# Effect of Seasonal Hunting of Mountain Goat on Horn length and Body mass

## Introduction

Seasonal Hunting is an act of hunting animals at certain periods of the year. This can be done to control excessive population growth which could tip the ecological balance. In this report we will be analyzing the effects of seasonal hunting of Mountain goats on their horn length and body mass of both the sexes. The data collected contains Sex: M/F, hunting date, horn Length of left and right, season of hunting, month of hunting, day of hunt, year of hunt, daynr of hunt, age of goat when killed, cohort, body mass in Kg, population density at birth of the goat.

## Analysis Methods

To analyse the effect of Seasonal Hunting on the Horn length and Body mass of Mountain Goat we first create a linear model to analyse the relationship between mass and age of mountain goats. After which we perform an ANOVA tests to find the effects of sex on horn length and bodymass. Parallelly, we perform a two way ANOVA to analyse the effect of Population density and sex on Bodymass. Finally, we analyse the effects of Hunting seasons and Sex on Body mass and Horn length in two different ANOVA analysis to find patterns over the hunting season from 1977-2016.

## Results

To find the relationship between bodymass and age we create a linear model and visualize it.

| Predictors | Estimates | Std.Error | t value | P value |
|---|---|---|---|---|
| **Intercept** | 19.25557 | 0.11981 | 160.72 | <2e -16 |
| **Age** | 0.73264 | 0.02296 | 31.91 | <2e-16 |

**Table 1: -Results of the ANOVA analysis. Here the first row represents whether the difference in mean values in the species. F>3.95 and P<0.05 is considered significant.**

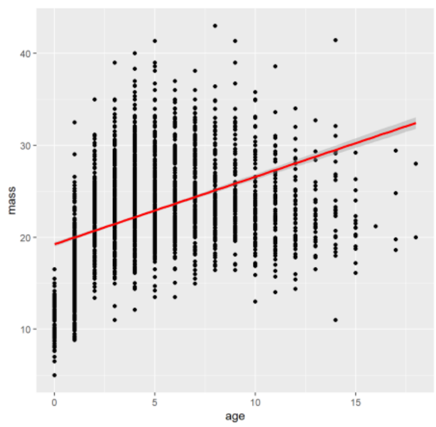


**Figure 1: -Plot of relationship between Age and Bodymass of Mountain Goats**

From Figure 1 and Table 1 we can see a positive relationship between age and bodymass proved by the t value and P value supported by the std error which is less than the estimate and in analytical terms on average the bodymass increases 0.732Kg for every year in age of the goats.

To find the differences between both sex hunted we visualize the difference in means of the bodymass and the average hornlength of the two sexes and perform an ANOVA test .

## ANOVA Analysis- Effects of Sex on Bodymass and Average horn length.

To analyse the effect of sex on bodymass and average hornlength two ANOVA analysis were performed.

**BodyMass**

| Predictors | Df | Sum Sq | Mean Sq | F value | P value |
|---|---|---|---|---|---|
| **Sex** | 1 | 17.915 | 17.9147 | 283.89 | <2.2e-16 |
| **Residuals** | 4392 | 277.152 | 0.0631 | | |

**Table 2: -Results of the ANOVA analysis. Here the first row represents whether the difference in mean values in the species. F>3.95 and P<0.05 is considered significant.**

| Predictors | Estimates | Std.Error | t value | P value |
|---|---|---|---|---|
| **Intercept** | 3.000819 | 0.005681 | 528.18 | <2e -16 |
| **Sex M** | 0.128486 | 0.007626 | 16.85 | <2e-16 |

**Table 3: -Summary of the ANOVA analysis here the first row represents the Females and the second row represents Males. t>+2|t<-2 and P<0.05 is considered significant.**

The ANOVA results from Table 2 and 3 show there is a significant relationship between bodymass and the sex of the mountain goat determined by the P and F value and the bodymass of males is on average 4.28% larger than the bodymass of females.This difference can be visualized on a boxplot.

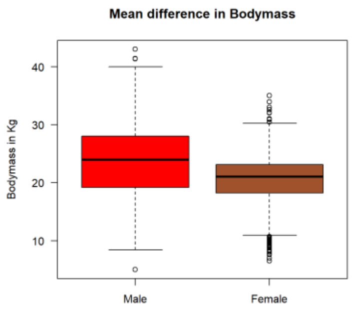


**Figure 2: -BoxPlot of relationship between Bodymass and Sexes of Mountain Goats.**

**Average Horn Length**

| Predictors | Df | Sum Sq | Mean Sq | F value | P value |
|---|---|---|---|---|---|
| **Sex** | 1 | 19.44 | 19.4359 | 157.62 | <2.2e-16 |
| **Residuals** | 4392 | 541.56 | 0.1233 | | |

**Table 4: -Results of the ANOVA analysis. Here the first row represents whether the difference in mean values in the species. F>3.95 and P<0.05 is considered significant.**

| Predictors | Estimates | Std.Error | t value | P value |
|---|---|---|---|---|
| **Intercept** | 5.082114 | 0.007942 | 639.92 | <2e -16 |
| **Sex M** | 0.133830 | 0.010660 | 12.55 | <2e-16 |

**Table 5: -Summary of the ANOVA analysis here the first row represents the Females and the second row represents Males. t>+2|t<-2 and P<0.05 is considered significant.**

The ANOVA results from Table 1 and 2 show there is a significant relationship between average horn length and the sex of the mountain goat determined by the P and F value and the average horn length of females is on average **2.6% larger** than the average horn length of males.This difference can be visualized in a box plot.

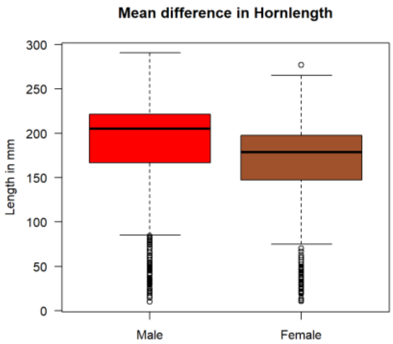


**Figure 3: -BoxPlot of relationship between Hornlength and Sexes of Mountain Goats.**

## II-way ANOVA Analysis-Effect of Population density and sex on Bodymass

To identify the effects of hunting and population density on Bodymass we perform a two-way ANOVA analysis.

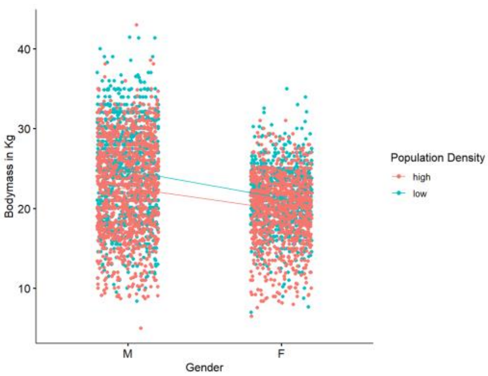


**Figure 4: -Relationship between bodymass Gender and Population Density**

| Predictors | Df | Sum Sq | Mean Sq | F value | P value |
|---|---|---|---|---|---|
| **Sex** | 1 | 10536 | 10536 | 408.310 | <2.2e-16 |
| **Density** | 1 | 3551 | 3551 | 137.618 | <2.2e-16 |
| **Sex:Density** | 1 | 131 | 131 | 5.094 | 0.0241 |
| **Residuals** | 4390 | 113280 | 26 | | |

**Table 6: -Summary of the ANOVA analysis for GA here the first row represents the effect of Species, the second row represents treatment(Wet or Dry) and the third row represents the interaction effect between the two.**

From, Figure 4 and Table 6 we can see that there is a significant effect of Gender and Population density and their interactions on the bodymass of the mountain goat.The Bodymass of Males are on average **2.75kg** higher than the females when the population density is high compared to **3.44kg** when the population density is lower. Females on average have a bodymass of **1.41kg** higher when the population density is lower compared to 2.10kg higher in males.

## ANOVA Analysis-Effect of Seasonal Hunting and sex on Bodymass and Hornlength

To identify the effects of sesonal hunting on body mass an anova analysis with sex and seasons was performed.

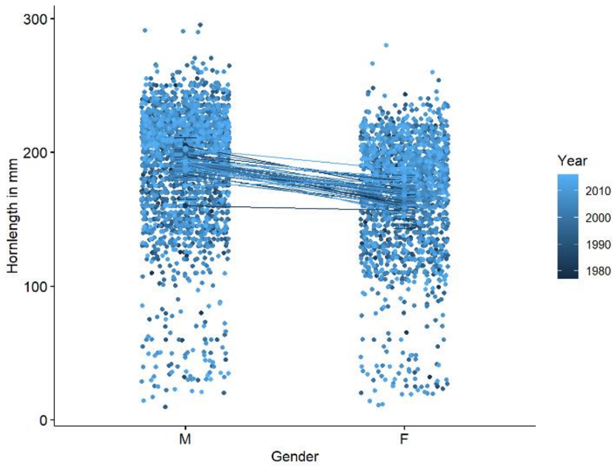


**Figure 5: -Relationship between Hornlength, Gender and Seasonal Hunting**

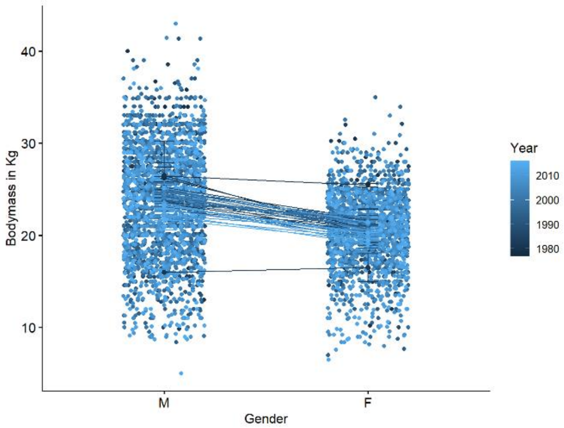


**Figure 6:-Relationship between Bodymass Gender and Seasonal Hunting**

| Predictors | Df | Sum Sq | Mean Sq | F value | P value |
|---|---|---|---|---|---|
| **Sex** | 1 | 575479 | 575479 | 322.530 | <2.2e-16 |
| **Season** | 36 | 127367 | 3538 | 1.983 | 0.000438 |
| **Residuals** | 4356 | 113280 | 26 | | |

**Table 7: -Summary of the ANOVA analysis corresponding to figure 5 here the first row represents the Sex and the second row represents Hunting seasons . F>3.95 and P<0.05 is considered significant.**

| Predictors | Df | Sum Sq | Mean Sq | F value | P value |
|---|---|---|---|---|---|
| **Sex** | 1 | 10536 | 10536 | 402.860 | <2.2e-16 |
| **Season** | 36 | 3039 | 84 | 3.228 | 3.29e-10 |
| **Residuals** | 4356 | 113923 | 26 | | |

**Table 8: -Summary of the ANOVA analysis corresponding to Figure 6 here the first row represents the Sex and the second row represents Hunting Seasons. F>3.95 and P<0.05 is considered significant.**

From Figures 5 and Table 7 we can conclude that there is a significant effect of Sex and an effect of Hunting Season on Hornlength supported by the P values. Comparing the years 2016 and 1977 we see an average reduction of 1mm in hornlength across both the species but when comparing the years 2016 and 2014 we see an average reduction of **22.79** mm in length in these time periods and the difference in males and females hornlengths in the year 1977 differ by about **21.66mm** and the males being longer.The effects on hornlength seem to be inconsistent across the seasons this is supported by the low F value in the analysis.From Figures 6 and 8 we can conclude a significant effect of Sex and Hunting Season on the Bodymass which is supported by the P values.There is a trend of average bodymass becoming lesser as the years progress comparing the years 1977 and 2016 we see an average decrease of **-5.268Kg** in bodymass of the mountain goat.

## Conclusion:

Male goats have on average higher bodymass and higher hornlength than their female counterparts.Due to seasonal hunting there has been a decreasing trend in the bodymass of the Mountain goat.This might be due to targeting of goats with higher body mass or due to increasing lack of food or an evolutionary difference to evade being hunted. Finally, the Hornlength of the goats seem to fluctuate over the years and there seems to be no to little connection with Seasonal hunting as they might still have a role in mate attraction and survival.

# APPENDIX

```
#R-code Q2.R
#Code used for analyzing mountain goat hunting data.
#13-01-2022 BIOS-14
data = read.table("exam2022_part2.txt", header=T)#Reading thr data

library(dplyr)#Used to filter the data
library(car)#Used for TukeyHSD
library(ggpubr)#Used to plot II-dimensional Anova Plots.

library(ggplot2)#Used to plot linear model

hornavg=(data$hornL+data$hornR)/2 #Finding the average length of the goat horns

#Model1
m1=lm(mass~age,data=data)
ggplot(data, aes(x = age, y = mass)) +
  geom_point() +
  stat_smooth(method = "lm", col = "red") #Linear Regression Plot for identifying relationship
#Filtering data based on sex
M=filter(data,data$sex=="M")
F=filter(data,data$sex=="F")



#Model2
#ANOVA for bodymass and sex of the mountain goats
m2=lm(log(mass)~sex,data=data)
#Boxplot to visualize ANOVA results
boxplot(M$mass,F$mass,names=c("Male","Female"),ylab="Bodymass in
Kg",las=1,col=c("red","sienna"),main="Mean difference in Bodymass")
##ANOVA for Average Hornlength and sex of the mountain goats
m3=lm(log(hornavg)~sex,data=data)
#Boxplot to visualize ANOVA results
boxplot((M$hornL+M$hornR)/2,(F$hornL+F$hornR)/2,names=c("Male","Female"),ylab="Length in
mm",las=1,col=c("red","sienna"),main="Mean difference in Hornlength")
```

```
density1=as.factor(data$density)#Initializing Population density as a Factor
#Two way ANOVA to analyse the effect of sex and density on mass.
m4=aov(mass~sex*density,data=data)
ggline(data,x="sex",y="mass",col="density",
       add=c("mean_se","jitter"),
       ylab="Bodymass in Kg",xlab="Gender",
       legend.title="Population Density",legend="right")
TukeyHSD(m4) #To get the mean differences from the model

season1=as.factor(data$season)#Initializing the Hunting season as factors
#ANOVA to analyse effect of sex and season on average horn length
m5=aov(hornavg~sex+season1,data=data)
ggline(data,x="sex",y="hornL",col="season",
       add=c("mean_se","jitter"),
       ylab="Hornlength in mm",xlab="Gender",
       legend.title="Year",legend="right")
TukeyHSD(m5)
#ANOVA to analyse effect of sex and season on Body mass
m6=aov(mass~sex+season1,data=data)
ggline(data,x="sex",y="mass",col="season",
       add=c("mean_se","jitter"),
       ylab="Bodymass in Kg",xlab="Gender",
       legend.title="Year",legend="right")
TukeyHSD(m6)
```