One-Way ANOVA

R Handout

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```
> options(show.signif.stars=FALSE)
> library(NCStats)
> library(multcomp)     # for glht()
```

Raspberry Example

A researcher is interested in the effect of irrigation on fruit production by raspberry plants. The researcher has determined that he will examine the effects of 100 ml (a maintenance amount), 200, 400, and 800 ml of water per pot. The researcher had 16 identical planting pots available and much more than that number of raspberry plant seedlings. A square table for growing the plants in a greenhouse is available. He had enough time to let the plants mature (i.e., produce berries) or not. At the end of this period, the total weight (g) of mature berries was recorded.

```
> setwd("C:/aaaWork/Web/GitHub/NCMTH207/modules/Anova-1Way")
> rasp <- read.csv("Raspberry.csv")
> str(rasp)
```

```
'data.frame':   16 obs. of  2 variables:
 $ water : int  100 100 100 100 200 200 200 200 400 400 ...
 $ weight: num  8.1 10.9 11.1 13.9 12.2 11.5 11.4 6.8 6.5 5.5 ...
```

```
> rasp$water <- factor(rasp$water)
> str(rasp)
```

```
'data.frame':   16 obs. of  2 variables:
 $ water : Factor w/ 4 levels "100","200","400",..: 1 1 1 1 2 2 2 2 3 3 ...
 $ weight: num  8.1 10.9 11.1 13.9 12.2 11.5 11.4 6.8 6.5 5.5 ...
```

Fitting the Linear Model

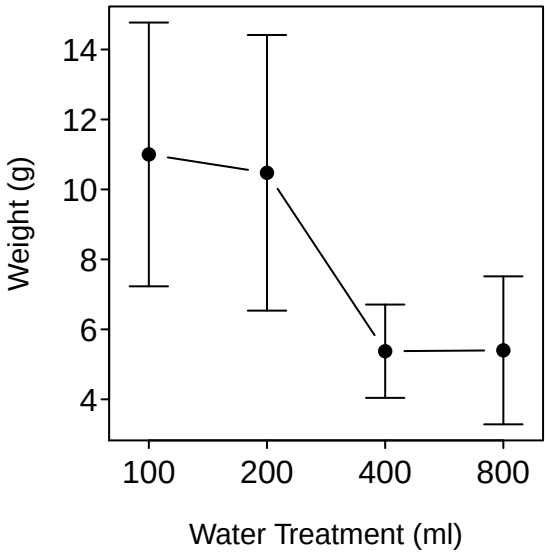
```
> lm1 <- lm(weight~water,data=rasp)
> anova(lm1)
```

```
          Df  Sum Sq Mean Sq F value   Pr(>F)
water      3 115.042  38.347  10.793 0.001004
Residuals 12  42.635   3.553
```

```
> cbind(Ests=coef(lm1),confint(lm1))
```

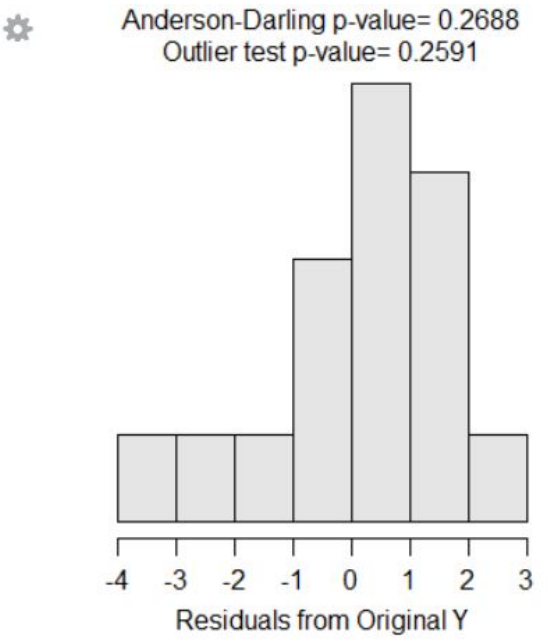
```
              Ests     2.5 %    97.5 %
(Intercept) 11.000  8.946558 13.053442
water200    -0.525 -3.429006  2.379006
water400    -5.625 -8.529006 -2.720994
water800    -5.600 -8.504006 -2.695994
```

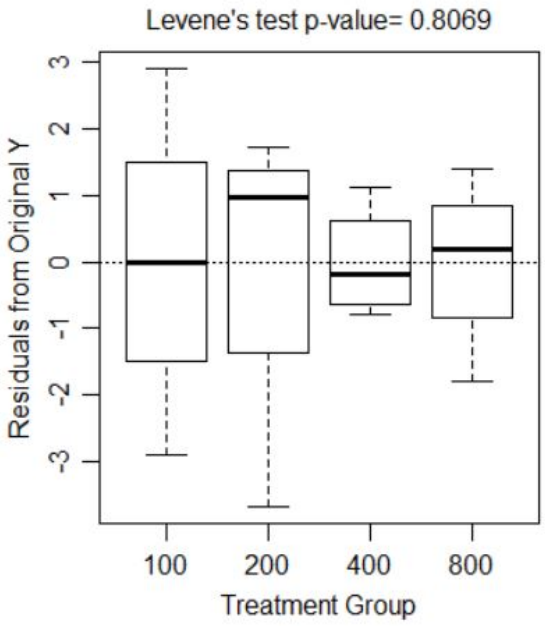
```
> fitPlot(lm1,xlab="Water Treatment (ml)",ylab="Weight (g)")
```



Checking Assumptions

```
> transChooser(lm1)
```





Multiple Comparison Tests

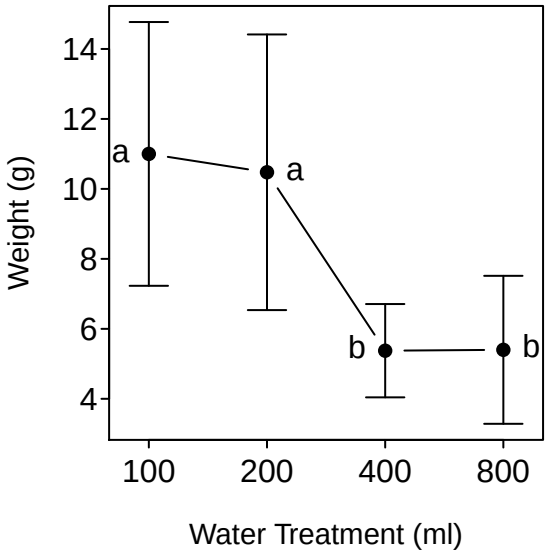
```
> rasp.mc <- glht(lm1, mcp(water = "Tukey"))
> summary(rasp.mc)
```

```
             Estimate Std. Error     t value     p value
200 - 100 = 0   -0.525   1.332838 -0.39389620 0.978341101
400 - 100 = 0   -5.625   1.332838 -4.22031642 0.005617495
800 - 100 = 0   -5.600   1.332838 -4.20155946 0.005647972
400 - 200 = 0   -5.100   1.332838 -3.82642022 0.011083694
800 - 200 = 0   -5.075   1.332838 -3.80766326 0.011861205
800 - 400 = 0    0.025   1.332838  0.01875696 0.999997485
```

```
> confint(rasp.mc)
```

```
          Estimate       lwr       upr
200 - 100   -0.525 -4.488075  3.438075
400 - 100   -5.625 -9.588075 -1.661925
800 - 100   -5.600 -9.563075 -1.636925
400 - 200   -5.100 -9.063075 -1.136925
800 - 200   -5.075 -9.038075 -1.111925
800 - 400    0.025 -3.938075  3.988075
```

```
> fitPlot(lm1,xlab="Water Treatment (ml)",ylab="Weight (g)",main="")
> addSigLetters(lm1,lets=c("a","a","b","b"),pos=c(2,4,2,4))
```



Benthic Infaunal Example

To examine the effect of effluent releases on benthic organisms in the release area, researchers recorded the total abundance of benthic organisms at eight haphazardly-selected sublocations at each of eight control locations (thought to have not been impacted by the effluent release) and one potentially impacted location. Use the data in `BenthicInfaunal.csv` to determine if the mean abundance of benthic organisms differs between the locations (and, especially, if the impacted location differs from any of the control locations).

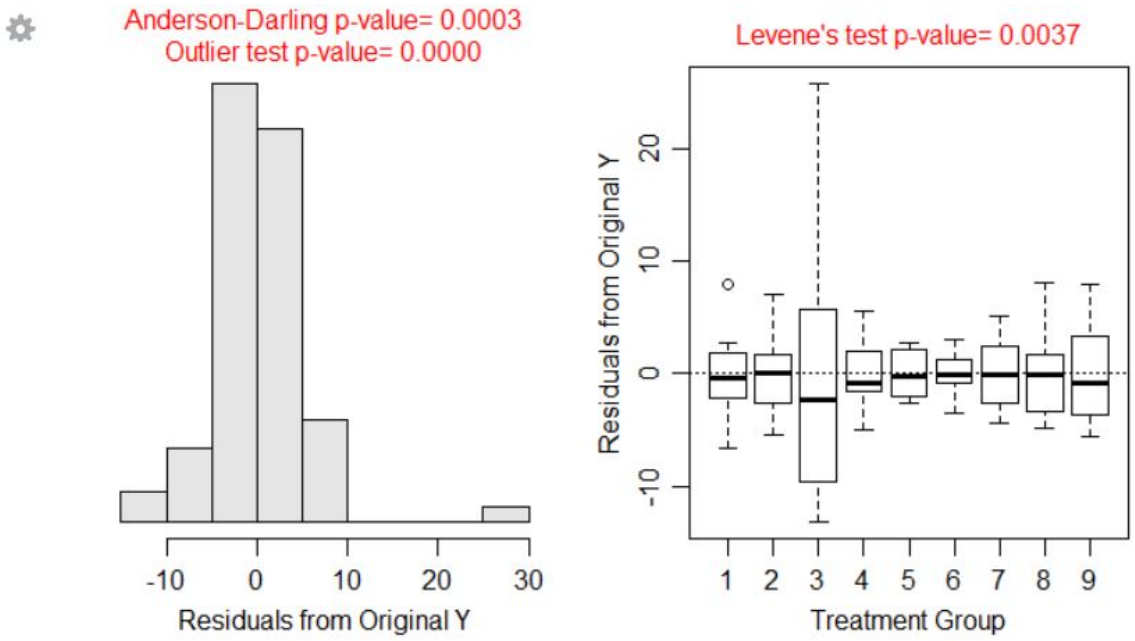
```
> ben <- read.csv("BenthicInfaunal.csv")
> ben$site <- factor(ben$site)
> str(ben)
```

```
'data.frame':   72 obs. of  2 variables:
 $ site     : Factor w/ 9 levels "1","2","3","4",..: 1 1 1 1 1 1 1 1 2 2 ...
 $ abundance: num  14.4 20.4 21.2 17.6 29 ...
```

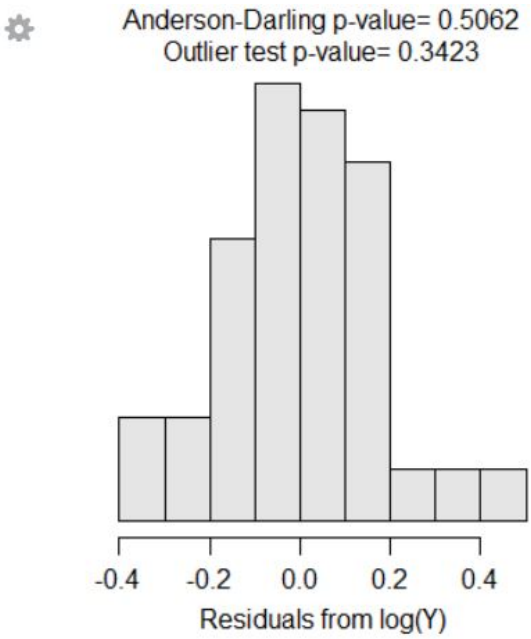
Assumption Checking with Possible Transformations

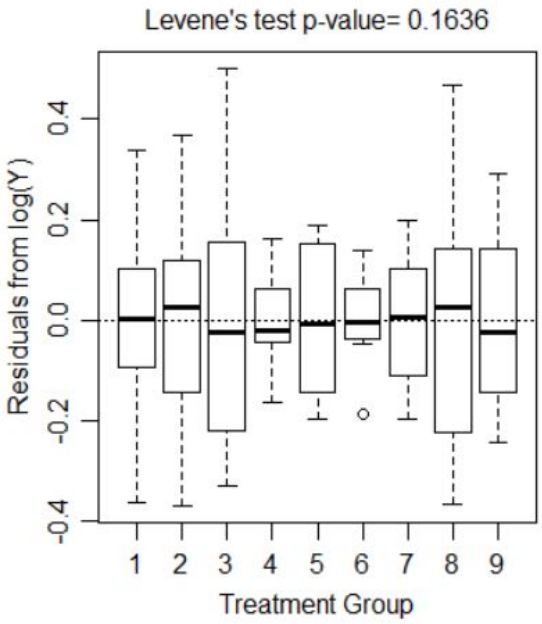
```
> lm2 <- lm(abundance~site,data=ben)
```

```
> transChooser(lm2)
```




```
> transChooser(lm2)  # interactively adjust lambdas
```






```
> ben$logab <- log(ben$abundance)
> lm3 <- lm(logab~site,data=ben)
```

Model Summarization

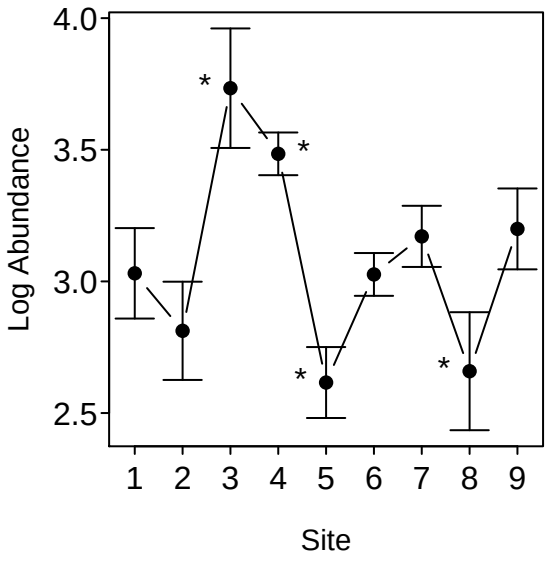
```
> anova(lm3)
```

```
          Df Sum Sq Mean Sq F value    Pr(>F)
site       8 8.6683 1.08353  29.066 < 2.2e-16
Residuals 63 2.3485 0.03728
```

```
> ben.mc <- glht(lm3, mcp(site = "Dunnett"))
> summary(ben.mc)
```

```
             Estimate Std. Error     t value      p value
2 - 1 = 0 -0.21843454 0.09653725 -2.26269698 1.456286e-01
3 - 1 = 0  0.70318863 0.09653725  7.28411718 3.557137e-09
4 - 1 = 0  0.45383639 0.09653725  4.70115314 1.012575e-04
5 - 1 = 0 -0.41485933 0.09653725 -4.29740160 4.489152e-04
6 - 1 = 0 -0.00423765 0.09653725 -0.04389653 1.000000e+00
7 - 1 = 0  0.14028047 0.09653725  1.45312275 5.797132e-01
8 - 1 = 0 -0.37186732 0.09653725 -3.85206051 2.027465e-03
9 - 1 = 0  0.16866808 0.09653725  1.74718135 3.798758e-01
```

```
> fitPlot(lm3,ylab="Log Abundance",xlab="Site",main="")
> addSigLetters(lm3,lets=c("","","*","*","*","","","*",""),pos=c(2,4,2,4,2,2,4,2,4))
```




```
> confint(ben.mc)
```

```
         Estimate         lwr         upr
2 - 1 -0.21843454 -0.48187397  0.04500489
3 - 1  0.70318863  0.43974920  0.96662806
4 - 1  0.45383639  0.19039696  0.71727582
5 - 1 -0.41485933 -0.67829876 -0.15141990
6 - 1 -0.00423765 -0.26767708  0.25920178
7 - 1  0.14028047 -0.12315896  0.40371990
8 - 1 -0.37186732 -0.63530676 -0.10842789
9 - 1  0.16866808 -0.09477135  0.43210751
```

```
> exp(confint(ben.mc)$confint)
```

```
       Estimate       lwr       upr
2 - 1 0.8037761 0.6175752 1.0461171
3 - 1 2.0201841 1.5521930 2.6292760
4 - 1 1.5743404 1.2096324 2.0490090
5 - 1 0.6604332 0.5074388 0.8595559
6 - 1 0.9957713 0.7650933 1.2959995
7 - 1 1.1505965 0.8840520 1.4975050
8 - 1 0.6894457 0.5297303 0.8973158
9 - 1 1.1837272 0.9095077 1.5406247
```