

Week 3 Lab Report

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Question 1 - 20 points

Your assignment is to conduct a one-way ANOVA to determine if the average weight of confiscated elephant tusks has changed over time. Elephants are poached for their ivory, and USFWS authorities confiscate ivory when they find it entering the country. The data in TuskData.csv are the average weights of elephant tusks from 20 different seizure sites in 1970, 1990, and 2010.

Answer

1. H_0 : The average weights of elephant tusks confiscated from 20 sites in 1970, 1990, and 2010 have no difference.

H_a : There is a difference in the average weights of elephant tusks confiscated from 20 sites in 1970, 1990, and 2010.

2. Check assumptions of one-way ANOVA:

- a. No outlier was detected, as R returned an empty data frame.
- b. Shapiro-Wilk tests for three Year groups returned insignificant p-values, which were 0.67, 0.37, and 0.78, for 1970, 1990, and 2010, respectively. QQ plot of data also looked normal and most data points fell within the 95% C.I. (Fig. 1).

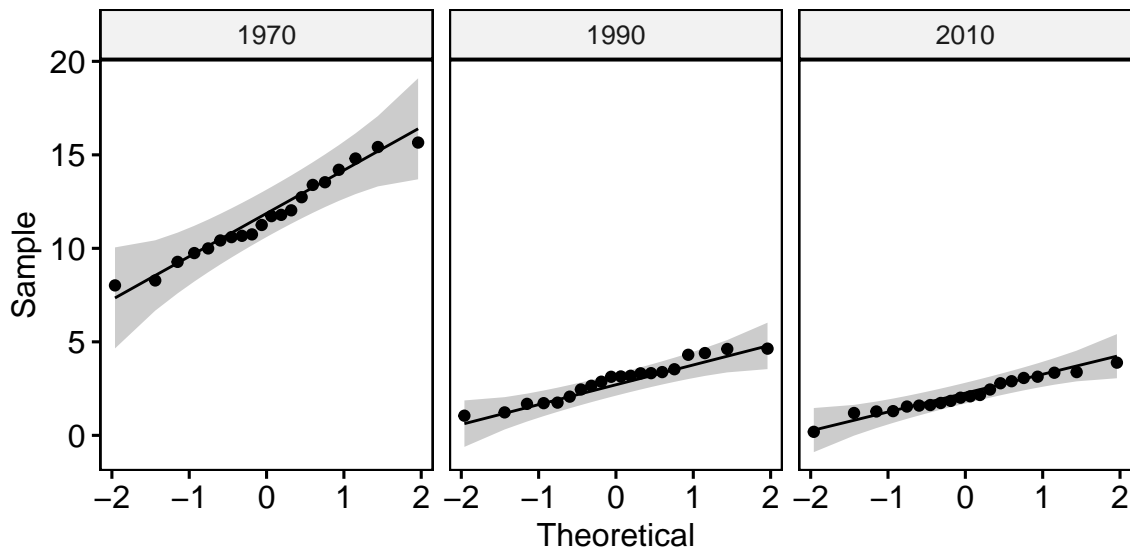


Figure 1. QQ plot of tusk weight data collected in 1970, 1990, and 2010.

- c. Levene's test for equal variance returned the significant p-value of 0. Therefore, there is a significant difference in variance among years (Fig. 2).

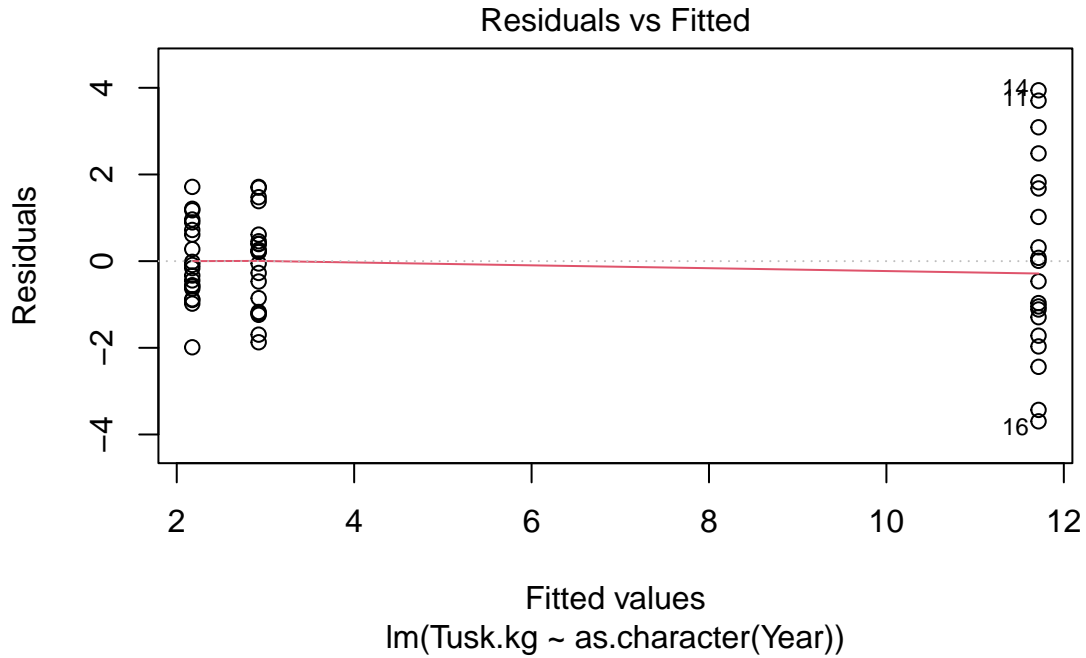


Figure 2. Residual plot of tusk weight data collected in 1970, 1990, and 2010.

d. Therefore, I am going to conduct a Welch one-way ANOVA, as the assumption of equal variance was violated.

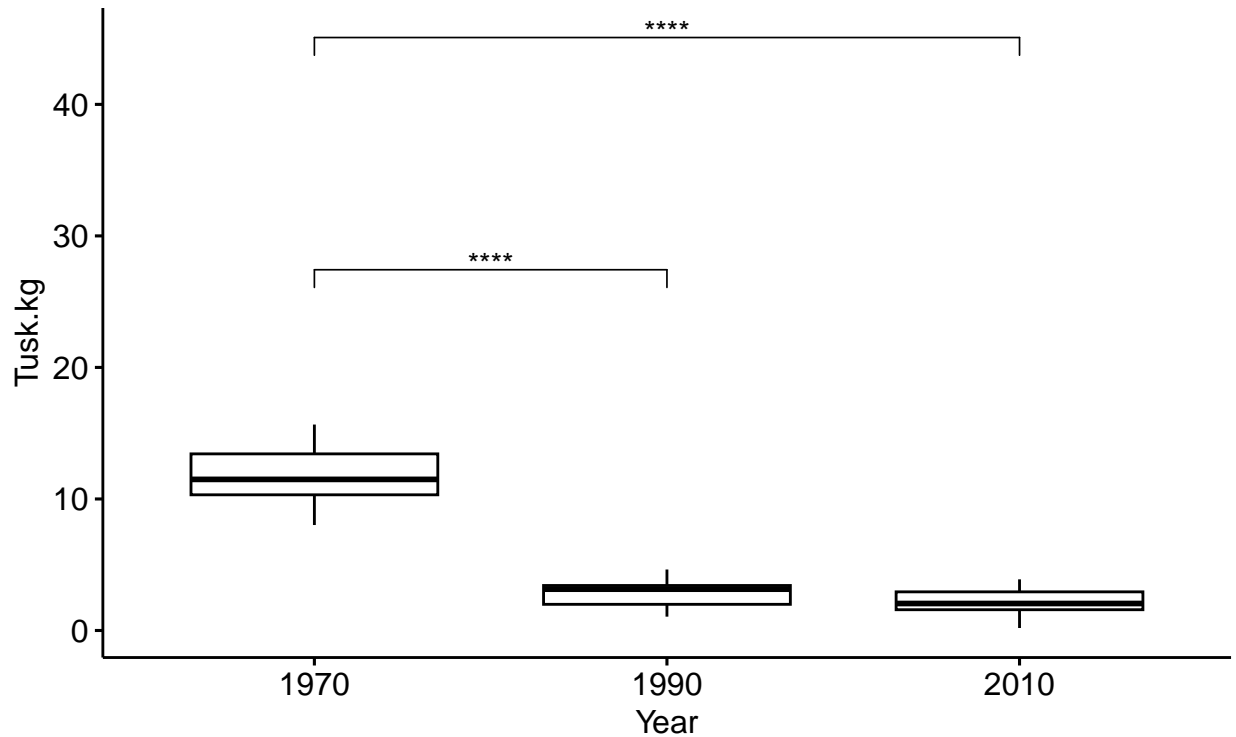
3. Welch one-way ANOVA test result

There is a significant difference in mean of tusk weight among years with a p-value of 3.64×10^{-18} and $F(2, 35.36) = 153.65$.

4. Post-hoc test result

Games-Howell post hoc test showed that there is a significant difference in mean of tusk weight between 1970 and 1990 ($p = 5.55 \times 10^{-16}$) and between 1970 and 2010 ($p = 4.25 \times 10^{-14}$).

Welch Anova, $F(2,35.36) = 153.65$, $p = <0.0001$, $n = 60$



pwc: **Games Howell**; p.adjust: **Tukey**

Question 2 - 20 points

We want to test whether four different antibiotics result in different levels of antibodies in the blood. Sixteen people are randomly assigned one of the four antibiotics, and samples of their blood are taken for analysis. To process the blood samples as quickly as possible, the samples are sent to four different laboratories – each lab receives one blood sample treated with one of the four antibiotics.

Each laboratory has its own instruments and personnel that might cause variation in the results across laboratories. Our variable of interest is the level of antibodies in the blood samples; laboratories are blocks whose uncontrolled effects we want to separate from the main effect.

Answer

1. H_0 : The average levels of antibodies in the blood among four different antibiotics have no difference, after accounting for the effect of the laboratory.

H_a : At least one pair of antibiotics has a significantly different effect on the average level of antibodies, after accounting for the effect of the laboratory.

2. Check assumptions of blocked ANOVA:

- a. There is one outlier reported, but not an extreme one.
- b. The average levels of antibodies among four types of antibiotics are normally distributed, as Shapiro-Wilk test reported non-significant p-values, which were 0.58, 0.41, 0.8, and 1, for antibiotics 1, 2, 3, and 4, respectively. Normality of antibiotic level is shown in Fig. 3, although data points are quite scattered and sparse.

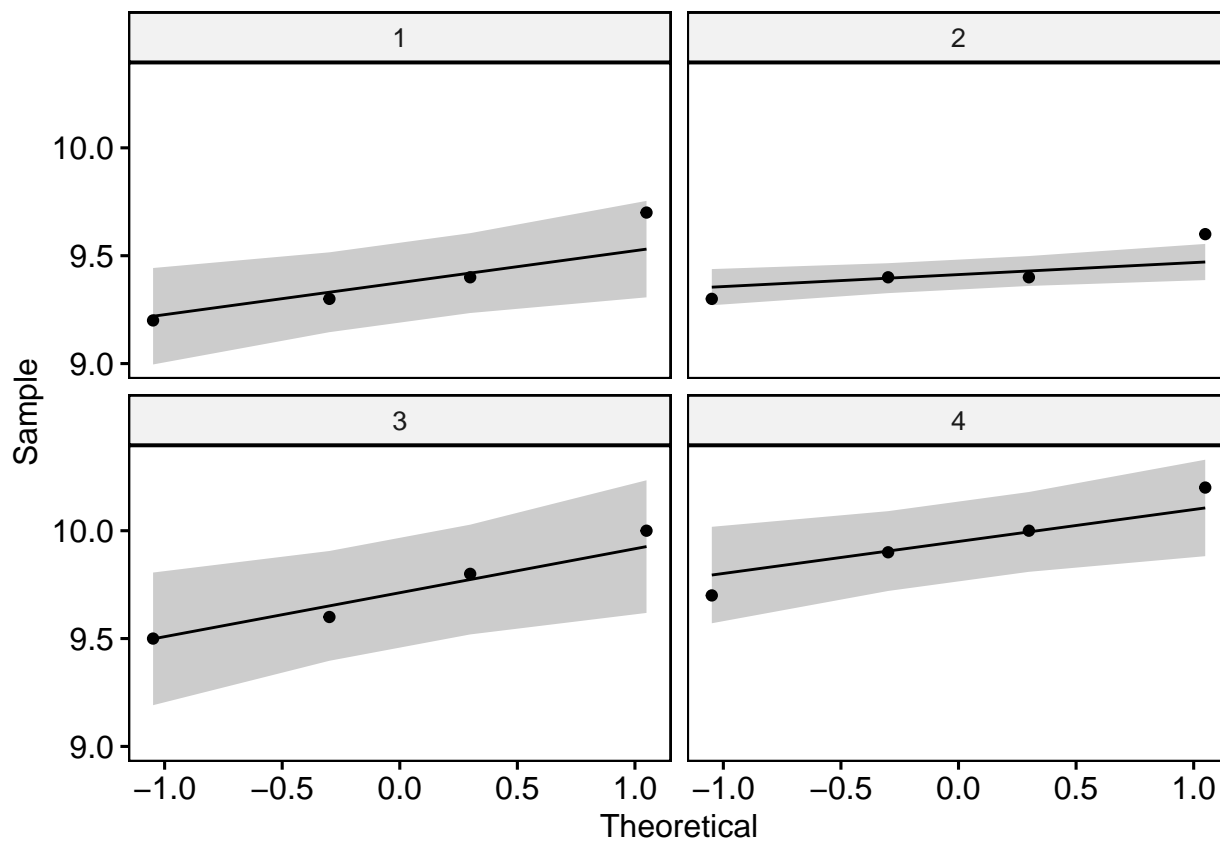


Figure 3. QQ plot of antibodies level collected from four different types of antibiotics.

c. Levene's test for equal variance returned the non-significant p-value of 0.64 across treatments and of 0.7 across blocks. Therefore, the assumption of equal variance is not violated (Fig. 3).

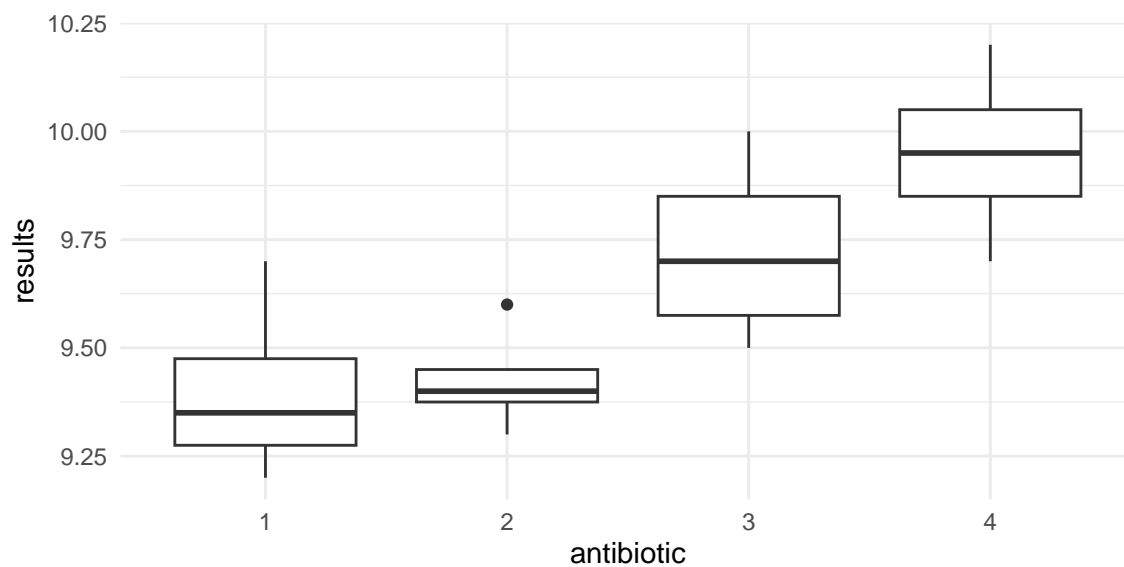


Figure 4. Box plot of antibodies level collected from four different types of antibiotics.

3. Block ANOVA test result:

Results showed that antibiotic treatment ($p = 4.52 \times 10^{-5}$) and lab ($p = 8.71 \times 10^{-4}$) had significant effects on the average level of antibodies.

4. Post-hoc test result:

Tukey HSD testn showed that the average levels of antibodies were different among:

- a. Antibiotic 1 and 3 ($p = 0.00398$)
- b. Antibiotic 1 and 4 ($p = 8.3 \times 10^{-5}$)
- c. Antibiotic 2 and 3 ($p = 0.00666$)
- d. Antibiotic 2 and 4 ($p = 1.2 \times 10^{-4}$)
- e. Antibiotic 3 and 4 ($p = 0.0342$)

