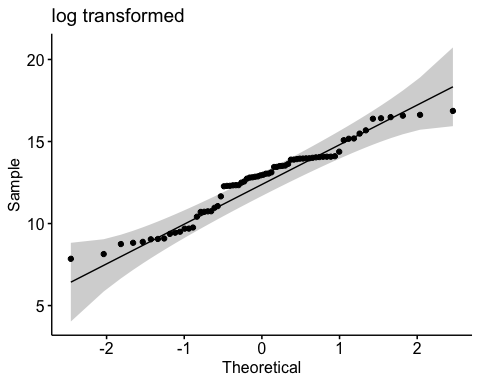
# log 10  
hist(log10(pw\_noday0$adh\_plus\_sup)) # much better...?



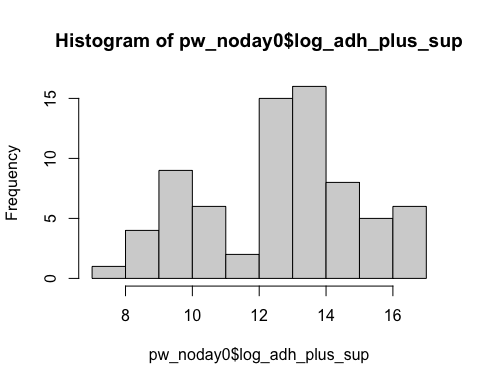
shapiro.test(log10(pw\_noday0$adh\_plus\_sup)) # closer

Shapiro-Wilk normality test  
  
data: log10(pw\_noday0$adh\_plus\_sup)  
W = 0.95623, p-value = 0.01361

# TRY ARCSIN  
  
  
# log transformed  
ggqqplot(pw\_noday0, "log\_adh\_plus\_sup", title = "log transformed") # gorgeous



hist(pw\_noday0$log\_adh\_plus\_sup) # better



shapiro.test(pw\_noday0$log\_adh\_plus\_sup) # p-value = 0.01361, does not pass shapiro, but this has an n of 72 which is more than the recommended <50 samples

Shapiro-Wilk normality test  
  
data: pw\_noday0$log\_adh\_plus\_sup  
W = 0.95623, p-value = 0.01361

# visualize comparisons  
# TB y or n  
# pw\_noday0 %>%   
# ggplot(aes(x = TB,   
# y = log\_adh\_plus\_sup)) +  
# geom\_boxplot()  
# # water\_treat  
# pw\_noday0 %>%   
# ggplot(aes(x = water\_treatment,   
# y = log\_adh\_plus\_sup)) +  
# geom\_boxplot()  
# # day  
# pw\_noday0 %>%   
# ggplot(aes(x = day,   
# y = log\_adh\_plus\_sup)) +  
# geom\_boxplot()

## 2b Stats

Most appropriate comaprison for study design: day*microbes*water\_treatment

* y variable: amount of Bd
* x vars: day, TB y/n, water\_treatment (pw with microbes, pw without, sterile water)

Question: Does the amount of Bd in the sample differ across the treatments of presence of water type (pw with microbes, pw without, sterile water), TB, and day?

Model: 2-way anova

Note: anovas, lm’s and glm’s are all linear models!

Note: whether the factor of day is ordered does not make a difference, see the appendix

## null

null <- lm(log\_adh\_plus\_sup ~ 1,  
 data = pw\_noday0)  
AIC(null) #326.4356

[1] 326.4356

## Try ANOVA with interactions: Bd ~ day\*TB\*water\_treatment

**important: this ANOVA does not have perfectly normally distributed residuals, but it is the best tool we have right now to answer our question**

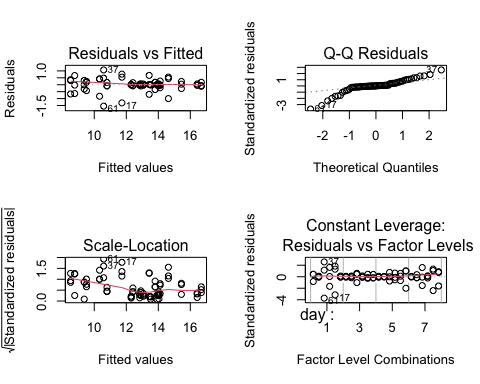
Tatum says it is normal enough to proceed.

Other option to try: arcsin transformation

Other option to try: poisson glm on untransformed data

Note: Kruskall wallace isn’t the best move here because I want interactions, if I cut the interactions, a normal anova works, so no need for a KW.

# log transformed  
aov\_2b <- aov(log\_adh\_plus\_sup ~ day\*TB\*water\_treatment,  
 data = pw\_noday0)  
  
# diagnostic plot  
par(mfrow = c(2,2))  
plot(aov\_2b) # qq is sus



AIC(aov\_2b) # better than null 127.7922

[1] 127.7922

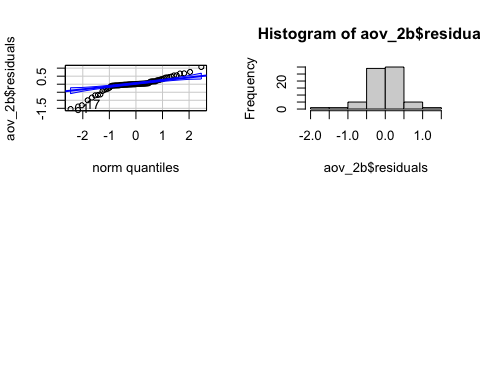
# make qq in car with 95% CI  
qqPlot(aov\_2b$residuals) # not good

[1] 61 17

hist(aov\_2b$residuals) # but this looks great!! what's happening here?  
shapiro.test(aov\_2b$residuals) # does not pass but it is over the 50

Shapiro-Wilk normality test  
  
data: aov\_2b$residuals  
W = 0.879, p-value = 4.861e-06

# # sqrt transformed, did not work!  
# mod5 <- aov(sqrt(adh\_plus\_sup) ~ day\*TB\*water\_treatment,  
# data = pw\_noday0)  
#   
# # diagnostic plot  
# par(mfrow = c(2,2))  
# plot(mod5) # NOT normal...  
# AIC(mod5) # horrible 968.6406  
#   
# # make qq in car with 95% CI  
# qqPlot(mod5$residuals)



## anova results

# interpret results  
summary(aov\_2b)

Df Sum Sq Mean Sq F value Pr(>F)   
day 3 35.40 11.80 45.608 4.31e-14 \*\*\*  
TB 1 20.99 20.99 81.127 6.92e-12 \*\*\*  
water\_treatment 2 228.85 114.42 442.251 < 2e-16 \*\*\*  
day:TB 3 11.71 3.90 15.084 4.78e-07 \*\*\*  
day:water\_treatment 6 37.33 6.22 24.047 6.45e-13 \*\*\*  
TB:water\_treatment 2 0.06 0.03 0.109 0.897   
day:TB:water\_treatment 6 24.57 4.09 15.825 6.30e-10 \*\*\*  
Residuals 48 12.42 0.26   
---  
Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

### post hoc

# post hoc  
TukeyHSD(aov\_2b)

Tukey multiple comparisons of means  
 95% family-wise confidence level  
  
Fit: aov(formula = log\_adh\_plus\_sup ~ day \* TB \* water\_treatment, data = pw\_noday0)  
  
$day  
 diff lwr upr p adj  
3-1 0.7878386 0.3365970 1.2390802 0.0001521  
5-1 -0.1715069 -0.6227485 0.2797347 0.7434984  
7-1 -1.1817503 -1.6329919 -0.7305087 0.0000000  
5-3 -0.9593455 -1.4105871 -0.5081039 0.0000049  
7-3 -1.9695889 -2.4208305 -1.5183474 0.0000000  
7-5 -1.0102434 -1.4614850 -0.5590018 0.0000017  
  
$TB  
 diff lwr upr p adj  
y-n 1.079872 0.8388136 1.32093 0  
  
$water\_treatment  
 diff lwr upr p adj  
PW-MO-sterile-water 0.340284 -0.01483837 0.6954063 0.0629087  
PW+MO-sterile-water -3.600293 -3.95541555 -3.2451709 0.0000000  
PW+MO-PW-MO -3.940577 -4.29569952 -3.5854549 0.0000000  
  
$`day:TB`  
 diff lwr upr p adj  
3:n-1:n -0.31984147 -1.07954248 0.43985955 0.8811923  
5:n-1:n -0.89827967 -1.65798069 -0.13857865 0.0104952  
7:n-1:n -1.64257839 -2.40227940 -0.88287737 0.0000003  
1:y-1:n -0.06776878 -0.82746980 0.69193223 0.9999917  
3:y-1:n 1.82774990 1.06804888 2.58745091 0.0000000  
5:y-1:n 0.48749705 -0.27220396 1.24719807 0.4714340  
7:y-1:n -0.78869107 -1.54839209 -0.02899005 0.0367370  
5:n-3:n -0.57843820 -1.33813922 0.18126282 0.2589734  
7:n-3:n -1.32273692 -2.08243794 -0.56303590 0.0000356  
1:y-3:n 0.25207268 -0.50762833 1.01177370 0.9635870  
3:y-3:n 2.14759136 1.38789035 2.90729238 0.0000000  
5:y-3:n 0.80733852 0.04763750 1.56703954 0.0299644  
7:y-3:n -0.46884960 -1.22855062 0.29085141 0.5214920  
7:n-5:n -0.74429872 -1.50399974 0.01540230 0.0586353  
1:y-5:n 0.83051089 0.07080987 1.59021190 0.0231296  
3:y-5:n 2.72602956 1.96632855 3.48573058 0.0000000  
5:y-5:n 1.38577672 0.62607571 2.14547774 0.0000144  
7:y-5:n 0.10958860 -0.65011242 0.86928962 0.9997851  
1:y-7:n 1.57480960 0.81510859 2.33451062 0.0000009  
3:y-7:n 3.47032828 2.71062727 4.23002930 0.0000000  
5:y-7:n 2.13007544 1.37037442 2.88977646 0.0000000  
7:y-7:n 0.85388732 0.09418630 1.61358833 0.0177057  
3:y-1:y 1.89551868 1.13581766 2.65521970 0.0000000  
5:y-1:y 0.55526584 -0.20443518 1.31496685 0.3066017  
7:y-1:y -0.72092229 -1.48062330 0.03877873 0.0742107  
5:y-3:y -1.34025284 -2.09995386 -0.58055182 0.0000277  
7:y-3:y -2.61644097 -3.37614198 -1.85673995 0.0000000  
7:y-5:y -1.27618812 -2.03588914 -0.51648711 0.0000691  
  
$`day:water\_treatment`  
 diff lwr upr p adj  
3:sterile-water-1:sterile-water 1.56409952 0.55570514 2.572493908 0.0001540  
5:sterile-water-1:sterile-water -0.13666277 -1.14505716 0.871731612 0.9999983  
7:sterile-water-1:sterile-water -1.00670881 -2.01510319 0.001685579 0.0507394  
1:PW-MO-1:sterile-water -0.73277523 -1.74116961 0.275619158 0.3673389  
3:PW-MO-1:sterile-water 1.74122159 0.73282720 2.749615972 0.0000195  
5:PW-MO-1:sterile-water 0.86539619 -0.14299819 1.873790576 0.1573217  
7:PW-MO-1:sterile-water -0.09197876 -1.10037314 0.916415625 1.0000000  
1:PW+MO-1:sterile-water -1.78762409 -2.79601848 -0.779229708 0.0000113  
3:PW+MO-1:sterile-water -3.46220461 -4.47059900 -2.453810227 0.0000000  
5:PW+MO-1:sterile-water -3.76365348 -4.77204787 -2.755259100 0.0000000  
7:PW+MO-1:sterile-water -4.96696276 -5.97535715 -3.958568379 0.0000000  
5:sterile-water-3:sterile-water -1.70076230 -2.70915668 -0.692367913 0.0000315  
7:sterile-water-3:sterile-water -2.57080833 -3.57920271 -1.562413946 0.0000000  
1:PW-MO-3:sterile-water -2.29687475 -3.30526913 -1.288480366 0.0000000  
3:PW-MO-3:sterile-water 0.17712206 -0.83127232 1.185516448 0.9999751  
5:PW-MO-3:sterile-water -0.69870333 -1.70709772 0.309691052 0.4388765  
7:PW-MO-3:sterile-water -1.65607828 -2.66447267 -0.647683900 0.0000531  
1:PW+MO-3:sterile-water -3.35172362 -4.36011800 -2.343329232 0.0000000  
3:PW+MO-3:sterile-water -5.02630414 -6.03469852 -4.017909751 0.0000000  
5:PW+MO-3:sterile-water -5.32775301 -6.33614739 -4.319358624 0.0000000  
7:PW+MO-3:sterile-water -6.53106229 -7.53945667 -5.522667903 0.0000000  
7:sterile-water-5:sterile-water -0.87004603 -1.87844042 0.138348351 0.1520910  
1:PW-MO-5:sterile-water -0.59611245 -1.60450684 0.412281930 0.6716810  
3:PW-MO-5:sterile-water 1.87788436 0.86948998 2.886278745 0.0000039  
5:PW-MO-5:sterile-water 1.00205896 -0.00633542 2.010453348 0.0528293  
7:PW-MO-5:sterile-water 0.04468401 -0.96371037 1.053078397 1.0000000  
1:PW+MO-5:sterile-water -1.65096132 -2.65935570 -0.642566935 0.0000563  
3:PW+MO-5:sterile-water -3.32554184 -4.33393622 -2.317147455 0.0000000  
5:PW+MO-5:sterile-water -3.62699071 -4.63538510 -2.618596327 0.0000000  
7:PW+MO-5:sterile-water -4.83029999 -5.83869437 -3.821905606 0.0000000  
1:PW-MO-7:sterile-water 0.27393358 -0.73446080 1.282327963 0.9983727  
3:PW-MO-7:sterile-water 2.74793039 1.73953601 3.756324778 0.0000000  
5:PW-MO-7:sterile-water 1.87210500 0.86371061 2.880499381 0.0000041  
7:PW-MO-7:sterile-water 0.91473005 -0.09366434 1.923124430 0.1085209  
1:PW+MO-7:sterile-water -0.78091529 -1.78930967 0.227479098 0.2775082  
3:PW+MO-7:sterile-water -2.45549581 -3.46389019 -1.447101422 0.0000000  
5:PW+MO-7:sterile-water -2.75694468 -3.76533906 -1.748550294 0.0000000  
7:PW+MO-7:sterile-water -3.96025396 -4.96864834 -2.951859573 0.0000000  
3:PW-MO-1:PW-MO 2.47399681 1.46560243 3.482391198 0.0000000  
5:PW-MO-1:PW-MO 1.59817142 0.58977703 2.606565802 0.0001040  
7:PW-MO-1:PW-MO 0.64079647 -0.36759792 1.649190851 0.5697876  
1:PW+MO-1:PW-MO -1.05484887 -2.06324325 -0.046454482 0.0330451  
3:PW+MO-1:PW-MO -2.72942939 -3.73782377 -1.721035001 0.0000000  
5:PW+MO-1:PW-MO -3.03087826 -4.03927264 -2.022483874 0.0000000  
7:PW+MO-1:PW-MO -4.23418754 -5.24258192 -3.225793153 0.0000000  
5:PW-MO-3:PW-MO -0.87582540 -1.88421978 0.132568987 0.1457799  
7:PW-MO-3:PW-MO -1.83320035 -2.84159473 -0.824805964 0.0000066  
1:PW+MO-3:PW-MO -3.52884568 -4.53724006 -2.520451296 0.0000000  
3:PW+MO-3:PW-MO -5.20342620 -6.21182058 -4.195031816 0.0000000  
5:PW+MO-3:PW-MO -5.50487507 -6.51326946 -4.496480688 0.0000000  
7:PW+MO-3:PW-MO -6.70818435 -7.71657874 -5.699789967 0.0000000  
7:PW-MO-5:PW-MO -0.95737495 -1.96576934 0.051019433 0.0770752  
1:PW+MO-5:PW-MO -2.65302028 -3.66141467 -1.644625900 0.0000000  
3:PW+MO-5:PW-MO -4.32760080 -5.33599519 -3.319206419 0.0000000  
5:PW+MO-5:PW-MO -4.62904968 -5.63744406 -3.620655292 0.0000000  
7:PW+MO-5:PW-MO -5.83235895 -6.84075334 -4.823964571 0.0000000  
1:PW+MO-7:PW-MO -1.69564533 -2.70403972 -0.687250948 0.0000334  
3:PW+MO-7:PW-MO -3.37022585 -4.37862024 -2.361831468 0.0000000  
5:PW+MO-7:PW-MO -3.67167472 -4.68006911 -2.663280340 0.0000000  
7:PW+MO-7:PW-MO -4.87498400 -5.88337839 -3.866589619 0.0000000  
3:PW+MO-1:PW+MO -1.67458052 -2.68297490 -0.666186136 0.0000428  
5:PW+MO-1:PW+MO -1.97602939 -2.98442378 -0.967635008 0.0000012  
7:PW+MO-1:PW+MO -3.17933867 -4.18773306 -2.170944287 0.0000000  
5:PW+MO-3:PW+MO -0.30144887 -1.30984326 0.706945511 0.9962387  
7:PW+MO-3:PW+MO -1.50475815 -2.51315254 -0.496363768 0.0003034  
7:PW+MO-5:PW+MO -1.20330928 -2.21170366 -0.194914895 0.0078960  
  
$`TB:water\_treatment`  
 diff lwr upr p adj  
y:sterile-water-n:sterile-water 1.0008405 0.3845328 1.6171483 0.0002063  
n:PW-MO-n:sterile-water 0.2793426 -0.3369651 0.8956503 0.7585152  
y:PW-MO-n:sterile-water 1.4020658 0.7857581 2.0183736 0.0000003  
n:PW+MO-n:sterile-water -3.6578986 -4.2742063 -3.0415908 0.0000000  
y:PW+MO-n:sterile-water -2.5418473 -3.1581551 -1.9255396 0.0000000  
n:PW-MO-y:sterile-water -0.7214979 -1.3378056 -0.1051902 0.0131854  
y:PW-MO-y:sterile-water 0.4012253 -0.2150824 1.0175330 0.3958413  
n:PW+MO-y:sterile-water -4.6587391 -5.2750468 -4.0424314 0.0000000  
y:PW+MO-y:sterile-water -3.5426879 -4.1589956 -2.9263802 0.0000000  
y:PW-MO-n:PW-MO 1.1227232 0.5064155 1.7390309 0.0000284  
n:PW+MO-n:PW-MO -3.9372412 -4.5535489 -3.3209335 0.0000000  
y:PW+MO-n:PW-MO -2.8211900 -3.4374977 -2.2048822 0.0000000  
n:PW+MO-y:PW-MO -5.0599644 -5.6762721 -4.4436567 0.0000000  
y:PW+MO-y:PW-MO -3.9439132 -4.5602209 -3.3276055 0.0000000  
y:PW+MO-n:PW+MO 1.1160512 0.4997435 1.7323589 0.0000317  
  
$`day:TB:water\_treatment`  
 diff lwr upr  
3:n:sterile-water-1:n:sterile-water 0.12748302 -1.47333045 1.72829649  
5:n:sterile-water-1:n:sterile-water -0.95922474 -2.56003820 0.64158873  
7:n:sterile-water-1:n:sterile-water -1.49396778 -3.09478124 0.10684569  
1:y:sterile-water-1:n:sterile-water -0.37237819 -1.97319165 1.22843528  
3:y:sterile-water-1:n:sterile-water 2.62833784 1.02752437 4.22915131  
5:y:sterile-water-1:n:sterile-water 0.31352101 -1.28729246 1.91433447  
7:y:sterile-water-1:n:sterile-water -0.89182802 -2.49264149 0.70898545  
1:n:PW-MO-1:n:sterile-water 0.23735219 -1.36346128 1.83816566  
3:n:PW-MO-1:n:sterile-water 0.22486268 -1.37595078 1.82567615  
5:n:PW-MO-1:n:sterile-water -0.28368820 -1.88450167 1.31712526  
7:n:PW-MO-1:n:sterile-water -1.38686565 -2.98767912 0.21394782  
1:y:PW-MO-1:n:sterile-water -2.07528082 -3.67609429 -0.47446736  
3:y:PW-MO-1:n:sterile-water 2.88520231 1.28438884 4.48601578  
5:y:PW-MO-1:n:sterile-water 1.64210240 0.04128893 3.24291587  
7:y:PW-MO-1:n:sterile-water 0.83052995 -0.77028352 2.43134342  
1:n:PW+MO-1:n:sterile-water -3.21466561 -4.81547908 -1.61385214  
3:n:PW+MO-1:n:sterile-water -4.28918353 -5.88999699 -2.68837006  
5:n:PW+MO-1:n:sterile-water -4.42923949 -6.03005295 -2.82842602  
7:n:PW+MO-1:n:sterile-water -5.02421515 -6.62502862 -3.42340168  
1:y:PW+MO-1:n:sterile-water -0.73296076 -2.33377423 0.86785271  
3:y:PW+MO-1:n:sterile-water -3.00760388 -4.60841735 -1.40679041  
5:y:PW+MO-1:n:sterile-water -3.47044567 -5.07125913 -1.86963220  
7:y:PW+MO-1:n:sterile-water -5.28208856 -6.88290203 -3.68127509  
5:n:sterile-water-3:n:sterile-water -1.08670776 -2.68752123 0.51410571  
7:n:sterile-water-3:n:sterile-water -1.62145080 -3.22226426 -0.02063733  
1:y:sterile-water-3:n:sterile-water -0.49986121 -2.10067467 1.10095226  
3:y:sterile-water-3:n:sterile-water 2.50085482 0.90004135 4.10166829  
5:y:sterile-water-3:n:sterile-water 0.18603799 -1.41477548 1.78685145  
7:y:sterile-water-3:n:sterile-water -1.01931104 -2.62012451 0.58150243  
1:n:PW-MO-3:n:sterile-water 0.10986917 -1.49094430 1.71068263  
3:n:PW-MO-3:n:sterile-water 0.09737966 -1.50343381 1.69819313  
5:n:PW-MO-3:n:sterile-water -0.41117123 -2.01198469 1.18964224  
7:n:PW-MO-3:n:sterile-water -1.51434867 -3.11516214 0.08646479  
1:y:PW-MO-3:n:sterile-water -2.20276385 -3.80357731 -0.60195038  
3:y:PW-MO-3:n:sterile-water 2.75771929 1.15690582 4.35853275  
5:y:PW-MO-3:n:sterile-water 1.51461938 -0.08619409 3.11543285  
7:y:PW-MO-3:n:sterile-water 0.70304693 -0.89776654 2.30386040  
1:n:PW+MO-3:n:sterile-water -3.34214863 -4.94296210 -1.74133516  
3:n:PW+MO-3:n:sterile-water -4.41666655 -6.01748001 -2.81585308  
5:n:PW+MO-3:n:sterile-water -4.55672251 -6.15753597 -2.95590904  
7:n:PW+MO-3:n:sterile-water -5.15169817 -6.75251164 -3.55088470  
1:y:PW+MO-3:n:sterile-water -0.86044378 -2.46125725 0.74036969  
3:y:PW+MO-3:n:sterile-water -3.13508690 -4.73590037 -1.53427344  
5:y:PW+MO-3:n:sterile-water -3.59792869 -5.19874216 -1.99711522  
7:y:PW+MO-3:n:sterile-water -5.40957158 -7.01038505 -3.80875811  
7:n:sterile-water-5:n:sterile-water -0.53474304 -2.13555651 1.06607043  
1:y:sterile-water-5:n:sterile-water 0.58684655 -1.01396692 2.18766002  
3:y:sterile-water-5:n:sterile-water 3.58756258 1.98674911 5.18837605  
5:y:sterile-water-5:n:sterile-water 1.27274574 -0.32806772 2.87355921  
7:y:sterile-water-5:n:sterile-water 0.06739672 -1.53341675 1.66821018  
1:n:PW-MO-5:n:sterile-water 1.19657692 -0.40423654 2.79739039  
3:n:PW-MO-5:n:sterile-water 1.18408742 -0.41672605 2.78490089  
5:n:PW-MO-5:n:sterile-water 0.67553653 -0.92527694 2.27635000  
7:n:PW-MO-5:n:sterile-water -0.42764092 -2.02845438 1.17317255  
1:y:PW-MO-5:n:sterile-water -1.11605609 -2.71686956 0.48475738  
3:y:PW-MO-5:n:sterile-water 3.84442704 2.24361358 5.44524051  
5:y:PW-MO-5:n:sterile-water 2.60132714 1.00051367 4.20214061  
7:y:PW-MO-5:n:sterile-water 1.78975469 0.18894122 3.39056815  
1:n:PW+MO-5:n:sterile-water -2.25544087 -3.85625434 -0.65462740  
3:n:PW+MO-5:n:sterile-water -3.32995879 -4.93077226 -1.72914532  
5:n:PW+MO-5:n:sterile-water -3.47001475 -5.07082822 -1.86920128  
7:n:PW+MO-5:n:sterile-water -4.06499041 -5.66580388 -2.46417695  
1:y:PW+MO-5:n:sterile-water 0.22626398 -1.37454949 1.82707744  
3:y:PW+MO-5:n:sterile-water -2.04837915 -3.64919261 -0.44756568  
5:y:PW+MO-5:n:sterile-water -2.51122093 -4.11203440 -0.91040746  
7:y:PW+MO-5:n:sterile-water -4.32286382 -5.92367729 -2.72205035  
1:y:sterile-water-7:n:sterile-water 1.12158959 -0.47922388 2.72240306  
3:y:sterile-water-7:n:sterile-water 4.12230562 2.52149215 5.72311909  
5:y:sterile-water-7:n:sterile-water 1.80748878 0.20667531 3.40830225  
7:y:sterile-water-7:n:sterile-water 0.60213976 -0.99867371 2.20295322  
1:n:PW-MO-7:n:sterile-water 1.73131996 0.13050650 3.33213343  
3:n:PW-MO-7:n:sterile-water 1.71883046 0.11801699 3.31964393  
5:n:PW-MO-7:n:sterile-water 1.21027957 -0.39053390 2.81109304  
7:n:PW-MO-7:n:sterile-water 0.10710212 -1.49371134 1.70791559  
1:y:PW-MO-7:n:sterile-water -0.58131305 -2.18212652 1.01950042  
3:y:PW-MO-7:n:sterile-water 4.37917008 2.77835662 5.97998355  
5:y:PW-MO-7:n:sterile-water 3.13607018 1.53525671 4.73688365  
7:y:PW-MO-7:n:sterile-water 2.32449772 0.72368426 3.92531119  
1:n:PW+MO-7:n:sterile-water -1.72069783 -3.32151130 -0.11988436  
3:n:PW+MO-7:n:sterile-water -2.79521575 -4.39602922 -1.19440228  
5:n:PW+MO-7:n:sterile-water -2.93527171 -4.53608518 -1.33445824  
7:n:PW+MO-7:n:sterile-water -3.53024738 -5.13106084 -1.92943391  
1:y:PW+MO-7:n:sterile-water 0.76100702 -0.83980645 2.36182048  
3:y:PW+MO-7:n:sterile-water -1.51363611 -3.11444957 0.08717736  
5:y:PW+MO-7:n:sterile-water -1.97647789 -3.57729136 -0.37566442  
7:y:PW+MO-7:n:sterile-water -3.78812078 -5.38893425 -2.18730732  
3:y:sterile-water-1:y:sterile-water 3.00071603 1.39990256 4.60152950  
5:y:sterile-water-1:y:sterile-water 0.68589919 -0.91491428 2.28671266  
7:y:sterile-water-1:y:sterile-water -0.51944984 -2.12026330 1.08136363  
1:n:PW-MO-1:y:sterile-water 0.60973037 -0.99108310 2.21054384  
3:n:PW-MO-1:y:sterile-water 0.59724087 -1.00357260 2.19805434  
5:n:PW-MO-1:y:sterile-water 0.08868998 -1.51212349 1.68950345  
7:n:PW-MO-1:y:sterile-water -1.01448747 -2.61530094 0.58632600  
1:y:PW-MO-1:y:sterile-water -1.70290264 -3.30371611 -0.10208917  
3:y:PW-MO-1:y:sterile-water 3.25758049 1.65676703 4.85839396  
5:y:PW-MO-1:y:sterile-water 2.01448059 0.41366712 3.61529406  
7:y:PW-MO-1:y:sterile-water 1.20290813 -0.39790533 2.80372160  
1:n:PW+MO-1:y:sterile-water -2.84228742 -4.44310089 -1.24147395  
3:n:PW+MO-1:y:sterile-water -3.91680534 -5.51761881 -2.31599187  
5:n:PW+MO-1:y:sterile-water -4.05686130 -5.65767477 -2.45604783  
7:n:PW+MO-1:y:sterile-water -4.65183697 -6.25265043 -3.05102350  
1:y:PW+MO-1:y:sterile-water -0.36058258 -1.96139604 1.24023089  
3:y:PW+MO-1:y:sterile-water -2.63522570 -4.23603916 -1.03441223  
5:y:PW+MO-1:y:sterile-water -3.09806748 -4.69888095 -1.49725401  
7:y:PW+MO-1:y:sterile-water -4.90971037 -6.51052384 -3.30889691  
5:y:sterile-water-3:y:sterile-water -2.31481684 -3.91563030 -0.71400337  
7:y:sterile-water-3:y:sterile-water -3.52016586 -5.12097933 -1.91935239  
1:n:PW-MO-3:y:sterile-water -2.39098565 -3.99179912 -0.79017219  
3:n:PW-MO-3:y:sterile-water -2.40347516 -4.00428863 -0.80266169  
5:n:PW-MO-3:y:sterile-water -2.91202605 -4.51283951 -1.31121258  
7:n:PW-MO-3:y:sterile-water -4.01520349 -5.61601696 -2.41439003  
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3:y:PW-MO-3:y:sterile-water 0.25686447 -1.34394900 1.85767793  
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7:y:sterile-water-1:y:sterile-water 0.9997874  
1:n:PW-MO-1:y:sterile-water 0.9978188  
3:n:PW-MO-1:y:sterile-water 0.9983547  
5:n:PW-MO-1:y:sterile-water 1.0000000  
7:n:PW-MO-1:y:sterile-water 0.7090765  
1:y:PW-MO-1:y:sterile-water 0.0256590  
3:y:PW-MO-1:y:sterile-water 0.0000001  
5:y:PW-MO-1:y:sterile-water 0.0027036  
7:y:PW-MO-1:y:sterile-water 0.3979493  
1:n:PW+MO-1:y:sterile-water 0.0000032  
3:n:PW+MO-1:y:sterile-water 0.0000000  
5:n:PW+MO-1:y:sterile-water 0.0000000  
7:n:PW+MO-1:y:sterile-water 0.0000000  
1:y:PW+MO-1:y:sterile-water 0.9999996  
3:y:PW+MO-1:y:sterile-water 0.0000181  
5:y:PW+MO-1:y:sterile-water 0.0000004  
7:y:PW+MO-1:y:sterile-water 0.0000000  
5:y:sterile-water-3:y:sterile-water 0.0002532  
7:y:sterile-water-3:y:sterile-water 0.0000000  
1:n:PW-MO-3:y:sterile-water 0.0001362  
3:n:PW-MO-3:y:sterile-water 0.0001230  
5:n:PW-MO-3:y:sterile-water 0.0000018  
7:n:PW-MO-3:y:sterile-water 0.0000000  
1:y:PW-MO-3:y:sterile-water 0.0000000  
3:y:PW-MO-3:y:sterile-water 1.0000000  
5:y:PW-MO-3:y:sterile-water 0.7528131  
7:y:PW-MO-3:y:sterile-water 0.0133258  
1:n:PW+MO-3:y:sterile-water 0.0000000  
3:n:PW+MO-3:y:sterile-water 0.0000000  
5:n:PW+MO-3:y:sterile-water 0.0000000  
7:n:PW+MO-3:y:sterile-water 0.0000000  
1:y:PW+MO-3:y:sterile-water 0.0000000  
3:y:PW+MO-3:y:sterile-water 0.0000000  
5:y:PW+MO-3:y:sterile-water 0.0000000  
7:y:PW+MO-3:y:sterile-water 0.0000000  
7:y:sterile-water-5:y:sterile-water 0.3942057  
1:n:PW-MO-5:y:sterile-water 1.0000000  
3:n:PW-MO-5:y:sterile-water 1.0000000  
5:n:PW-MO-5:y:sterile-water 0.9983559  
7:n:PW-MO-5:y:sterile-water 0.0260973  
1:y:PW-MO-5:y:sterile-water 0.0001387  
3:y:PW-MO-5:y:sterile-water 0.0000307  
5:y:PW-MO-5:y:sterile-water 0.2305634  
7:y:PW-MO-5:y:sterile-water 0.9998024  
1:n:PW+MO-5:y:sterile-water 0.0000000  
3:n:PW+MO-5:y:sterile-water 0.0000000  
5:n:PW+MO-5:y:sterile-water 0.0000000  
7:n:PW+MO-5:y:sterile-water 0.0000000  
1:y:PW+MO-5:y:sterile-water 0.6570027  
3:y:PW+MO-5:y:sterile-water 0.0000001  
5:y:PW+MO-5:y:sterile-water 0.0000000  
7:y:PW+MO-5:y:sterile-water 0.0000000  
1:n:PW-MO-7:y:sterile-water 0.5173594  
3:n:PW-MO-7:y:sterile-water 0.5384257  
5:n:PW-MO-7:y:sterile-water 0.9978944  
7:n:PW-MO-7:y:sterile-water 0.9999006  
1:y:PW-MO-7:y:sterile-water 0.4283495  
3:y:PW-MO-7:y:sterile-water 0.0000000  
5:y:PW-MO-7:y:sterile-water 0.0000420  
7:y:PW-MO-7:y:sterile-water 0.0224915  
1:n:PW+MO-7:y:sterile-water 0.0002373  
3:n:PW+MO-7:y:sterile-water 0.0000000  
5:n:PW+MO-7:y:sterile-water 0.0000000  
7:n:PW+MO-7:y:sterile-water 0.0000000  
1:y:PW+MO-7:y:sterile-water 1.0000000  
3:y:PW+MO-7:y:sterile-water 0.0012364  
5:y:PW+MO-7:y:sterile-water 0.0000290  
7:y:PW+MO-7:y:sterile-water 0.0000000  
3:n:PW-MO-1:n:PW-MO 1.0000000  
5:n:PW-MO-1:n:PW-MO 0.9997770  
7:n:PW-MO-1:n:PW-MO 0.0430727  
1:y:PW-MO-1:n:PW-MO 0.0002577  
3:y:PW-MO-1:n:PW-MO 0.0000163  
5:y:PW-MO-1:n:PW-MO 0.1569390  
7:y:PW-MO-1:n:PW-MO 0.9985027  
1:n:PW+MO-1:n:PW-MO 0.0000000  
3:n:PW+MO-1:n:PW-MO 0.0000000  
5:n:PW+MO-1:n:PW-MO 0.0000000  
7:n:PW+MO-1:n:PW-MO 0.0000000  
1:y:PW+MO-1:n:PW-MO 0.7762575  
3:y:PW+MO-1:n:PW-MO 0.0000001  
5:y:PW+MO-1:n:PW-MO 0.0000000  
7:y:PW+MO-1:n:PW-MO 0.0000000  
5:n:PW-MO-3:n:PW-MO 0.9998474  
7:n:PW-MO-3:n:PW-MO 0.0466545  
1:y:PW-MO-3:n:PW-MO 0.0002851  
3:y:PW-MO-3:n:PW-MO 0.0000147  
5:y:PW-MO-3:n:PW-MO 0.1468313  
7:y:PW-MO-3:n:PW-MO 0.9980074  
1:n:PW+MO-3:n:PW-MO 0.0000000  
3:n:PW+MO-3:n:PW-MO 0.0000000  
5:n:PW+MO-3:n:PW-MO 0.0000000  
7:n:PW+MO-3:n:PW-MO 0.0000000  
1:y:PW+MO-3:n:PW-MO 0.7939449  
3:y:PW+MO-3:n:PW-MO 0.0000001  
5:y:PW+MO-3:n:PW-MO 0.0000000  
7:y:PW+MO-3:n:PW-MO 0.0000000  
7:n:PW-MO-5:n:PW-MO 0.5613329  
1:y:PW-MO-5:n:PW-MO 0.0139229  
3:y:PW-MO-5:n:PW-MO 0.0000002  
5:y:PW-MO-5:n:PW-MO 0.0052700  
7:y:PW-MO-5:n:PW-MO 0.5426102  
1:n:PW+MO-5:n:PW-MO 0.0000015  
3:n:PW+MO-5:n:PW-MO 0.0000000  
5:n:PW+MO-5:n:PW-MO 0.0000000  
7:n:PW+MO-5:n:PW-MO 0.0000000  
1:y:PW+MO-5:n:PW-MO 0.9999801  
3:y:PW+MO-5:n:PW-MO 0.0000086  
5:y:PW+MO-5:n:PW-MO 0.0000002  
7:y:PW+MO-5:n:PW-MO 0.0000000  
1:y:PW-MO-7:n:PW-MO 0.9899042  
3:y:PW-MO-7:n:PW-MO 0.0000000  
5:y:PW-MO-7:n:PW-MO 0.0000007  
7:y:PW-MO-7:n:PW-MO 0.0005540  
1:n:PW+MO-7:n:PW-MO 0.0107673  
3:n:PW+MO-7:n:PW-MO 0.0000019  
5:n:PW+MO-7:n:PW-MO 0.0000006  
7:n:PW+MO-7:n:PW-MO 0.0000000  
1:y:PW+MO-7:n:PW-MO 0.9945870  
3:y:PW+MO-7:n:PW-MO 0.0440450  
5:y:PW+MO-7:n:PW-MO 0.0015888  
7:y:PW+MO-7:n:PW-MO 0.0000000  
3:y:PW-MO-1:y:PW-MO 0.0000000  
5:y:PW-MO-1:y:PW-MO 0.0000000  
7:y:PW-MO-1:y:PW-MO 0.0000019  
1:n:PW+MO-1:y:PW-MO 0.5002634  
3:n:PW+MO-1:y:PW-MO 0.0005697  
5:n:PW+MO-1:y:PW-MO 0.0001843  
7:n:PW+MO-1:y:PW-MO 0.0000013  
1:y:PW+MO-1:y:PW-MO 0.2157143  
3:y:PW+MO-1:y:PW-MO 0.8279277  
5:y:PW+MO-1:y:PW-MO 0.1650591  
7:y:PW+MO-1:y:PW-MO 0.0000002  
5:y:PW-MO-3:y:PW-MO 0.3385588  
7:y:PW-MO-3:y:PW-MO 0.0019868  
1:n:PW+MO-3:y:PW-MO 0.0000000  
3:n:PW+MO-3:y:PW-MO 0.0000000  
5:n:PW+MO-3:y:PW-MO 0.0000000  
7:n:PW+MO-3:y:PW-MO 0.0000000  
1:y:PW+MO-3:y:PW-MO 0.0000000  
3:y:PW+MO-3:y:PW-MO 0.0000000  
5:y:PW+MO-3:y:PW-MO 0.0000000  
7:y:PW+MO-3:y:PW-MO 0.0000000  
7:y:PW-MO-5:y:PW-MO 0.9434968  
1:n:PW+MO-5:y:PW-MO 0.0000000  
3:n:PW+MO-5:y:PW-MO 0.0000000  
5:n:PW+MO-5:y:PW-MO 0.0000000  
7:n:PW+MO-5:y:PW-MO 0.0000000  
1:y:PW+MO-5:y:PW-MO 0.0001552  
3:y:PW+MO-5:y:PW-MO 0.0000000  
5:y:PW+MO-5:y:PW-MO 0.0000000  
7:y:PW+MO-5:y:PW-MO 0.0000000  
1:n:PW+MO-7:y:PW-MO 0.0000000  
3:n:PW+MO-7:y:PW-MO 0.0000000  
5:n:PW+MO-7:y:PW-MO 0.0000000  
7:n:PW+MO-7:y:PW-MO 0.0000000  
1:y:PW+MO-7:y:PW-MO 0.0631035  
3:y:PW+MO-7:y:PW-MO 0.0000000  
5:y:PW+MO-7:y:PW-MO 0.0000000  
7:y:PW+MO-7:y:PW-MO 0.0000000  
3:n:PW+MO-1:n:PW+MO 0.6099665  
5:n:PW+MO-1:n:PW+MO 0.3802096  
7:n:PW+MO-1:n:PW+MO 0.0122628  
1:y:PW+MO-1:n:PW+MO 0.0000647  
3:y:PW+MO-1:n:PW+MO 1.0000000  
5:y:PW+MO-1:n:PW+MO 1.0000000  
7:y:PW+MO-1:n:PW+MO 0.0018006  
5:n:PW+MO-3:n:PW+MO 1.0000000  
7:n:PW+MO-3:n:PW+MO 0.9789155  
1:y:PW+MO-3:n:PW+MO 0.0000000  
3:y:PW+MO-3:n:PW+MO 0.2866730  
5:y:PW+MO-3:n:PW+MO 0.9387984  
7:y:PW+MO-3:n:PW+MO 0.7427186  
7:n:PW+MO-5:n:PW+MO 0.9984387  
1:y:PW+MO-5:n:PW+MO 0.0000000  
3:y:PW+MO-5:n:PW+MO 0.1433988  
5:y:PW+MO-5:n:PW+MO 0.7925941  
7:y:PW+MO-5:n:PW+MO 0.9127621  
1:y:PW+MO-7:n:PW+MO 0.0000000  
3:y:PW+MO-7:n:PW+MO 0.0026601  
5:y:PW+MO-7:n:PW+MO 0.0669760  
7:y:PW+MO-7:n:PW+MO 1.0000000  
3:y:PW+MO-1:y:PW+MO 0.0003502  
5:y:PW+MO-1:y:PW+MO 0.0000077  
7:y:PW+MO-1:y:PW+MO 0.0000000  
5:y:PW+MO-3:y:PW+MO 0.9999671  
7:y:PW+MO-3:y:PW+MO 0.0003506  
7:y:PW+MO-5:y:PW+MO 0.0120819

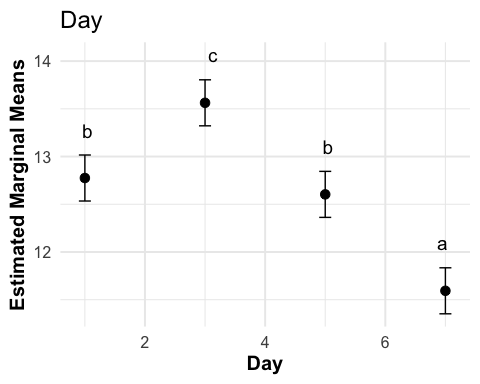
# emmeans and cld  
  
cld\_day <- emmeans(aov\_2b, pairwise ~ day, adjust = "tukey") %>%  
 cld(Letters = letters)

NOTE: Results may be misleading due to involvement in interactions

cld\_day\_2b <- ggplot(cld\_day, aes(x = as.numeric(as.character(day)), y = emmean)) +  
 geom\_point(size = 3) + # Plot the estimated means  
 geom\_errorbar(aes(ymin = lower.CL, ymax = upper.CL), width = 0.2) + # Error bars  
 geom\_text(aes(label = .group), nudge\_y = 0.5, size = 5, color = "black") + # Add CLD letters  
 xlab("Day") +  
 ylab("Estimated Marginal Means") +  
 ggtitle("Day") +  
 theme\_minimal(base\_size = 15) + # Use minimal theme for clean look  
 theme(axis.text.x = element\_text(size = 12), # Adjust text size for better readability  
 axis.title.x = element\_text(face = "bold"),  
 axis.title.y = element\_text(face = "bold"))  
#cld\_day\_2b  
  
# Compute CLD letters for 'day'  
cld\_day <- emmeans(aov\_2b, pairwise ~ day, adjust = "tukey") %>%  
 cld(Letters = letters)

NOTE: Results may be misleading due to involvement in interactions

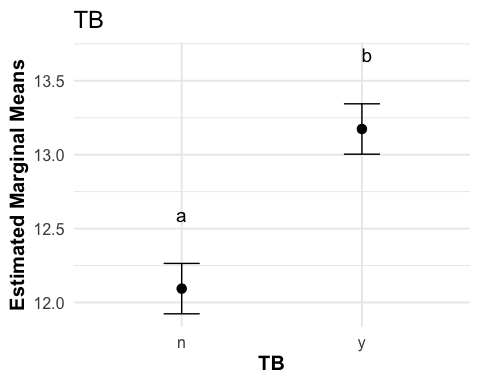
cld\_day\_2b <- ggplot(cld\_day, aes(x = as.numeric(as.character(day)), y = emmean)) +  
 geom\_point(size = 3) + # Plot the estimated means  
 geom\_errorbar(aes(ymin = lower.CL, ymax = upper.CL), width = 0.2) + # Error bars  
 geom\_text(aes(label = .group), nudge\_y = 0.5, size = 5, color = "black") + # Add CLD letters  
 xlab("Day") +  
 ylab("Estimated Marginal Means") +  
 ggtitle("Day") +  
 theme\_minimal(base\_size = 15) + # Use minimal theme for clean look  
 theme(axis.text.x = element\_text(size = 12), # Adjust text size for better readability  
 axis.title.x = element\_text(face = "bold"),  
 axis.title.y = element\_text(face = "bold"))  
cld\_day\_2b



# Compute CLD letters for 'TB'  
cld\_TB <- emmeans(aov\_2b, pairwise ~ TB, adjust = "tukey") %>%  
 cld(Letters = letters)

NOTE: Results may be misleading due to involvement in interactions

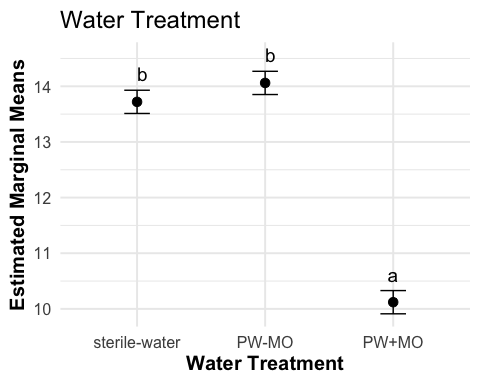
cld\_TB\_2b <- ggplot(cld\_TB, aes(x = TB, y = emmean)) +  
 geom\_point(size = 3) + # Plot the estimated means  
 geom\_errorbar(aes(ymin = lower.CL, ymax = upper.CL), width = 0.2) + # Error bars  
 geom\_text(aes(label = .group), nudge\_y = 0.5, size = 5, color = "black") + # Add CLD letters  
 xlab("TB") +  
 ylab("Estimated Marginal Means") +  
 ggtitle("TB") +  
 theme\_minimal(base\_size = 15) + # Use minimal theme for clean look  
 theme(axis.text.x = element\_text(size = 12), # Adjust text size for better readability  
 axis.title.x = element\_text(face = "bold"),  
 axis.title.y = element\_text(face = "bold"))  
cld\_TB\_2b



# Compute CLD letters for 'water\_treatment'  
cld\_water\_treatment <- emmeans(aov\_2b, pairwise ~ water\_treatment, adjust = "tukey") %>%  
 cld(Letters = letters)

NOTE: Results may be misleading due to involvement in interactions

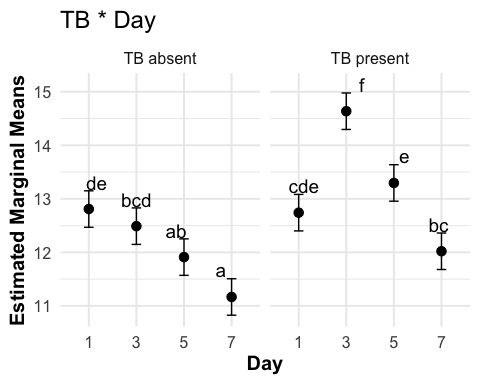
cld\_water\_treatment\_2b <-ggplot(cld\_water\_treatment, aes(x = water\_treatment, y = emmean)) +  
 geom\_point(size = 3) + # Plot the estimated means  
 geom\_errorbar(aes(ymin = lower.CL, ymax = upper.CL), width = 0.2) + # Error bars  
 geom\_text(aes(label = .group), nudge\_y = 0.5, size = 5, color = "black") + # Add CLD letters  
 xlab("Water Treatment") +  
 ylab("Estimated Marginal Means") +  
 ggtitle("Water Treatment") +  
 theme\_minimal(base\_size = 15) + # Use minimal theme for clean look  
 theme(axis.text.x = element\_text(size = 12), # Adjust text size for better readability  
 axis.title.x = element\_text(face = "bold"),  
 axis.title.y = element\_text(face = "bold"))  
cld\_water\_treatment\_2b



# Compute CLD letters for 'TB \* day'  
cld\_day\_TB <- emmeans(aov\_2b, pairwise ~ TB \* day, adjust = "tukey") %>%  
 cld(Letters = letters)

NOTE: Results may be misleading due to involvement in interactions

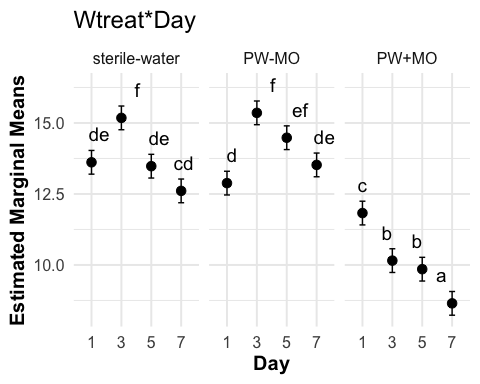
tb\_labels <- c("n" = "TB absent", "y" = "TB present")  
# Create the plot with custom labels for 'TB'  
cld\_tb\_day\_int\_2b <- ggplot(cld\_day\_TB, aes(x = factor(day), y = emmean)) +  
 geom\_point(size = 3) + # Plot the estimated means  
 geom\_errorbar(aes(ymin = lower.CL, ymax = upper.CL), width = 0.2) + # Error bars  
 geom\_text(aes(label = .group), nudge\_y = 0.5, size = 5, color = "black") + # Add CLD letters  
 facet\_wrap(~ TB, labeller = as\_labeller(tb\_labels)) + # Facet by TB with custom labels  
 xlab("Day") +  
 ylab("Estimated Marginal Means") +  
 ggtitle("TB \* Day") +  
 theme\_minimal(base\_size = 15) + # Use minimal theme for clean look  
 theme(axis.text.x = element\_text(size = 12), # Rotate x-axis labels 45 degrees  
 axis.title.x = element\_text(face = "bold"),  
 axis.title.y = element\_text(face = "bold"))  
cld\_tb\_day\_int\_2b



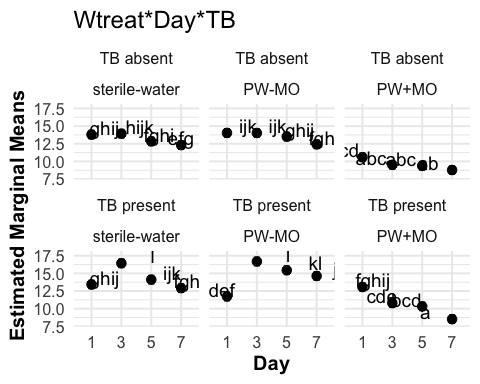
# Compute CLD letters for 'water\_treatment \* day'  
cld\_water\_treatment\_day <- emmeans(aov\_2b, pairwise ~ water\_treatment \* day, adjust = "tukey") %>%  
 cld(Letters = letters)

NOTE: Results may be misleading due to involvement in interactions

cld\_watertreat\_day\_int\_2b <- ggplot(cld\_water\_treatment\_day, aes(x = factor(day), y = emmean)) +  
 geom\_point(size = 3) + # Plot the estimated means  
 geom\_errorbar(aes(ymin = lower.CL, ymax = upper.CL), width = 0.2) + # Error bars  
 geom\_text(aes(label = .group), nudge\_y = 1, size = 5, color = "black") + # Add CLD letters  
 facet\_wrap(~ water\_treatment) + # Facet by water\_treatment  
 xlab("Day") +  
 ylab("Estimated Marginal Means") +  
 ggtitle("Wtreat\*Day") +  
 theme\_minimal(base\_size = 15) + # Use minimal theme for clean look  
 theme(axis.text.x = element\_text(size = 12), # Rotate x-axis labels 45 degrees  
 axis.title.x = element\_text(face = "bold"),  
 axis.title.y = element\_text(face = "bold"))  
cld\_watertreat\_day\_int\_2b



# third order...prepare for chaos  
# Compute CLD letters for 'water\_treatment \* day'  
cld\_water\_thirdorder <- emmeans(aov\_2b, pairwise ~ water\_treatment \* day \* TB, adjust = "tukey") %>%  
 cld(Letters = letters)  
tb\_labels <- c("n" = "TB absent", "y" = "TB present")  
cld\_water\_thirdorder\_2b <- ggplot(cld\_water\_thirdorder, aes(x = factor(day), y = emmean)) +  
 geom\_point(size = 3) + # Plot the estimated means  
 geom\_errorbar(aes(ymin = lower.CL, ymax = upper.CL), width = 0.2) + # Error bars  
 geom\_text(aes(label = .group), nudge\_y = 1, size = 5, color = "black") + # Add CLD letters  
 facet\_wrap(TB ~ water\_treatment, labeller = labeller(TB = tb\_labels)) + # Facet by water\_treatment with custom labels for TB  
 xlab("Day") +  
 ylab("Estimated Marginal Means") +  
 ggtitle("Wtreat\*Day\*TB") +  
 theme\_minimal(base\_size = 15) + # Use minimal theme for clean look  
 theme(axis.text.x = element\_text(size = 12), # Rotate x-axis labels 45 degrees  
 axis.title.x = element\_text(face = "bold"),  
 axis.title.y = element\_text(face = "bold"))  
cld\_water\_thirdorder\_2b



## GLM poisson untransformed Bd ~ day\*TB\*water\_treatment

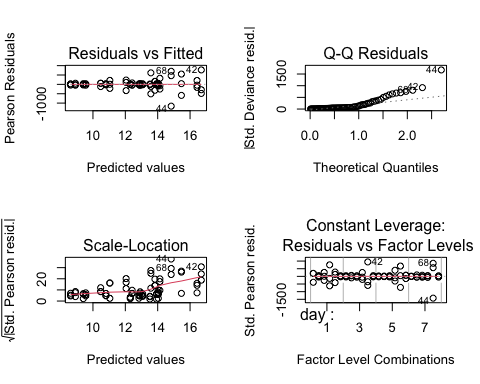
.L and .Q and .C are estimating things for model we do not need, turn it off, see the bolker thing Tatum is sending

https://stats.stackexchange.com/questions/387735/interpreting-the-estimate-of-an-ordered-factor-in-regression

pw\_noday0$adh\_plus\_sup\_rounded <- round(pw\_noday0$adh\_plus\_sup)  
  
pw\_noday0

day sample\_ID adh sup adh\_plus\_sup replicate microbes  
1 1 1%TB 1203296 131232 1334529 1 n  
2 3 1%TB 13820819 614229 14435048 1 n  
3 5 1%TB 1241691 47489 1289180 1 n  
4 7 1%TB 374678 40374 415051 1 n  
5 1 MQ 55715 1119310 1175025 1 n  
6 3 MQ 97420 989171 1086591 1 n  
7 5 MQ 50775 330455 381229 1 n  
8 7 MQ 37740 181836 219575 1 n  
9 1 1%TB+PW+microorganism 64747 395171 459917 1 y  
10 3 1%TB+PW+microorganism 4222 40438 44660 1 y  
11 5 1%TB+PW+microorganism 610 45721 46331 1 y  
12 7 1%TB+PW+microorganism 1166 6039 7205 1 y  
13 1 PW+microorganism 63742 21 63763 1 y  
14 3 PW+microorganism 16020 153 16174 1 y  
15 5 PW+microorganism 15313 783 16096 1 y  
16 7 PW+microorganism 12081 512 12593 1 y  
17 1 1%TB+PW-microorganism 26238 7160 33398 1 n  
18 3 1%TB+PW-microorganism 15461355 297759 15759114 1 n  
19 5 1%TB+PW-microorganism 4249727 1045302 5295029 1 n  
20 7 1%TB+PW-microorganism 3123961 414911 3538872 1 n  
21 1 PW-microorganism 54675 1190768 1245443 1 n  
22 3 PW-microorganism 23556 1243595 1267151 1 n  
23 5 PW-microorganism 97216 658323 755539 1 n  
24 7 PW-microorganism 34470 251379 285849 1 n  
25 1 1%TB 208438 131232 339670 2 n  
26 3 1%TB 12452545 614229 13066774 2 n  
27 5 1%TB 1710701 47489 1758190 2 n  
28 7 1%TB 328523 40374 368897 2 n  
29 1 MQ 51867 1119310 1171177 2 n  
30 3 MQ 128991 989171 1118162 2 n  
31 5 MQ 32239 330455 362694 2 n  
32 7 MQ 36665 181836 218501 2 n  
33 1 1%TB+PW+microorganism 69237 395171 464407 2 y  
34 3 1%TB+PW+microorganism 17030 40438 57468 2 y  
35 5 1%TB+PW+microorganism 914 45721 46635 2 y  
36 7 1%TB+PW+microorganism 761 6039 6800 2 y  
37 1 PW+microorganism 115428 21 115448 2 y  
38 3 PW+microorganism 17125 153 17279 2 y  
39 5 PW+microorganism 10937 783 11720 2 y  
40 7 PW+microorganism 2919 512 3431 2 y  
41 1 1%TB+PW-microorganism 258811 7160 265971 2 n  
42 3 1%TB+PW-microorganism 20758761 297759 21056520 2 n  
43 5 1%TB+PW-microorganism 2817437 1045302 3862739 2 n  
44 7 1%TB+PW-microorganism 417917 414911 832829 2 n  
45 1 PW-microorganism 19062 1190768 1209830 2 n  
46 3 PW-microorganism 50367 1243595 1293963 2 n  
47 5 PW-microorganism 81931 658323 740255 2 n  
48 7 PW-microorganism 22440 205975 228415 2 n  
49 1 1%TB 599345 92698 692043 3 n  
50 3 1%TB 13236028 269604 13505632 3 n  
51 5 1%TB 1037555 45837 1083392 3 n  
52 7 1%TB 406550 24700 431250 3 n  
53 1 MQ 52755 643894 696649 3 n  
54 3 MQ 78687 1077980 1156667 3 n  
55 5 MQ 47918 342203 390121 3 n  
56 7 MQ 28587 197452 226038 3 n  
57 1 1%TB+PW+microorganism 88247 409653 497901 3 y  
58 3 1%TB+PW+microorganism 9517 35543 45059 3 y  
59 5 1%TB+PW+microorganism 1167 12185 13351 3 y  
60 7 1%TB+PW+microorganism 1481 1087 2568 3 y  
61 1 PW+microorganism 8432 10 8441 3 y  
62 3 PW+microorganism 8370 483 8852 3 y  
63 5 PW+microorganism 8458 156 8615 3 y  
64 7 PW+microorganism 6079 233 6312 3 y  
65 1 1%TB+PW-microorganism 190323 23119 213442 3 n  
66 3 1%TB+PW-microorganism 16225944 364102 16590046 3 n  
67 5 1%TB+PW-microorganism 5265643 1196671 6462313 3 n  
68 7 1%TB+PW-microorganism 3295234 634350 3929585 3 n  
69 1 PW-microorganism 96892 1199922 1296814 3 n  
70 3 PW-microorganism 100570 1047328 1147898 3 n  
71 5 PW-microorganism 61803 670065 731868 3 n  
72 7 PW-microorganism 22352 206681 229033 3 n  
 water\_treatment TB log\_adh\_plus\_sup adh\_plus\_sup\_rounded  
1 sterile-water y 14.104089 1334529  
2 sterile-water y 16.485170 14435048  
3 sterile-water y 14.069517 1289180  
4 sterile-water y 12.936157 415051  
5 sterile-water n 13.976800 1175025  
6 sterile-water n 13.898556 1086591  
7 sterile-water n 12.851156 381229  
8 sterile-water n 12.299449 219575  
9 PW+MO y 13.038801 459917  
10 PW+MO y 10.706834 44660  
11 PW+MO y 10.743567 46331  
12 PW+MO y 8.882531 7205  
13 PW+MO n 11.062928 63763  
14 PW+MO n 9.691160 16174  
15 PW+MO n 9.686326 16096  
16 PW+MO n 9.440896 12593  
17 PW-MO y 10.416251 33398  
18 PW-MO y 16.572929 15759114  
19 PW-MO y 15.482279 5295029  
20 PW-MO y 15.079319 3538872  
21 PW-MO n 14.035002 1245443  
22 PW-MO n 14.052282 1267151  
23 PW-MO n 13.535187 755539  
24 PW-MO n 12.563219 285849  
25 sterile-water y 12.735730 339670  
26 sterile-water y 16.385583 13066774  
27 sterile-water y 14.379795 1758190  
28 sterile-water y 12.818273 368897  
29 sterile-water n 13.973520 1171177  
30 sterile-water n 13.927197 1118162  
31 sterile-water n 12.801315 362694  
32 sterile-water n 12.294546 218501  
33 PW+MO y 13.048517 464407  
34 PW+MO y 10.958984 57468  
35 PW+MO y 10.750107 46635  
36 PW+MO y 8.824678 6800  
37 PW+MO n 11.656575 115448  
38 PW+MO n 9.757247 17279  
39 PW+MO n 9.369052 11720  
40 PW+MO n 8.140607 3431  
41 PW-MO y 12.491143 265971  
42 PW-MO y 16.862721 21056520  
43 PW-MO y 15.166887 3862739  
44 PW-MO y 13.632584 832829  
45 PW-MO n 14.005990 1209830  
46 PW-MO n 14.073220 1293963  
47 PW-MO n 13.514750 740255  
48 PW-MO n 12.338919 228415  
49 sterile-water y 13.447403 692043  
50 sterile-water y 16.418617 13505632  
51 sterile-water y 13.895607 1083392  
52 sterile-water y 12.974443 431250  
53 sterile-water n 13.454037 696649  
54 sterile-water n 13.961053 1156667  
55 sterile-water n 12.874212 390121  
56 sterile-water n 12.328458 226038  
57 PW+MO y 13.118157 497901  
58 PW+MO y 10.715728 45059  
59 PW+MO y 9.499347 13351  
60 PW+MO y 7.850883 2568  
61 PW+MO n 9.040856 8441  
62 PW+MO n 9.088399 8852  
63 PW+MO n 9.061260 8615  
64 PW+MO n 8.750208 6312  
65 PW-MO y 12.271120 213442  
66 PW-MO y 16.624313 16590046  
67 PW-MO y 15.681498 6462313  
68 PW-MO y 15.184044 3929585  
69 PW-MO n 14.075421 1296814  
70 PW-MO n 13.953443 1147898  
71 PW-MO n 13.503355 731868  
72 PW-MO n 12.341621 229033

# normal distribution, should be relatively the same as the anova  
mod3\_glm <- glm(adh\_plus\_sup\_rounded ~ day \* TB \* water\_treatment,  
 data = pw\_noday0,  
 family = poisson(link = "log"))  
  
par(mfrow = c(2,2))  
plot(mod3\_glm) # look into how to interpret this with a poisson



summary(mod3\_glm) # ok this is sketch, I dont think it converged... look at those p values

Call:  
glm(formula = adh\_plus\_sup\_rounded ~ day \* TB \* water\_treatment,   
 family = poisson(link = "log"), data = pw\_noday0)  
  
Coefficients:  
 Estimate Std. Error z value Pr(>|z|)   
(Intercept) 13.2273100 0.0004340 30477.662 < 2e-16 \*\*\*  
day.L -1.2640185 0.0009405 -1344.057 < 2e-16 \*\*\*  
day.Q -0.3173300 0.0008680 -365.587 < 2e-16 \*\*\*  
day.C 0.3885446 0.0007889 492.499 < 2e-16 \*\*\*  
TBy 1.0366947 0.0005318 1949.254 < 2e-16 \*\*\*  
water\_treatmentPW-MO 0.2739310 0.0005779 473.985 < 2e-16 \*\*\*  
water\_treatmentPW+MO -3.4978885 0.0025520 -1370.664 < 2e-16 \*\*\*  
day.L:TBy 0.3037436 0.0012076 251.530 < 2e-16 \*\*\*  
day.Q:TBy -1.7206728 0.0010637 -1617.655 < 2e-16 \*\*\*  
day.C:TBy 1.0021734 0.0008970 1117.263 < 2e-16 \*\*\*  
day.L:water\_treatmentPW-MO 0.0639816 0.0012829 49.874 < 2e-16 \*\*\*  
day.Q:water\_treatmentPW-MO -0.2257027 0.0011559 -195.268 < 2e-16 \*\*\*  
day.C:water\_treatmentPW-MO -0.4085648 0.0010131 -403.290 < 2e-16 \*\*\*  
day.L:water\_treatmentPW+MO -0.1971745 0.0050974 -38.681 < 2e-16 \*\*\*  
day.Q:water\_treatmentPW+MO 0.8175618 0.0051039 160.183 < 2e-16 \*\*\*  
day.C:water\_treatmentPW+MO -0.7641892 0.0051104 -149.535 < 2e-16 \*\*\*  
TBy:water\_treatmentPW-MO 0.2227218 0.0007504 296.809 < 2e-16 \*\*\*  
TBy:water\_treatmentPW+MO -0.0255028 0.0033815 -7.542 4.63e-14 \*\*\*  
day.L:TBy:water\_treatmentPW-MO 2.4891374 0.0017763 1401.272 < 2e-16 \*\*\*  
day.Q:TBy:water\_treatmentPW-MO -0.3752504 0.0015008 -250.037 < 2e-16 \*\*\*  
day.C:TBy:water\_treatmentPW-MO 0.4651055 0.0011616 400.406 < 2e-16 \*\*\*  
day.L:TBy:water\_treatmentPW+MO -1.9019137 0.0074052 -256.836 < 2e-16 \*\*\*  
day.Q:TBy:water\_treatmentPW+MO 1.4252528 0.0067630 210.742 < 2e-16 \*\*\*  
day.C:TBy:water\_treatmentPW+MO -1.4038681 0.0060532 -231.923 < 2e-16 \*\*\*  
---  
Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
  
(Dispersion parameter for poisson family taken to be 1)  
  
 Null deviance: 373695575 on 71 degrees of freedom  
Residual deviance: 5506365 on 48 degrees of freedom  
AIC: 5507455  
  
Number of Fisher Scoring iterations: 5

# all comparisons  
em <- emmeans(mod3\_glm, ~ day \* TB \* water\_treatment)  
# Perform the Tukey test for pairwise comparisons  
pairwise\_comparisons <- contrast(em, method = "pairwise", adjust = "tukey")  
summary(pairwise\_comparisons)

contrast estimate SE df  
 (day1 n sterile-water) - (day3 n sterile-water) -0.099569 0.00079128 Inf  
 (day1 n sterile-water) - (day5 n sterile-water) 0.987005 0.00110020 Inf  
 (day1 n sterile-water) - (day7 n sterile-water) 1.522096 0.00135440 Inf  
 (day1 n sterile-water) - (day1 y sterile-water) 0.251492 0.00086675 Inf  
 (day1 n sterile-water) - (day3 y sterile-water) -2.600959 0.00059416 Inf  
 (day1 n sterile-water) - (day5 y sterile-water) -0.305667 0.00075546 Inf  
 (day1 n sterile-water) - (day7 y sterile-water) 0.917888 0.00107310 Inf  
 (day1 n sterile-water) - (day1 n PW-MO) -0.209517 0.00077147 Inf  
 (day1 n sterile-water) - (day3 n PW-MO) -0.197971 0.00077347 Inf  
 (day1 n sterile-water) - (day5 n PW-MO) 0.311842 0.00088178 Inf  
 (day1 n sterile-water) - (day7 n PW-MO) 1.409454 0.00129383 Inf  
 (day1 n sterile-water) - (day1 y PW-MO) 1.780643 0.00150953 Inf  
 (day1 n sterile-water) - (day3 y PW-MO) -2.865122 0.00058938 Inf  
 (day1 n sterile-water) - (day5 y PW-MO) -1.635762 0.00062663 Inf  
 (day1 n sterile-water) - (day7 y PW-MO) -1.003616 0.00067015 Inf  
 (day1 n sterile-water) - (day1 n PW+MO) 2.785961 0.00237858 Inf  
 (day1 n sterile-water) - (day3 n PW+MO) 4.275645 0.00489556 Inf  
 (day1 n sterile-water) - (day5 n PW+MO) 4.425130 0.00527046 Inf  
 (day1 n sterile-water) - (day7 n PW+MO) 4.914350 0.00671561 Inf  
 (day1 n sterile-water) - (day1 y PW+MO) 0.760572 0.00101576 Inf  
 (day1 n sterile-water) - (day3 y PW+MO) 3.028846 0.00266884 Inf  
 (day1 n sterile-water) - (day5 y PW+MO) 3.354125 0.00312001 Inf  
 (day1 n sterile-water) - (day7 y PW+MO) 5.212775 0.00778895 Inf  
 (day3 n sterile-water) - (day5 n sterile-water) 1.086573 0.00108595 Inf  
 (day3 n sterile-water) - (day7 n sterile-water) 1.621665 0.00134286 Inf  
 (day3 n sterile-water) - (day1 y sterile-water) 0.351060 0.00084859 Inf  
 (day3 n sterile-water) - (day3 y sterile-water) -2.501390 0.00056734 Inf  
 (day3 n sterile-water) - (day5 y sterile-water) -0.206098 0.00073456 Inf  
 (day3 n sterile-water) - (day7 y sterile-water) 1.017456 0.00105849 Inf  
 (day3 n sterile-water) - (day1 n PW-MO) -0.109949 0.00075101 Inf  
 (day3 n sterile-water) - (day3 n PW-MO) -0.098402 0.00075307 Inf  
 (day3 n sterile-water) - (day5 n PW-MO) 0.411411 0.00086394 Inf  
 (day3 n sterile-water) - (day7 n PW-MO) 1.509023 0.00128174 Inf  
 (day3 n sterile-water) - (day1 y PW-MO) 1.880211 0.00149918 Inf  
 (day3 n sterile-water) - (day3 y PW-MO) -2.765554 0.00056233 Inf  
 (day3 n sterile-water) - (day5 y PW-MO) -1.536194 0.00060126 Inf  
 (day3 n sterile-water) - (day7 y PW-MO) -0.904047 0.00064650 Inf  
 (day3 n sterile-water) - (day1 n PW+MO) 2.885530 0.00237203 Inf  
 (day3 n sterile-water) - (day3 n PW+MO) 4.375214 0.00489238 Inf  
 (day3 n sterile-water) - (day5 n PW+MO) 4.524699 0.00526751 Inf  
 (day3 n sterile-water) - (day7 n PW+MO) 5.013919 0.00671329 Inf  
 (day3 n sterile-water) - (day1 y PW+MO) 0.860141 0.00100031 Inf  
 (day3 n sterile-water) - (day3 y PW+MO) 3.128415 0.00266300 Inf  
 (day3 n sterile-water) - (day5 y PW+MO) 3.453694 0.00311502 Inf  
 (day3 n sterile-water) - (day7 y PW+MO) 5.312344 0.00778695 Inf  
 (day5 n sterile-water) - (day7 n sterile-water) 0.535091 0.00154517 Inf  
 (day5 n sterile-water) - (day1 y sterile-water) -0.735513 0.00114211 Inf  
 (day5 n sterile-water) - (day3 y sterile-water) -3.587964 0.00095194 Inf  
 (day5 n sterile-water) - (day5 y sterile-water) -1.292672 0.00106014 Inf  
 (day5 n sterile-water) - (day7 y sterile-water) -0.069117 0.00130565 Inf  
 (day5 n sterile-water) - (day1 n PW-MO) -1.196522 0.00107160 Inf  
 (day5 n sterile-water) - (day3 n PW-MO) -1.184976 0.00107304 Inf  
 (day5 n sterile-water) - (day5 n PW-MO) -0.675163 0.00115356 Inf  
 (day5 n sterile-water) - (day7 n PW-MO) 0.422450 0.00149237 Inf  
 (day5 n sterile-water) - (day1 y PW-MO) 0.793638 0.00168281 Inf  
 (day5 n sterile-water) - (day3 y PW-MO) -3.852127 0.00094896 Inf  
 (day5 n sterile-water) - (day5 y PW-MO) -2.622767 0.00097253 Inf  
 (day5 n sterile-water) - (day7 y PW-MO) -1.990620 0.00100113 Inf  
 (day5 n sterile-water) - (day1 n PW+MO) 1.798956 0.00249215 Inf  
 (day5 n sterile-water) - (day3 n PW+MO) 3.288640 0.00495173 Inf  
 (day5 n sterile-water) - (day5 n PW+MO) 3.438125 0.00532268 Inf  
 (day5 n sterile-water) - (day7 n PW+MO) 3.927346 0.00675667 Inf  
 (day5 n sterile-water) - (day1 y PW+MO) -0.226433 0.00125894 Inf  
 (day5 n sterile-water) - (day3 y PW+MO) 2.041841 0.00277054 Inf  
 (day5 n sterile-water) - (day5 y PW+MO) 2.367120 0.00320743 Inf  
 (day5 n sterile-water) - (day7 y PW+MO) 4.225770 0.00782438 Inf  
 (day7 n sterile-water) - (day1 y sterile-water) -1.270605 0.00138866 Inf  
 (day7 n sterile-water) - (day3 y sterile-water) -4.123055 0.00123699 Inf  
 (day7 n sterile-water) - (day5 y sterile-water) -1.827763 0.00132206 Inf  
 (day7 n sterile-water) - (day7 y sterile-water) -0.604208 0.00152600 Inf  
 (day7 n sterile-water) - (day1 n PW-MO) -1.731614 0.00133127 Inf  
 (day7 n sterile-water) - (day3 n PW-MO) -1.720067 0.00133243 Inf  
 (day7 n sterile-water) - (day5 n PW-MO) -1.210254 0.00139809 Inf  
 (day7 n sterile-water) - (day7 n PW-MO) -0.112642 0.00168853 Inf  
 (day7 n sterile-water) - (day1 y PW-MO) 0.258546 0.00185898 Inf  
 (day7 n sterile-water) - (day3 y PW-MO) -4.387219 0.00123470 Inf  
 (day7 n sterile-water) - (day5 y PW-MO) -3.157859 0.00125291 Inf  
 (day7 n sterile-water) - (day7 y PW-MO) -2.525712 0.00127524 Inf  
 (day7 n sterile-water) - (day1 n PW+MO) 1.263865 0.00261434 Inf  
 (day7 n sterile-water) - (day3 n PW+MO) 2.753549 0.00501434 Inf  
 (day7 n sterile-water) - (day5 n PW+MO) 2.903034 0.00538098 Inf  
 (day7 n sterile-water) - (day7 n PW+MO) 3.392254 0.00680269 Inf  
 (day7 n sterile-water) - (day1 y PW+MO) -0.761524 0.00148623 Inf  
 (day7 n sterile-water) - (day3 y PW+MO) 1.506750 0.00288095 Inf  
 (day7 n sterile-water) - (day5 y PW+MO) 1.832029 0.00330327 Inf  
 (day7 n sterile-water) - (day7 y PW+MO) 3.690679 0.00786415 Inf  
 (day1 y sterile-water) - (day3 y sterile-water) -2.852451 0.00066858 Inf  
 (day1 y sterile-water) - (day5 y sterile-water) -0.557159 0.00081529 Inf  
 (day1 y sterile-water) - (day7 y sterile-water) 0.666396 0.00111603 Inf  
 (day1 y sterile-water) - (day1 n PW-MO) -0.461009 0.00083014 Inf  
 (day1 y sterile-water) - (day3 n PW-MO) -0.449462 0.00083200 Inf  
 (day1 y sterile-water) - (day5 n PW-MO) 0.060350 0.00093355 Inf  
 (day1 y sterile-water) - (day7 n PW-MO) 1.157963 0.00132965 Inf  
 (day1 y sterile-water) - (day1 y PW-MO) 1.529151 0.00154034 Inf  
 (day1 y sterile-water) - (day3 y PW-MO) -3.116614 0.00066433 Inf  
 (day1 y sterile-water) - (day5 y PW-MO) -1.887254 0.00069759 Inf  
 (day1 y sterile-water) - (day7 y PW-MO) -1.255107 0.00073694 Inf  
 (day1 y sterile-water) - (day1 n PW+MO) 2.534469 0.00239825 Inf  
 (day1 y sterile-water) - (day3 n PW+MO) 4.024153 0.00490515 Inf  
 (day1 y sterile-water) - (day5 n PW+MO) 4.173638 0.00527937 Inf  
 (day1 y sterile-water) - (day7 n PW+MO) 4.662859 0.00672260 Inf  
 (day1 y sterile-water) - (day1 y PW+MO) 0.509080 0.00106101 Inf  
 (day1 y sterile-water) - (day3 y PW+MO) 2.777354 0.00268639 Inf  
 (day1 y sterile-water) - (day5 y PW+MO) 3.102633 0.00313503 Inf  
 (day1 y sterile-water) - (day7 y PW+MO) 4.961283 0.00779498 Inf  
 (day3 y sterile-water) - (day5 y sterile-water) 2.295292 0.00051621 Inf  
 (day3 y sterile-water) - (day7 y sterile-water) 3.518847 0.00092049 Inf  
 (day3 y sterile-water) - (day1 n PW-MO) 2.391442 0.00053936 Inf  
 (day3 y sterile-water) - (day3 n PW-MO) 2.402988 0.00054222 Inf  
 (day3 y sterile-water) - (day5 n PW-MO) 2.912801 0.00068796 Inf  
 (day3 y sterile-water) - (day7 n PW-MO) 4.010413 0.00117036 Inf  
 (day3 y sterile-water) - (day1 y PW-MO) 4.381602 0.00140514 Inf  
 (day3 y sterile-water) - (day3 y PW-MO) -0.264163 0.00020763 Inf  
 (day3 y sterile-water) - (day5 y PW-MO) 0.965197 0.00029733 Inf  
 (day3 y sterile-water) - (day7 y PW-MO) 1.597343 0.00038059 Inf  
 (day3 y sterile-water) - (day1 n PW+MO) 5.386920 0.00231374 Inf  
 (day3 y sterile-water) - (day3 n PW+MO) 6.876604 0.00486439 Inf  
 (day3 y sterile-water) - (day5 n PW+MO) 7.026089 0.00524152 Inf  
 (day3 y sterile-water) - (day7 n PW+MO) 7.515309 0.00669292 Inf  
 (day3 y sterile-water) - (day1 y PW+MO) 3.361531 0.00085294 Inf  
 (day3 y sterile-water) - (day3 y PW+MO) 5.629805 0.00261122 Inf  
 (day3 y sterile-water) - (day5 y PW+MO) 5.955084 0.00307087 Inf  
 (day3 y sterile-water) - (day7 y PW+MO) 7.813734 0.00776940 Inf  
 (day5 y sterile-water) - (day7 y sterile-water) 1.223555 0.00103199 Inf  
 (day5 y sterile-water) - (day1 n PW-MO) 0.096150 0.00071316 Inf  
 (day5 y sterile-water) - (day3 n PW-MO) 0.107696 0.00071533 Inf  
 (day5 y sterile-water) - (day5 n PW-MO) 0.617509 0.00083126 Inf  
 (day5 y sterile-water) - (day7 n PW-MO) 1.715121 0.00125994 Inf  
 (day5 y sterile-water) - (day1 y PW-MO) 2.086310 0.00148058 Inf  
 (day5 y sterile-water) - (day3 y PW-MO) -2.559455 0.00051070 Inf  
 (day5 y sterile-water) - (day5 y PW-MO) -1.330095 0.00055327 Inf  
 (day5 y sterile-water) - (day7 y PW-MO) -0.697949 0.00060212 Inf  
 (day5 y sterile-water) - (day1 n PW+MO) 3.091628 0.00236032 Inf  
 (day5 y sterile-water) - (day3 n PW+MO) 4.581312 0.00488671 Inf  
 (day5 y sterile-water) - (day5 n PW+MO) 4.730797 0.00526225 Inf  
 (day5 y sterile-water) - (day7 n PW+MO) 5.220017 0.00670916 Inf  
 (day5 y sterile-water) - (day1 y PW+MO) 1.066239 0.00097222 Inf  
 (day5 y sterile-water) - (day3 y PW+MO) 3.334513 0.00265258 Inf  
 (day5 y sterile-water) - (day5 y PW+MO) 3.659792 0.00310611 Inf  
 (day5 y sterile-water) - (day7 y PW+MO) 5.518442 0.00778339 Inf  
 (day7 y sterile-water) - (day1 n PW-MO) -1.127405 0.00104376 Inf  
 (day7 y sterile-water) - (day3 n PW-MO) -1.115859 0.00104524 Inf  
 (day7 y sterile-water) - (day5 n PW-MO) -0.606046 0.00112775 Inf  
 (day7 y sterile-water) - (day7 n PW-MO) 0.491567 0.00147250 Inf  
 (day7 y sterile-water) - (day1 y PW-MO) 0.862755 0.00166522 Inf  
 (day7 y sterile-water) - (day3 y PW-MO) -3.783010 0.00091741 Inf  
 (day7 y sterile-water) - (day5 y PW-MO) -2.553650 0.00094177 Inf  
 (day7 y sterile-water) - (day7 y PW-MO) -1.921503 0.00097127 Inf  
 (day7 y sterile-water) - (day1 n PW+MO) 1.868073 0.00248031 Inf  
 (day7 y sterile-water) - (day3 n PW+MO) 3.357757 0.00494578 Inf  
 (day7 y sterile-water) - (day5 n PW+MO) 3.507242 0.00531715 Inf  
 (day7 y sterile-water) - (day7 n PW+MO) 3.996463 0.00675231 Inf  
 (day7 y sterile-water) - (day1 y PW+MO) -0.157316 0.00123533 Inf  
 (day7 y sterile-water) - (day3 y PW+MO) 2.110958 0.00275989 Inf  
 (day7 y sterile-water) - (day5 y PW+MO) 2.436237 0.00319824 Inf  
 (day7 y sterile-water) - (day7 y PW+MO) 4.294887 0.00782061 Inf  
 (day1 n PW-MO) - (day3 n PW-MO) 0.011547 0.00073221 Inf  
 (day1 n PW-MO) - (day5 n PW-MO) 0.521360 0.00084583 Inf  
 (day1 n PW-MO) - (day7 n PW-MO) 1.618972 0.00126960 Inf  
 (day1 n PW-MO) - (day1 y PW-MO) 1.990160 0.00148881 Inf  
 (day1 n PW-MO) - (day3 y PW-MO) -2.655605 0.00053408 Inf  
 (day1 n PW-MO) - (day5 y PW-MO) -1.426245 0.00057493 Inf  
 (day1 n PW-MO) - (day7 y PW-MO) -0.794098 0.00062208 Inf  
 (day1 n PW-MO) - (day1 n PW+MO) 2.995478 0.00236549 Inf  
 (day1 n PW-MO) - (day3 n PW+MO) 4.485162 0.00488921 Inf  
 (day1 n PW-MO) - (day5 n PW+MO) 4.634647 0.00526457 Inf  
 (day1 n PW-MO) - (day7 n PW+MO) 5.123868 0.00671098 Inf  
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 (day1 n PW-MO) - (day5 y PW+MO) 3.563642 0.00311004 Inf  
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 (day3 n PW-MO) - (day5 n PW-MO) 0.509813 0.00084765 Inf  
 (day3 n PW-MO) - (day7 n PW-MO) 1.607425 0.00127082 Inf  
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 (day3 n PW-MO) - (day3 n PW+MO) 4.473616 0.00488953 Inf  
 (day3 n PW-MO) - (day5 n PW+MO) 4.623101 0.00526486 Inf  
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 69.758 <.0001  
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 77.223 <.0001  
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 828.411 <.0001  
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 569.849 <.0001  
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Results are given on the log (not the response) scale.   
P value adjustment: tukey method for comparing a family of 24 estimates

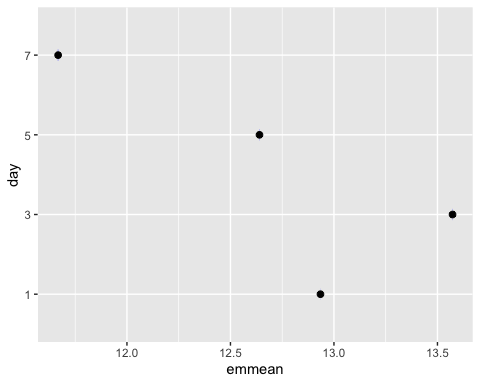
## First order comparisons  
  
# Pairwise comparisons for 'day'  
# Day 3 > Day 1 = Day 5 > Day 7  
pairwise\_day\_2b <- emmeans(mod3\_glm, pairwise ~ day, adjust = "tukey")

NOTE: Results may be misleading due to involvement in interactions

pairwise\_day\_2b # df infinity?? definitely sketchy

$emmeans  
 day emmean SE df asymp.LCL asymp.UCL  
 1 12.935 0.00050000 Inf 12.934 12.936  
 3 13.573 0.00092859 Inf 13.571 13.575  
 5 12.640 0.00103403 Inf 12.638 12.642  
 7 11.668 0.00173929 Inf 11.664 11.671  
  
Results are averaged over the levels of: TB, water\_treatment   
Results are given on the log (not the response) scale.   
Confidence level used: 0.95   
  
$contrasts  
 contrast estimate SE df z.ratio p.value  
 day1 - day3 -0.6380 0.001055 Inf -604.986 <.0001  
 day1 - day5 0.2946 0.001149 Inf 256.481 <.0001  
 day1 - day7 1.2673 0.001810 Inf 700.270 <.0001  
 day3 - day5 0.9326 0.001390 Inf 671.064 <.0001  
 day3 - day7 1.9053 0.001972 Inf 966.372 <.0001  
 day5 - day7 0.9727 0.002023 Inf 480.721 <.0001  
  
Results are averaged over the levels of: TB, water\_treatment   
Results are given on the log (not the response) scale.   
P value adjustment: tukey method for comparing a family of 4 estimates

plot(pairwise\_day\_2b)



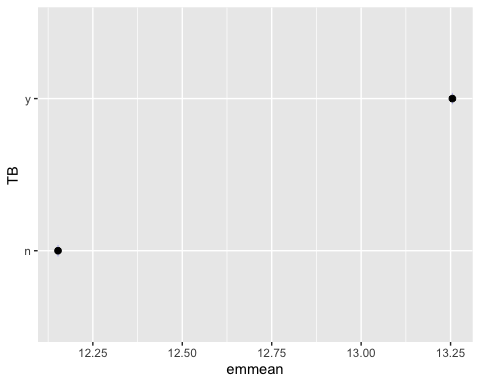
# Pairwise comparisons for 'TB'  
# note I dont need to test this bc its only 2 levels, bc I am "wasting" df  
# or bonferroni comparisons by hand is another option  
pairwise\_TB\_2b <- emmeans(mod3\_glm, pairwise ~ TB, adjust = "tukey")

NOTE: Results may be misleading due to involvement in interactions

pairwise\_TB\_2b

$emmeans  
 TB emmean SE df asymp.LCL asymp.UCL  
 n 12.153 0.00086011 Inf 12.151 12.154  
 y 13.255 0.00074957 Inf 13.254 13.257  
  
Results are averaged over the levels of: day, water\_treatment   
Results are given on the log (not the response) scale.   
Confidence level used: 0.95   
  
$contrasts  
 contrast estimate SE df z.ratio p.value  
 n - y -1.102 0.001141 Inf -966.284 <.0001  
  
Results are averaged over the levels of: day, water\_treatment   
Results are given on the log (not the response) scale.

plot(pairwise\_TB\_2b)



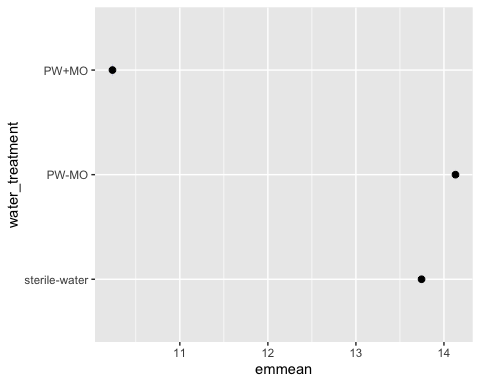
# Pairwise comparisons for 'water\_treatment'  
pairwise\_water\_treatment\_2b <- emmeans(mod3\_glm, pairwise ~ water\_treatment, adjust = "tukey")

NOTE: Results may be misleading due to involvement in interactions

pairwise\_water\_treatment\_2b

$emmeans  
 water\_treatment emmean SE df asymp.LCL asymp.UCL  
 sterile-water 13.7457 0.000265921 Inf 13.7451 13.7462  
 PW-MO 14.1309 0.000264682 Inf 14.1304 14.1315  
 PW+MO 10.2350 0.001669716 Inf 10.2317 10.2383  
  
Results are averaged over the levels of: day, TB   
Results are given on the log (not the response) scale.   
Confidence level used: 0.95   
  
$contrasts  
 contrast estimate SE df z.ratio p.value  
 (sterile-water) - (PW-MO) -0.3853 0.0003752 Inf -1026.913 <.0001  
 (sterile-water) - (PW+MO) 3.5106 0.0016908 Inf 2076.369 <.0001  
 (PW-MO) - (PW+MO) 3.8959 0.0016906 Inf 2304.515 <.0001  
  
Results are averaged over the levels of: day, TB   
Results are given on the log (not the response) scale.   
P value adjustment: tukey method for comparing a family of 3 estimates

plot(pairwise\_water\_treatment\_2b)



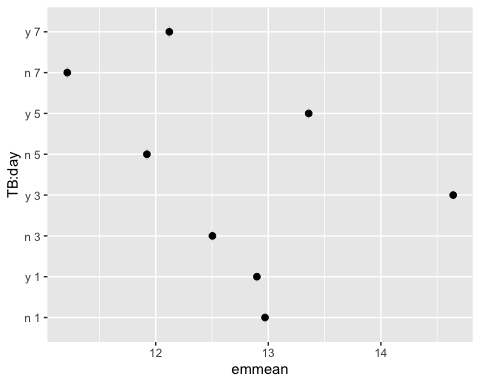
## second order comparisons  
  
# day:TB  
pairwise\_day\_TB\_2b <- emmeans(mod3\_glm, pairwise ~ TB \* day, adjust = "tukey")

NOTE: Results may be misleading due to involvement in interactions

pairwise\_day\_TB\_2b

$emmeans  
 TB day emmean SE df asymp.LCL asymp.UCL  
 n 1 12.971 0.00081132 Inf 12.969 12.972  
 y 1 12.899 0.00058460 Inf 12.898 12.900  
 n 3 12.504 0.00163995 Inf 12.500 12.507  
 y 3 14.642 0.00087160 Inf 14.640 14.644  
 n 5 11.922 0.00178823 Inf 11.918 11.925  
 y 5 13.359 0.00103880 Inf 13.357 13.361  
 n 7 11.214 0.00230029 Inf 11.210 11.219  
 y 7 12.121 0.00260944 Inf 12.116 12.126  
  
Results are averaged over the levels of: water\_treatment   
Results are given on the log (not the response) scale.   
Confidence level used: 0.95   
  
$contrasts  
 contrast estimate SE df z.ratio p.value  
 n day1 - y day1 0.07209 0.001000 Inf 72.088 <.0001  
 n day1 - n day3 0.46722 0.001830 Inf 255.358 <.0001  
 n day1 - y day3 -1.67123 0.001191 Inf -1403.486 <.0001  
 n day1 - n day5 1.04918 0.001964 Inf 534.294 <.0001  
 n day1 - y day5 -0.38792 0.001318 Inf -294.303 <.0001  
 n day1 - n day7 1.75649 0.002439 Inf 720.116 <.0001  
 n day1 - y day7 0.85020 0.002733 Inf 311.126 <.0001  
 y day1 - n day3 0.39513 0.001741 Inf 226.953 <.0001  
 y day1 - y day3 -1.74331 0.001049 Inf -1661.098 <.0001  
 y day1 - n day5 0.97709 0.001881 Inf 519.353 <.0001  
 y day1 - y day5 -0.46000 0.001192 Inf -385.910 <.0001  
 y day1 - n day7 1.68440 0.002373 Inf 709.695 <.0001  
 y day1 - y day7 0.77811 0.002674 Inf 290.979 <.0001  
 n day3 - y day3 -2.13845 0.001857 Inf -1151.446 <.0001  
 n day3 - n day5 0.58196 0.002426 Inf 239.848 <.0001  
 n day3 - y day5 -0.85514 0.001941 Inf -440.503 <.0001  
 n day3 - n day7 1.28927 0.002825 Inf 456.373 <.0001  
 n day3 - y day7 0.38298 0.003082 Inf 124.264 <.0001  
 y day3 - n day5 2.72040 0.001989 Inf 1367.495 <.0001  
 y day3 - y day5 1.28331 0.001356 Inf 946.380 <.0001  
 y day3 - n day7 3.42771 0.002460 Inf 1393.447 <.0001  
 y day3 - y day7 2.52143 0.002751 Inf 916.498 <.0001  
 n day5 - y day5 -1.43709 0.002068 Inf -694.900 <.0001  
 n day5 - n day7 0.70731 0.002914 Inf 242.761 <.0001  
 n day5 - y day7 -0.19898 0.003163 Inf -62.900 <.0001  
 y day5 - n day7 2.14440 0.002524 Inf 849.614 <.0001  
 y day5 - y day7 1.23812 0.002809 Inf 440.830 <.0001  
 n day7 - y day7 -0.90629 0.003479 Inf -260.533 <.0001  
  
Results are averaged over the levels of: water\_treatment   
Results are given on the log (not the response) scale.   
P value adjustment: tukey method for comparing a family of 8 estimates

plot(pairwise\_day\_TB\_2b)



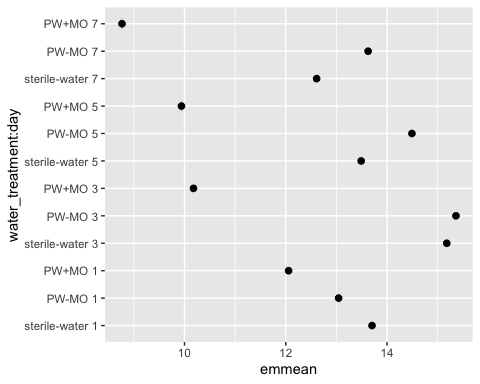
# day:water\_treatment  
pairwise\_water\_treatment\_day\_2b <- emmeans(mod3\_glm, pairwise ~ water\_treatment \* day, adjust = "tukey")

NOTE: Results may be misleading due to involvement in interactions

pairwise\_water\_treatment\_day\_2b

$emmeans  
 water\_treatment day emmean SE df asymp.LCL asymp.UCL  
 sterile-water 1 13.70395 0.000433373 Inf 13.70310 13.70480  
 PW-MO 1 13.04413 0.000744405 Inf 13.04267 13.04559  
 PW+MO 1 12.05643 0.001228020 Inf 12.05402 12.05883  
 sterile-water 3 15.17996 0.000283672 Inf 15.17940 15.18051  
 PW-MO 3 15.36124 0.000268486 Inf 15.36071 15.36177  
 PW+MO 3 10.17745 0.002758258 Inf 10.17204 10.18285  
 sterile-water 5 13.48902 0.000530067 Inf 13.48799 13.49006  
 PW-MO 5 14.49165 0.000358093 Inf 14.49095 14.49235  
 PW+MO 5 9.94007 0.003035415 Inf 9.93412 9.94601  
 sterile-water 7 12.60970 0.000763000 Inf 12.60821 12.61120  
 PW-MO 7 13.62677 0.000605355 Inf 13.62559 13.62796  
 PW+MO 7 8.76613 0.005126155 Inf 8.75608 8.77618  
  
Results are averaged over the levels of: TB   
Results are given on the log (not the response) scale.   
Confidence level used: 0.95   
  
$contrasts  
 contrast estimate SE df z.ratio  
 (sterile-water day1) - (PW-MO day1) 0.65982 0.0008614 Inf 766.012  
 (sterile-water day1) - (PW+MO day1) 1.64752 0.0013022 Inf 1265.137  
 (sterile-water day1) - (sterile-water day3) -1.47601 0.0005180 Inf -2849.661  
 (sterile-water day1) - (PW-MO day3) -1.65729 0.0005098 Inf -3250.861  
 (sterile-water day1) - (PW+MO day3) 3.52650 0.0027921 Inf 1263.030  
 (sterile-water day1) - (sterile-water day5) 0.21492 0.0006847 Inf 313.904  
 (sterile-water day1) - (PW-MO day5) -0.78771 0.0005622 Inf -1401.171  
 (sterile-water day1) - (PW+MO day5) 3.76388 0.0030662 Inf 1227.541  
 (sterile-water day1) - (sterile-water day7) 1.09425 0.0008775 Inf 1247.024  
 (sterile-water day1) - (PW-MO day7) 0.07717 0.0007445 Inf 103.659  
 (sterile-water day1) - (PW+MO day7) 4.93782 0.0051444 Inf 959.835  
 (PW-MO day1) - (PW+MO day1) 0.98770 0.0014360 Inf 687.803  
 (PW-MO day1) - (sterile-water day3) -2.13583 0.0007966 Inf -2681.100  
 (PW-MO day1) - (PW-MO day3) -2.31711 0.0007913 Inf -2928.073  
 (PW-MO day1) - (PW+MO day3) 2.86668 0.0028569 Inf 1003.409  
 (PW-MO day1) - (sterile-water day5) -0.44489 0.0009138 Inf -486.838  
 (PW-MO day1) - (PW-MO day5) -1.44752 0.0008261 Inf -1752.330  
 (PW-MO day1) - (PW+MO day5) 3.10406 0.0031254 Inf 993.186  
 (PW-MO day1) - (sterile-water day7) 0.43443 0.0010660 Inf 407.541  
 (PW-MO day1) - (PW-MO day7) -0.58264 0.0009595 Inf -607.252  
 (PW-MO day1) - (PW+MO day7) 4.27800 0.0051799 Inf 825.881  
 (PW+MO day1) - (sterile-water day3) -3.12353 0.0012604 Inf -2478.287  
 (PW+MO day1) - (PW-MO day3) -3.30481 0.0012570 Inf -2629.070  
 (PW+MO day1) - (PW+MO day3) 1.87898 0.0030193 Inf 622.328  
 (PW+MO day1) - (sterile-water day5) -1.43260 0.0013375 Inf -1071.071  
 (PW+MO day1) - (PW-MO day5) -2.43523 0.0012792 Inf -1903.762  
 (PW+MO day1) - (PW+MO day5) 2.11636 0.0032744 Inf 646.333  
 (PW+MO day1) - (sterile-water day7) -0.55327 0.0014458 Inf -382.689  
 (PW+MO day1) - (PW-MO day7) -1.57035 0.0013691 Inf -1146.976  
 (PW+MO day1) - (PW+MO day7) 3.29030 0.0052712 Inf 624.203  
 (sterile-water day3) - (PW-MO day3) -0.18128 0.0003906 Inf -464.135  
 (sterile-water day3) - (PW+MO day3) 5.00251 0.0027728 Inf 1804.132  
 (sterile-water day3) - (sterile-water day5) 1.69093 0.0006012 Inf 2812.597  
 (sterile-water day3) - (PW-MO day5) 0.68830 0.0004568 Inf 1506.672  
 (sterile-water day3) - (PW+MO day5) 5.23989 0.0030486 Inf 1718.763  
 (sterile-water day3) - (sterile-water day7) 2.57026 0.0008140 Inf 3157.460  
 (sterile-water day3) - (PW-MO day7) 1.55318 0.0006685 Inf 2323.301  
 (sterile-water day3) - (PW+MO day7) 6.41383 0.0051340 Inf 1249.285  
 (PW-MO day3) - (PW+MO day3) 5.18379 0.0027713 Inf 1870.531  
 (PW-MO day3) - (sterile-water day5) 1.87221 0.0005942 Inf 3150.895  
 (PW-MO day3) - (PW-MO day5) 0.86959 0.0004476 Inf 1942.925  
 (PW-MO day3) - (PW+MO day5) 5.42117 0.0030473 Inf 1779.029  
 (PW-MO day3) - (sterile-water day7) 2.75154 0.0008089 Inf 3401.751  
 (PW-MO day3) - (PW-MO day7) 1.73447 0.0006622 Inf 2619.156  
 (PW-MO day3) - (PW+MO day7) 6.59511 0.0051332 Inf 1284.800  
 (PW+MO day3) - (sterile-water day5) -3.31158 0.0028087 Inf -1179.030  
 (PW+MO day3) - (PW-MO day5) -4.31421 0.0027814 Inf -1551.088  
 (PW+MO day3) - (PW+MO day5) 0.23738 0.0041014 Inf 57.878  
 (PW+MO day3) - (sterile-water day7) -2.43225 0.0028618 Inf -849.890  
 (PW+MO day3) - (PW-MO day7) -3.44933 0.0028239 Inf -1221.474  
 (PW+MO day3) - (PW+MO day7) 1.41132 0.0058211 Inf 242.448  
 (sterile-water day5) - (PW-MO day5) -1.00263 0.0006397 Inf -1567.370  
 (sterile-water day5) - (PW+MO day5) 3.54896 0.0030814 Inf 1151.754  
 (sterile-water day5) - (sterile-water day7) 0.87932 0.0009291 Inf 946.472  
 (sterile-water day5) - (PW-MO day7) -0.13775 0.0008046 Inf -171.196  
 (sterile-water day5) - (PW+MO day7) 4.72289 0.0051535 Inf 916.446  
 (PW-MO day5) - (PW+MO day5) 4.55159 0.0030565 Inf 1489.167  
 (PW-MO day5) - (sterile-water day7) 1.88195 0.0008429 Inf 2232.838  
 (PW-MO day5) - (PW-MO day7) 0.86488 0.0007033 Inf 1229.677  
 (PW-MO day5) - (PW+MO day7) 5.72552 0.0051386 Inf 1114.208  
 (PW+MO day5) - (sterile-water day7) -2.66963 0.0031298 Inf -852.962  
 (PW+MO day5) - (PW-MO day7) -3.68671 0.0030952 Inf -1191.109  
 (PW+MO day5) - (PW+MO day7) 1.17393 0.0059575 Inf 197.053  
 (sterile-water day7) - (PW-MO day7) -1.01707 0.0009740 Inf -1044.251  
 (sterile-water day7) - (PW+MO day7) 3.84357 0.0051826 Inf 741.626  
 (PW-MO day7) - (PW+MO day7) 4.86064 0.0051618 Inf 941.661  
 p.value  
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Results are averaged over the levels of: TB   
Results are given on the log (not the response) scale.   
P value adjustment: tukey method for comparing a family of 12 estimates

plot(pairwise\_water\_treatment\_day\_2b)



# should I go for the cld letter comparisons for these? I think that may be the easiest to show

cld post hoc plots

library(multcompView)

# \*Publication figure

2a

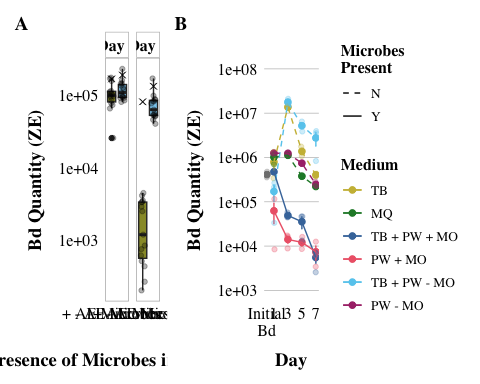
fig\_2a <- eb\_pw %>%  
 # combine floating and adherent for total\_Bd  
 pivot\_wider(names\_from = bd\_location, values\_from = bd\_qty) %>%  
 mutate(combined\_bd = adherent + floating) %>%   
   
 # create the plot  
 ggplot(aes(y= combined\_bd, x = filter, fill = filter)) +   
 geom\_boxplot() +  
 geom\_jitter(width = 0.2, alpha = 0.3) +  
 scale\_y\_log10() +  
 facet\_wrap(~day, labeller = labeller(day = c("Day\_1" = "Day 1",  
 "Day\_7" = "Day 7")))+  
   
 scale\_fill\_manual(values = c("40um\_filter" = with\_microbes\_40\_color,   
 "0.22um\_filter" = no\_microbes\_.22\_color)) +  
 myCustomTheme() +  
 theme(legend.position = "none",  
 strip.text = element\_text(face="bold"),  
 axis.title = element\_text(face = "bold")) +   
 scale\_x\_discrete (labels= c("40um\_filter" = "+ AE Microbes", "0.22um\_filter" = "- AE Microbes")) +  
 xlab("Presence of Microbes in Pond Water") +  
 ylab("Bd Quantity (ZE)") +  
   
 # add controls ad x's  
 geom\_point(data = eb\_pw\_controls, aes(x = filter, y = combined\_bd), shape = 4, size = 2)

2b

# Convert factor day to numeric while preserving original values  
pw\_noday0$day <- as.numeric(as.character(pw\_noday0$day))  
  
fig2B <- pw\_summary %>%   
 # reorder to match Renwei's plot  
 mutate(sample\_ID = factor(sample\_ID,   
 levels = c("1%TB", "MQ", "1%TB+PW+microorganism", "PW+microorganism", "1%TB+PW-microorganism", "PW-microorganism", "Added Bd"))) %>%   
 mutate(day = as.numeric(day)) %>%   
 ggplot(aes(x = day,   
 y = mean,   
 color = sample\_ID)) +  
 geom\_point(size = 2) +  
 geom\_errorbar(aes(ymin = mean - se, # plot the standard error  
 ymax = mean + se),  
 width = 0.1) +  
  
 # Adding the raw data as a layer with jitter  
 geom\_point(data = pw\_noday0,   
 aes(x = day,   
 y = adh\_plus\_sup,   
 color = sample\_ID), # Raw data points  
 position = position\_jitter(width = 0.1, seed = 1),  
 alpha = 0.3) +  
 # add control raw data too  
 geom\_point(data = pw\_control\_data,   
 aes(x = day,   
 y = adh\_plus\_sup,   
 color = "#BBBBBB"), # Raw data points  
 position = position\_jitter(width = 0.1, seed = 1),  
 alpha = 0.3) +  
   
 scale\_y\_log10(limits = c(1e3, 1e8),   
 breaks = c(1e3, 1e4, 1e5, 1e6, 1e7, 1e8)) +  
 labs(x = "Day",  
 y = "Bd Quantity (ZE)",  
 color = "Medium", # Title for color legend  
 linetype = "Microbes\nPresent" # Title for linetype legend  
 ) +  
 scale\_color\_manual(values = c("1%TB" = "#CCBB44",   
 "MQ" = "#228833",   
 "1%TB+PW+microorganism" = "#4477AA",   
 "PW+microorganism" = "#EE6677",   
 "1%TB+PW-microorganism" = "#66CCEE",  
 #"Added Bd" = "#BBBBBB" # removed bc not really a medium  
 "PW-microorganism" = "#AA3377"),   
 labels = c("1%TB" = "TB",  
 "MQ" = "MQ",  
 "1%TB+PW+microorganism" = "TB + PW + MO",  
 "PW+microorganism" = "PW + MO",  
 "1%TB+PW-microorganism" = "TB + PW - MO",  
 "PW-microorganism" = "PW - MO",  
 "Added Bd" = "Initial Bd")) + # Custom labels for the color legend  
   
 geom\_line(aes(linetype = microbes)) +   
 scale\_linetype\_manual(values = c("n" = "dashed",   
 "y" = "solid"),  
 labels = c("n" = "N", "y" = "Y")) + # Change labels to uppercase N and Y  
 myCustomTheme()+  
 scale\_x\_continuous(breaks = c(0, 1, 3, 5, 7),  
 labels = c("Initial\nBd", "1", "3", "5", "7")) +  
 theme(legend.position = "right",  
 panel.grid.major.y = element\_line(color = "grey"), # Add major y grid lines  
 panel.border = element\_blank())

combine

# Combine fig\_2a and fig\_2b side by side  
fig2 <- fig\_2a + fig2B +   
 plot\_layout(widths = c(1, 1)) + # Ensure equal widths for both plots  
 plot\_annotation(tag\_levels = 'A') # Adds "A" and "B" to the upper corners  
  
fig2



#ggsave("2a\_2b.png", plot = fig2, width = 14, height = 5, dpi = 1000)

# \*SI figures and tables

## 2b anova table

# anova table  
anova\_output <- tidy(aov\_2b)  
  
aov\_2b\_tbl <- anova\_output %>%  
 dplyr::select(term, df, sumsq, meansq, statistic, p.value) %>%  
 gt() %>%  
 tab\_header(  
 title = "ANOVA Table"  
 ) %>%  
 fmt\_number(  
 columns = c(sumsq, meansq, statistic),  
 decimals = 2  
 ) %>%  
 cols\_label(  
 term = "Term",  
 df = "Df",  
 sumsq = "Sum Sq",  
 meansq = "Mean Sq",  
 statistic = "F value",  
 p.value = "P-value"  
 ) %>% # scientific number format for values <0.001 in p values  
 fmt\_scientific(  
 columns = c(p.value),  
 decimals = 1,  
 rows = p.value < 0.001  
 ) %>%  
 # 3 decimals for p values >=0.001  
 fmt\_number(  
 columns = c(p.value),  
 decimals = 3,  
 rows = p.value >= 0.001  
 )  
aov\_2b\_tbl

Table 1: ANOVA Table

| Term | Df | Sum Sq | Mean Sq | F value | P-value |
| --- | --- | --- | --- | --- | --- |
| day | 3 | 35.40 | 11.80 | 45.61 | 4.3 × 10^-14 |
| TB | 1 | 20.99 | 20.99 | 81.13 | 6.9 × 10^-12 |
| water\_treatment | 2 | 228.85 | 114.42 | 442.25 | 1.2 × 10^-31 |
| day:TB | 3 | 11.71 | 3.90 | 15.08 | 4.8 × 10^-7 |
| day:water\_treatment | 6 | 37.33 | 6.22 | 24.05 | 6.4 × 10^-13 |
| TB:water\_treatment | 2 | 0.06 | 0.03 | 0.11 | 0.897 |
| day:TB:water\_treatment | 6 | 24.57 | 4.09 | 15.82 | 6.3 × 10^-10 |
| Residuals | 48 | 12.42 | 0.26 | NA | NA |

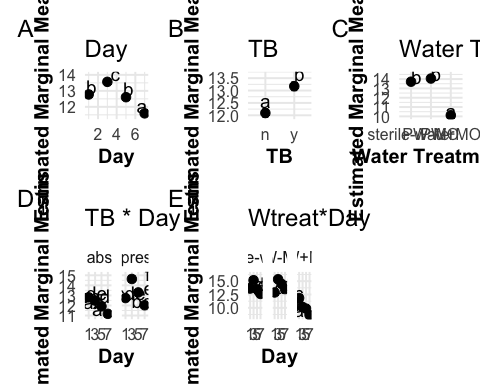
# prettier, simplified  
anova\_output <- tidy(aov\_2b)  
  
# Modify term to include degrees of freedom in \*italics\*  
anova\_output <- anova\_output %>%  
 mutate(term = ifelse(grepl("day:medium", term), "day x medium", term)) %>%   
 mutate (term = paste0(term, " (\*df = ", df, ", ", anova\_output[df == max(df), "df"], "\*)")) %>%   
 filter(term != "Residuals (\*df = 48, 48\*)")  
  
# Create the gt table with selected columns  
aov\_2b\_tbl\_b <- anova\_output %>%  
 dplyr::select(term, statistic, p.value) %>%  
 gt() %>%  
 tab\_header(  
 title = "ANOVA Table"  
 ) %>%  
 fmt\_markdown(  
 columns = c(term)  
 ) %>%  
 fmt\_number(  
 columns = c(statistic),  
 decimals = 2  
 ) %>%  
 cols\_label(  
 term = "",  
 statistic = "F value",  
 p.value = "P-value"  
 ) %>%  
 fmt\_scientific(  
 columns = c(p.value),  
 decimals = 1,  
 rows = p.value < 0.001  
 ) %>%  
 fmt\_number(  
 columns = c(p.value),  
 decimals = 3,  
 rows = p.value >= 0.001  
 )  
  
aov\_2b\_tbl\_b

Table 1: ANOVA Table

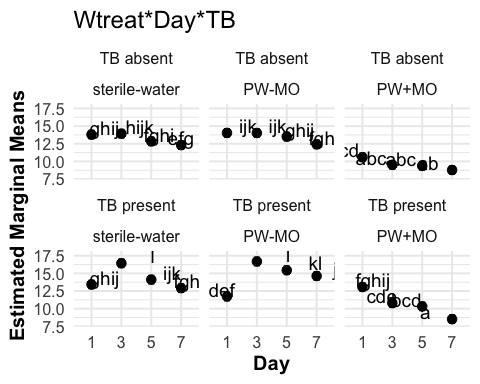
|  | F value | P-value |
| --- | --- | --- |
| day (*df = 3, 48*) | 45.61 | 4.3 × 10^-14 |
| TB (*df = 1, 48*) | 81.13 | 6.9 × 10^-12 |
| water\_treatment (*df = 2, 48*) | 442.25 | 1.2 × 10^-31 |
| day:TB (*df = 3, 48*) | 15.08 | 4.8 × 10^-7 |
| day:water\_treatment (*df = 6, 48*) | 24.05 | 6.4 × 10^-13 |
| TB:water\_treatment (*df = 2, 48*) | 0.11 | 0.897 |
| day:TB:water\_treatment (*df = 6, 48*) | 15.82 | 6.3 × 10^-10 |

## 2b cld plots

pairwise\_cld\_2b <- cld\_day\_2b + cld\_TB\_2b + cld\_water\_treatment\_2b + cld\_tb\_day\_int\_2b + cld\_watertreat\_day\_int\_2b +  
 plot\_annotation(tag\_levels = 'A')  
  
# Display the combined plot  
pairwise\_cld\_2b



#ggsave("2b\_pairwise\_cld.png", plot = pairwise\_cld\_2b, width = 14, height = 8, dpi = 1000)  
  
cld\_water\_thirdorder\_2b



#ggsave("2b\_thirdorder\_pairwise\_cld.png", plot = cld\_water\_thirdorder\_2b , width = 14, height = 8, dpi = 1000)

# Appendix

## ordered or unordered factor 2b

## 2B stats glm

glm output

let’s try anova table of a glm??

post hoc try again