Analysis of Factors Affecting Mammal Longevity

Em Schissler

4/9/2021

Background

Previous studies have aimed to determine the factors contributing to animal longevity. These factors have included size, metabolism, weight, predation, environment, and diet. However, the definitive factors of longevity remain unknown, and the general pattern of heavier animals living longer has been questioned as the sole determinant of increased lifespan, given the exceptions to this rule within the Animal Kingdom (Ebert, 2008). Additionally, there has been debate over whether animals with a strictly plant-based diet, a strictly meat-based diet, or a combination of both have an increased average lifespan, due to the varying nutritional benefits different foods provide (Wilder et al., 2013).

In this project, we will analyze two datasets. First, I will investigate whether a combination of diet and body mass impacts the average lifespan of mammals using Animal Diversity Web (ADW) data. To further validate the data and results, I will compare the ADW data with the MammalDIET data to determine if the proportion of each diet group is consistent across both datasets, thereby assessing if the ADW sample is representative.

The hypothesis is that increased body mass and a specific diet result in higher average lifespans when combined, as some of the longest-living mammals on the planet have diets consisting of plants (herbivores/omnivores) and possess the largest body mass within the class Mammalia. We will test whether there is a difference in the mean lifespan of mammals across at least one of three diet groups, whether there is an association between mean body mass and mean lifespan of mammals, and whether the effect of diet on mammal longevity depends on the average body mass. Additionally, we will examine the interaction between diet and average body mass.

Open the Dataset

Down below I imported data from the CSV file FinalMammalData into an R data frame (mammal.data).

```
mammal.data <- read.csv("FinalMammalData.csv", header=T)
print(mammal.data)

##                         Species Lifespan    AvgMass      Diet
## 1              Canis lupus dingo    14.80   14500.00 Carnivore
## 2     Crossarchus platycephalus    13.30    1100.00 Carnivore
## 3           Tadarida aegyptiaca    10.00      16.30 Carnivore
## 4           Cystophora cristata    35.00  230000.00 Carnivore
## 5                Mustela itatsi     2.00     300.00 Carnivore
## 6             Mellivora capensis     7.50   10000.00 Carnivore
```

```
## 7              Mustela erminea     1.50      70.50 Carnivore
## 8            Myotis lucifugus     6.50       9.50 Carnivore
## 9              Myotis sodalis    20.00       8.00 Carnivore
## 10           Leopardus guigna    11.00    2200.00 Carnivore
## 11                Felis chaus    13.00   10000.00 Carnivore
## 12       Myrmecobius fasciatus     5.00     526.00 Carnivore
## 13   Lasionycteris noctivagans    12.00      10.00 Carnivore
## 14         Leopardus geoffroyi    14.50    4000.00 Carnivore
## 15       Orcaella brevirostris    32.00  124000.00 Carnivore
## 16             Mustela nivalis     2.00      55.00 Carnivore
## 17          Otaria flavescens    18.00  245000.00 Carnivore
## 18           Martes zibellina     8.00    1250.00 Carnivore
## 19           Orycteropus afer    18.00   61000.00 Carnivore
## 20         Tursiops truncatus    25.00  400000.00 Carnivore
## 21       Myotis austroriparius    21.00       6.60 Carnivore
## 22   Rhinolophus ferrumequinum    30.00      25.50 Carnivore
## 23       Macrotus californicus    10.40      12.50 Carnivore
## 24       Peponocephala electra    30.00  228000.00 Carnivore
## 25           Myotis auriculus     3.00       6.50 Carnivore
## 26             Aonyx capensis    11.00   15800.00 Carnivore
## 27                Felis manul     2.26       3.75 Carnivore
## 28            Vulpes macrotis     5.50    2150.00 Carnivore
## 29        Nycticeius humeralis     2.00      10.00 Carnivore
## 30          Neofelis nebulosa    11.00   20000.00 Carnivore
## 31             Cryptotis parva     1.00       4.50 Carnivore
## 32          Delphinus delphis    20.00  118000.00 Carnivore
## 33           Eptesicus fuscus    19.00      23.00 Carnivore
## 34     Myotis septentrionalis    18.50       7.50 Carnivore
## 35          Nyctalus leisleri     9.00      15.50 Carnivore
## 36         Monachus tropicalis    20.00  135000.00 Carnivore
## 37       Didelphis albiventris     1.67    1625.00 Carnivore
## 38         Ommatophoca rossii    21.00  182500.00 Carnivore
## 39            Tarsius tarsier    10.00     116.00 Carnivore
## 40            Myosorex varius     0.00      12.00 Carnivore
## 41          Eumetopias jubatus    25.00  735000.00 Carnivore
## 42           Plecotus auritus    15.00       8.00 Carnivore
## 43       Hyperoodon ampullatus    37.00 6650000.00 Carnivore
## 44             Talpa europaea     2.50     100.00 Carnivore
## 45         Zalophus wollebaeki    20.00  150000.00 Carnivore
## 46           Acinonyx jubatus     8.00   46500.00 Carnivore
## 47          Odobenus rosmarus    35.00 1000000.00 Carnivore
## 48            Galago demidoff     4.50      60.00 Carnivore
## 49            Caracal caracal    12.00   13500.00 Carnivore
## 50         Hipposideros fulvus    12.00       9.00 Carnivore
## 51          Blarina brevicauda     2.50      21.63 Carnivore
## 52                Panthera leo    14.00  199000.00 Carnivore
## 53          Hydrurga leptonyx    26.00  400000.00 Carnivore
## 54     Arctocephalus australis    21.00  130000.00 Carnivore
## 55            Lynx canadensis    14.50   10900.00 Carnivore
## 56     Cephalorhynchus hectori    20.00   55000.00 Carnivore
```

```
## 57              Scapanus orarius     3.50      76.00 Carnivore
## 58         Stenella coeruleoalba    50.00     150.00 Carnivore
## 59                   Phoca largha    32.00   90000.00 Carnivore
## 60             Monodon monoceros    40.00 1250000.00 Carnivore
## 61           Plecotus austriacus    15.00      10.00 Carnivore
## 62           Parascalops breweri     3.00      62.50 Carnivore
## 63   Balaenoptera acutorostrata    45.00 7500000.00 Carnivore
## 64             Leopardus pardalis     8.50   12250.00 Carnivore
## 65        Pontoporia blainvillei    12.00   40500.00 Carnivore
## 66      Lutrogale perspicillata     7.00    9000.00 Carnivore
## 67               Sousa chinensis    40.00  265000.00 Carnivore
## 68         Arctocephalus gazella    25.00   83500.00 Carnivore
## 69                  Sorex araneus     2.00       9.50 Carnivore
## 70             Stenella attenuata    46.00  112500.00 Carnivore
## 71             Myotis grisescens    14.50      11.50 Carnivore
## 72           Gracilinanus agilis     1.50      17.00 Carnivore
## 73                Suncus murinus     1.50      85.15 Carnivore
## 74                  Sousa teuszii     0.00  125000.00 Carnivore
## 75              Monachus monachus    30.00  307500.00 Carnivore
## 76        Peromyscus maniculatus     1.00      17.00   Omnivore
## 77           Peromyscus leucopus     1.00      23.00   Omnivore
## 78             Pseudomys higginsi     1.50      65.00   Omnivore
## 79          Miopithecus talapoin    28.00    1350.00   Omnivore
## 80              Ursus thibetanus    25.00  100000.00   Omnivore
## 81                    Tupaia glis     2.50     142.00   Omnivore
## 82           Galago zanzibaricus    16.50     146.80   Omnivore
## 83        Leontopithecus rosalia    15.00     654.50   Omnivore
## 84              Didelphis aurita     2.00    1290.00   Omnivore
## 85                Tamias amoenus     5.00      51.50   Omnivore
## 86                Macaca mulatta    30.00    8000.00   Omnivore
## 87          Salpingotus pallidus     2.50       9.80   Omnivore
## 88                   Vulpes cana    10.00    2250.00   Omnivore
## 89      Calyptophractus retusus    13.50    1000.00   Omnivore
## 90                  Cebus apella    40.00    3050.00   Omnivore
## 91             Aotus trivirgatus    20.00     800.00   Omnivore
## 92                  Ursus arctos    25.00  340000.00   Omnivore
## 93           Erinaceus europaeus     8.00    1000.00   Omnivore
## 94            Sekeetamys calurus     2.08      64.00   Omnivore
## 95          Didelphis virginiana     1.75    3950.00   Omnivore
## 96                 Sciurus niger     0.58     800.00   Omnivore
## 97             Mephitis mephitis     6.00    3500.00   Omnivore
## 98                Tamias palmeri     2.50      59.70   Omnivore
## 99                  Mus musculus     1.25      21.00   Omnivore
## 100           Rattus norvegicus     2.00     400.00   Omnivore
## 101         Sciurus carolinensis    12.50     540.33   Omnivore
## 102            Dryomys nitedula     5.50      26.00   Omnivore
## 103          Cercopithecus diana    20.00    5500.00   Omnivore
## 104           Peromyscus aztecus     1.25      29.00   Omnivore
## 105 Allenopithecus nigroviridis    23.00    4702.50   Omnivore
## 106            Vulpes rueppellii     6.00    2400.00   Omnivore
```

```
## 107       Chiropotes albinasus   17.00    2500.00  Omnivore
## 108     Phacochoerus africanus   16.50  100000.00  Omnivore
## 109         Erythrocebus patas   21.00   10000.00  Omnivore
## 110         Saimiri vanzolinii   15.00     910.00  Omnivore
## 111         Glirulus japonicus    6.00      27.00  Omnivore
## 112             Sus verrucosus    8.00   76000.00  Omnivore
## 113      Didelphis marsupialis    2.00    1530.00  Omnivore
## 114     Oryzomys galapagoensis    2.00      64.50  Omnivore
## 115     Potamochoerus larvatus   20.00   84500.00  Omnivore
## 116            Isoodon auratus    2.50     485.00  Omnivore
## 117           Microcebus rufus    7.00      50.00  Omnivore
## 118                 Sus scrofa   12.50  169000.00  Omnivore
## 119   Nyctereutes procyonoides   11.00    7000.00  Omnivore
## 120 Leontopithecus chrysopygus   10.00     572.50  Omnivore
## 121             Vulpes pallida   10.00    2550.00  Omnivore
## 122        Caluromys philander    3.40     250.00  Omnivore
## 123        Procyon cancrivorus   14.00    5000.00  Omnivore
## 124          Philander opossum    2.50     437.00  Omnivore
## 125           Ursus americanus   10.00  224000.00  Omnivore
## 126               Vulpes zerda   10.00    1500.00  Omnivore
## 127            Papio hamadryas   37.00   15350.00  Omnivore
## 128          Muntiacus reevesi   11.00   18000.00  Omnivore
## 129       Chlorocebus aethiops   31.00    4000.00  Omnivore
## 130         Mustela subpalmata    1.00     307.50  Omnivore
## 131          Cercocebus agilis   20.00    9000.00  Omnivore
## 132        Peromyscus eremicus    1.00      25.00  Omnivore
## 133               Martes foina   10.00    1700.00  Omnivore
## 134       Sigmodon fulviventer    0.17     210.00  Omnivore
## 135               Vulpes velox    4.50    2500.00  Omnivore
## 136            Cebus olivaceus   42.00    2655.00  Omnivore
## 137     Elephantulus rufescens    1.00      42.50  Omnivore
## 138       Cercocebus torquatus   30.00    9492.50  Omnivore
## 139       Euoticus elegantulus    3.50     315.00  Omnivore
## 140              Akodon azarae    0.79      19.00  Omnivore
## 141       Napaeozapus insignis    3.00      26.00  Omnivore
## 142     Chaetophractus nationi   14.00    2150.00  Omnivore
## 143       Callithrix geoffroyi   10.00     270.00  Omnivore
## 144     Spermophilus lateralis    7.00     257.00  Omnivore
## 145       Saguinus nigricollis   13.90     475.00  Omnivore
## 146     Canis lupus familiaris   29.50   35500.00  Omnivore
## 147       Peromyscus attwateri    0.57      30.00  Omnivore
## 148            Macaca sylvanus   22.00   13500.00  Omnivore
## 149       Mesocricetus auratus    1.75     112.50  Omnivore
## 150            Pan troglodytes   51.00   48000.00  Omnivore
## 151          Bettongia lesueur    3.00    1100.00 Herbivore
## 152          Ammotragus lervia   10.00  105000.00 Herbivore
## 153           Cavia intermedia    1.01     622.50 Herbivore
## 154        Sciurus granatensis    7.00     374.00 Herbivore
## 155             Cacajao calvus   18.00    2500.00 Herbivore
## 156         Erethizon dorsatum    6.00    9500.00 Herbivore
```

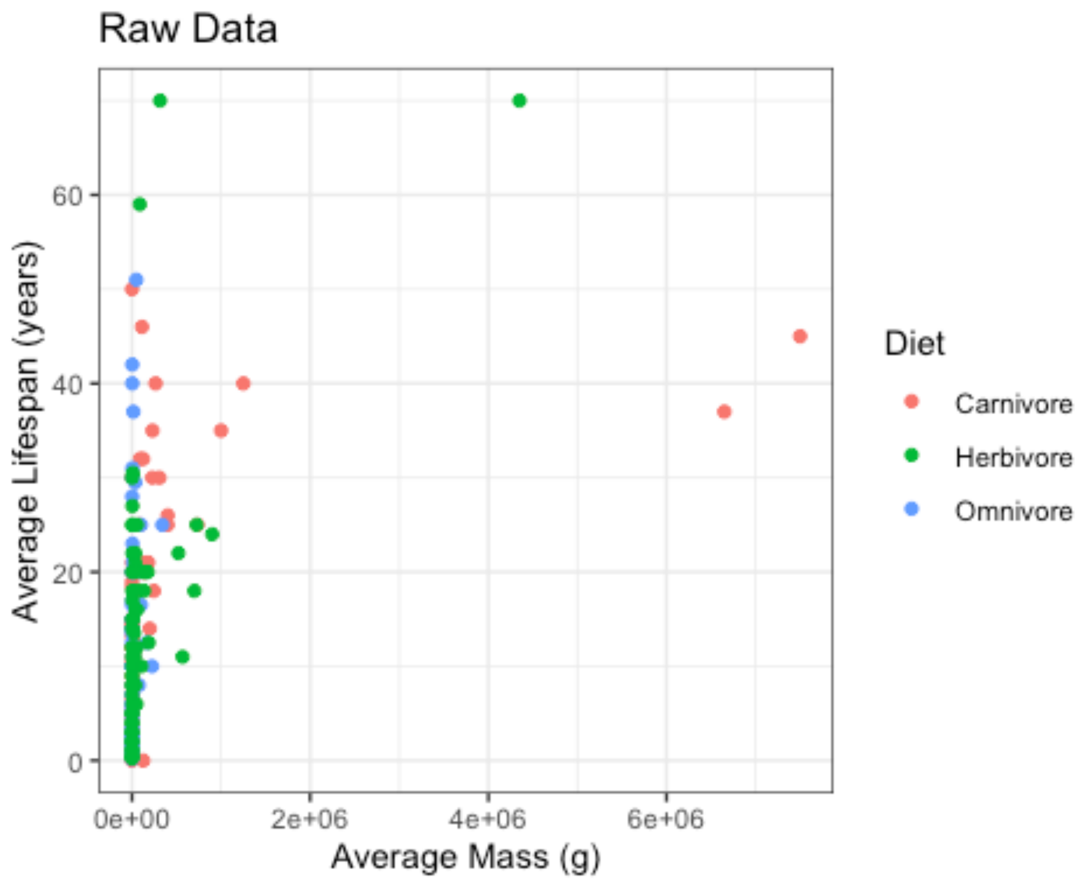
```
## 157         Orthogeomys grandis     2.00     830.00  Herbivore
## 158          Ammodorcas clarkei    11.00   28500.00  Herbivore
## 159               Varecia rubra    20.00    3450.00  Herbivore
## 160     Hemibelideus lemuroides     4.00     945.00  Herbivore
## 161         Rucervus duvaucelii    20.00  176500.00  Herbivore
## 162       Propithecus coquereli    27.00    4000.00  Herbivore
## 163         Dipodomys compactus     2.00      52.00  Herbivore
## 164            Myodes glareolus     1.25      18.50  Herbivore
## 165            Ochotona pusilla     4.00     262.50  Herbivore
## 166             Bubalus bubalis    25.00  725000.00  Herbivore
## 167        Sylvilagus palustris     4.00    1700.00  Herbivore
## 168               Axis porcinus    20.00   43000.00  Herbivore
## 169        Artibeus jamaicensis     8.00      50.00  Herbivore
## 170          Marmota himalayana    15.00    6600.00  Herbivore
## 171             Pongo pygmaeus    59.00   87000.00  Herbivore
## 172            Lepus townsendii     8.00    3500.00  Herbivore
## 173                 Alces alces    22.00  520500.00  Herbivore
## 174           Spalax ehrenbergi     3.00     325.00  Herbivore
## 175         Capricornis crispus    21.00   37000.00  Herbivore
## 176                   Glis glis     9.00     135.00  Herbivore
## 177        Macropus antilopinus    16.00   42500.00  Herbivore
## 178            Myocastor coypus     6.00    7500.00  Herbivore
## 179           Rangifer tarandus    12.50  186500.00  Herbivore
## 180         Chinchilla lanigera    10.00     650.00  Herbivore
## 181             Lepus tibetanus     0.51    2062.50  Herbivore
## 182   Hydrochoerus hydrochaeris     6.00   50500.00  Herbivore
## 183         Coendou prehensilis    17.00    3500.00  Herbivore
## 184          Georychus capensis     3.00     181.00  Herbivore
## 185           Cephalophus niger    11.00   17500.00  Herbivore
## 186             Syncerus caffer    11.00  567500.00  Herbivore
## 187    Przewalskium albirostris    18.00  135000.00  Herbivore
## 188           Colobus polykomos    30.50    9500.00  Herbivore
## 189             Gazella gazella     8.00   23250.00  Herbivore
## 190               Marmota bobak    15.00    7300.00  Herbivore
## 191     Hypsignathus monstrosus    30.00     326.00  Herbivore
## 192         Oreamnos americanus    18.00   69300.00  Herbivore
## 193            Procolobus verus    20.00    3350.00  Herbivore
## 194       Oryctolagus cuniculus     9.00    2000.00  Herbivore
## 195             Capra pyrenaica    16.00   57500.00  Herbivore
## 196               Nanger granti    12.00   55000.00  Herbivore
## 197          Ochotona curzoniae     0.33     150.00  Herbivore
## 198         Rupicapra pyrenaica    22.00   37000.00  Herbivore
## 199       Sciurus variegatoides    12.00     668.50  Herbivore
## 200 Pseudochirulus herbertensis     5.00    1165.00  Herbivore
## 201           Connochaetes gnou    20.00  133500.00  Herbivore
## 202            Hylobates agilis    25.00    5000.00  Herbivore
## 203                Castor fiber    13.50   24000.00  Herbivore
## 204         Chaetodipus nelsoni     2.08      14.25  Herbivore
## 205               Bison bonasus    24.00  900000.00  Herbivore
## 206          Microtus pinetorum     0.25      25.50  Herbivore
```

```
## 207              Ailurus fulgens    14.00    4950.00  Herbivore
## 208                    Dama dama    25.00   55000.00  Herbivore
## 209         Cercopithecus cephus    22.00    4000.00  Herbivore
## 210            Kerodon rupestris     5.00     950.00  Herbivore
## 211               Cervus elaphus    20.00  154200.00  Herbivore
## 212              Aotus nigriceps    11.00     750.00  Herbivore
## 213          Loxodonta cyclotis    70.00 4350000.00  Herbivore
## 214         Propithecus perrieri    15.00    4300.00  Herbivore
## 215        Dendrolagus matschiei     8.00    9500.00  Herbivore
## 216     Tamiasciurus hudsonicus     5.00     212.97  Herbivore
## 217                Dugong dugon    70.00  315000.00  Herbivore
## 218         Marmota flaviventris    14.00    3350.00  Herbivore
## 219                Bos javanicus    18.00  700000.00  Herbivore
## 220         Pantholops hodgsonii     8.00   33000.00  Herbivore
## 221     Trichosurus cunninghami     12.00    3500.00  Herbivore
## 222        Cynopterus brachyotis    25.00      65.00  Herbivore
## 223          Sylvilagus obscurus     1.00     900.00  Herbivore
## 224           Reithrodon auritus     0.31      80.00  Herbivore
## 225          Arctictis binturong    18.00   14500.00  Herbivore
```

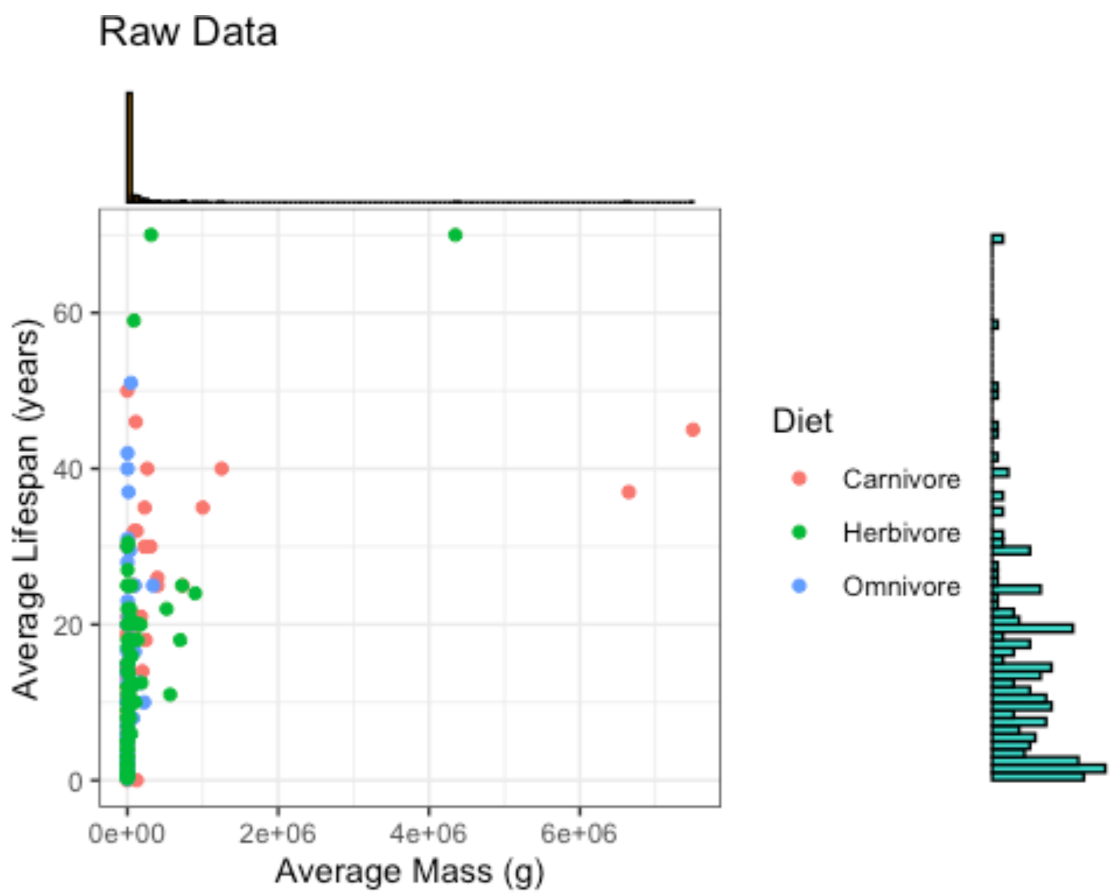
Preliminary Analyses

Visualizations Scatterplot and Histogram The data was tested for normality within each treatment group by plotting the original data on a scatter plot and adding histograms of both variables to the graph.

```
library(ggExtra)
library(ggplot2)

## Warning: package 'ggplot2' was built under R version 4.2.3

plot1<-ggplot()+
  geom_point(data=mammal.data, aes(x=AvgMass, y=Lifespan, color=Diet))+
  theme_bw()+
  xlab("Average Mass (g)")+
  ylab("Average Lifespan (years)")+
  labs(title=paste("Raw Data"))


print(plot1)
```




```
ggMarginal(plot1, type = "histogram",
           xparams = list(binwidth =55000, fill = "orange"),
           yparams = list(binwidth = 1, fill = "turquoise"),
           data=mammal.data)
```



Transformations of the Data The initial data showed non-normal distributions, with the average mass data being right-skewed. To address this, a log transformation was applied to the average mass, and a square root transformation was used for the count data of average lifespan. After applying these transformations, the data was plotted again to visually assess whether it appeared more normally distributed within each treatment group.

```
mammal.data$Mass.tr <- log(mammal.data$AvgMass)
mammal.data$Lifespan.tr <- sqrt(mammal.data$Lifespan + 0.5)
```

New Scatter plots and Histograms after Transformation

```
library(ggExtra)
library(ggplot2)
plot2<-ggplot()+
  geom_point(data=mammal.data, aes(x=Mass.tr, y=Lifespan.tr, color=Diet))+
  theme_bw()+
  xlab("Average Mass (g)")+
  ylab("Average Lifespan (years)")+
  labs(title=paste("Transformed Data"))


print(plot2)
```


```
ggMarginal(plot2, type = "histogram",
           xparams = list(binwidth = 0.25, fill = "orange"),
           yparams = list(binwidth = 0.1, fill = "turquoise"),
           data=mammal.data)
```

Reassigning Variables for Each Diet Category

Below, each original diet category (Carnivore, Omnivore, and Herbivore) was assgined their own variable so each diet category could be individually tested for normal distributions and equal variance within their data.

```
carnivore <- subset(mammal.data, Diet == "Carnivore ")
omnivore <- subset(mammal.data, Diet == "Omnivore")
herbivore <- subset(mammal.data, Diet == "Herbivore")
```

Regression normality test (Sharpio-Wilk)

Here, I conducted a test for normality on the average lifespan and average body mass variables for each diet dataset.

```
shapiro.test(carnivore$Mass.tr)

##
##  Shapiro-Wilk normality test
##
## data:  carnivore$Mass.tr
## W = 0.9047, p-value = 3.373e-05

shapiro.test(omnivore$Mass.tr)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  omnivore$Mass.tr
## W = 0.97024, p-value = 0.07439
```

```r
shapiro.test(herbivore$Mass.tr)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  herbivore$Mass.tr
## W = 0.98915, p-value = 0.7762
```

```r
shapiro.test(carnivore$Lifespan.tr)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  carnivore$Lifespan.tr
## W = 0.97472, p-value = 0.1384
```

```r
shapiro.test(omnivore$Lifespan.tr)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  omnivore$Lifespan.tr
## W = 0.94413, p-value = 0.002408
```

```r
shapiro.test(herbivore$Lifespan.tr)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  herbivore$Lifespan.tr
## W = 0.94605, p-value = 0.003045
```

Levene's Test

Down below, I then tested the assumption that the variances are equal within each diet to make sure that variance of mass and average lifespan is not higher in one diet group compared to the others.

```r
#install.packages("lawstat")
library(lawstat)

levene.test(carnivore$Lifespan.tr, carnivore$Mass.tr)
```

```
##
##  Modified robust Brown-Forsythe Levene-type test based on the absolute
##  deviations from the median
```

```
##
## data:  carnivore$Lifespan.tr
## Test Statistic = 0.10875, p-value = 1
```

```
levene.test(omnivore$Lifespan.tr, omnivore$Mass.tr)
```

```
## Warning in anova.lm(lm(resp.mean ~ d)): ANOVA F-tests on an essentially
perfect
## fit are unreliable
```

```
##
##  Modified robust Brown-Forsythe Levene-type test based on the absolute
##  deviations from the median
##
## data:  omnivore$Lifespan.tr
## Test Statistic = 2.3236e+28, p-value < 2.2e-16
```

```
levene.test(herbivore$Lifespan.tr, herbivore$Mass.tr)
```

```
##
##  Modified robust Brown-Forsythe Levene-type test based on the absolute
##  deviations from the median
##
## data:  herbivore$Lifespan.tr
## Test Statistic = 0.12208, p-value = 1
```

Although the variances were not equal and the data did not meet the criteria for normality, the general linear model test was conducted with approval from my professor. It is important to note that with a large sample size (n=225, with 75 per diet group), it can be challenging to achieve normality.

General Linear Model Test

Down below, the general linear model test was conducted to determine if the variables are associated with one another and to see if there is an interaction between the two explanatory variables.

```
glm.results<-lm(Lifespan.tr ~ Diet + Mass.tr +Diet:Mass.tr, data=mammal.data)
summary(glm.results)
```

```
##
## Call:
## lm(formula = Lifespan.tr ~ Diet + Mass.tr + Diet:Mass.tr, data =
mammal.data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.8782 -0.8198 -0.1932  0.7264  3.9991
##
## Coefficients:
##                        Estimate Std. Error t value Pr(>|t|)
```

```
## (Intercept)           2.00599    0.28461   7.048 2.33e-11 ***
## DietHerbivore        -1.52115    0.53287  -2.855 0.004723 **
## DietOmnivore         -1.71394    0.48901  -3.505 0.000554 ***
## Mass.tr               0.21978    0.03270   6.721 1.54e-10 ***
## DietHerbivore:Mass.tr  0.13483    0.05943   2.269 0.024273 *
## DietOmnivore:Mass.tr   0.19139    0.06320   3.028 0.002757 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.222 on 219 degrees of freedom
## Multiple R-squared:  0.4257, Adjusted R-squared:  0.4126
## F-statistic: 32.46 on 5 and 219 DF,  p-value: < 2.2e-16
```

Results

The general linear model results are significant, with a p-value of 2.2e-16. The explanatory variables—average body mass and diet—account for 42.57% of the variability in average lifespan, which is substantial given the complexity of factors influencing longevity.

Diet (Carnivore, Herbivore, Omnivore) - Categorical Explanatory Variable

The model rejects the null hypothesis, indicating significant differences in mean lifespan among the diet groups. Specifically, there is a mean difference of -1.52115 between carnivores and herbivores (p-value 0.004723), and -1.71394 between carnivores and omnivores (p-value 0.000554)

Body Mass - Numerical Explanatory Variable

The analysis reveals a positive association between mean body mass and mean lifespan, with each additional year of lifespan corresponding to a 0.21978 unit increase in body mass on average. This relationship is statistically significant (p-value 1.54e-10).

Diet x Body - Interaction between Explanatory Variables

The model identifies a significant interaction between diet and average body mass. This interaction is evident in the graphical representation (Figure 1), as the lines are not parallel. Specifically, there is an interaction when comparing carnivores to herbivores (0.12483, p-value 0.024273) and carnivores to omnivores (0.19139, p-value 0.002757).

General Linear Model Scatter plot with 2 Explanatory Variables & Regression Line

Down below the results of the general linear model test on were plotted on a scatter plot with regression lines.

```
library(ggplot2)
ggplot()+
  geom_point(data=mammal.data, aes(x=Mass.tr, y=Lifespan.tr, color=Diet))+
  geom_smooth(data=mammal.data, aes(x=Mass.tr, y=Lifespan.tr, color=Diet),
method="lm", se=F)+
```

```
  theme_bw()+
  xlab("Average Mass (g)")+
  ylab("Average Lifespan (years)")+
  labs(title=paste("The Effect of Average Mass and Diet on Average Lifespan in Mammals"))

## `geom_smooth()` using formula = 'y ~ x'
```

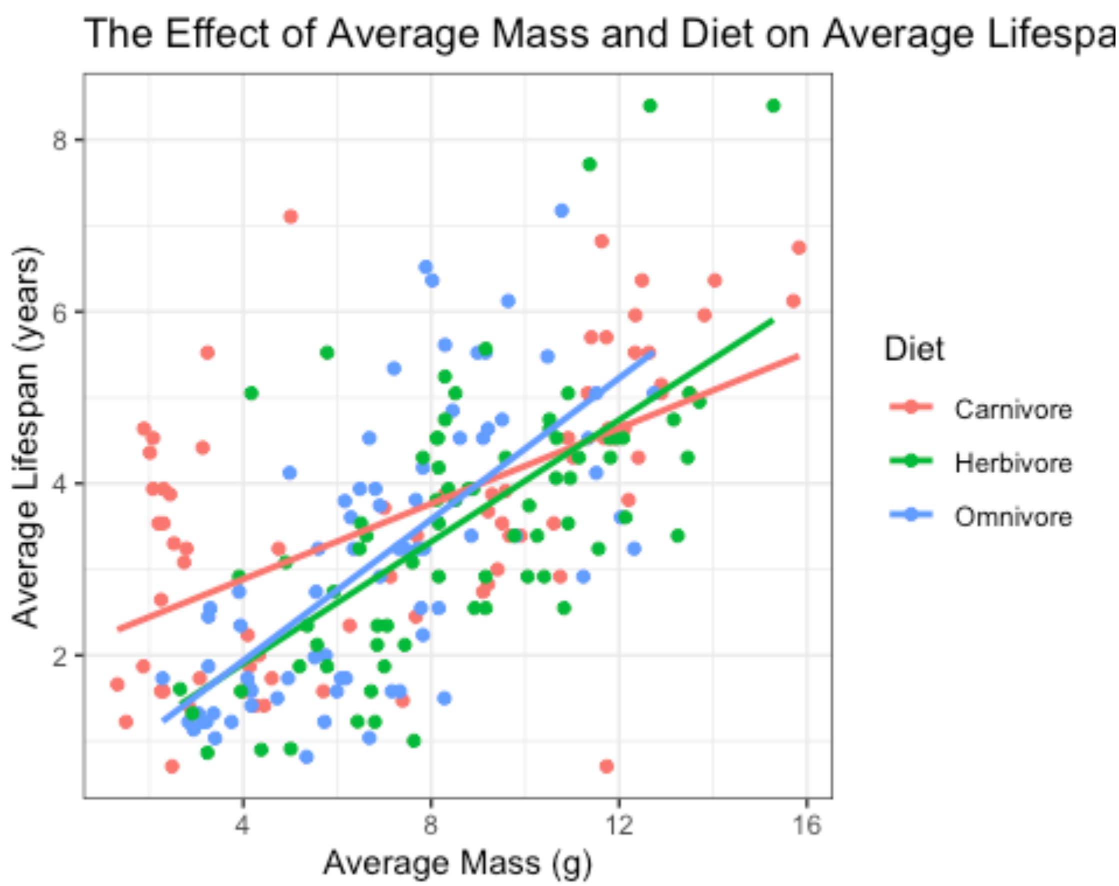


Figure 1: Scatter plot measuring average lifespan (years) compared with diet (Carnivore, Herbivore, Omnivore) and average mass (g). Regression lines are shown and color-coded according to diet (n=225, n=75 per diet category). Data provided by Animal Diversity Web.

Comparing datasets to see the proportion of each diet group in mammals are the same.

For this next step, we compared the proportion of each diet in mammals from the MammalDiet dataset and Animal Diversity Website dateset to see if the proprtions were the same.

Open the Second Dataset

- Download the full dataset here:

Down below the dataset csv titles were changed to ADWdiet.data and mammalDIET.data respectfully

```
ADWdiet.data <- read.csv("FinalADWMammal.csv", header=T)
head(ADWdiet.data)

##                    Species      Diet
## 1       Acinonyx jubatus Carnivore
## 2      Aepyceros melampus Herbivore
## 3 Ailuropoda melanoleuca Herbivore
## 4         Ailurus fulgens Herbivore
## 5           Akodon azarae  Omnivore
## 6  Alcelaphus buselaphus Herbivore

mammalDIET.data <- read.csv("FinalMammalDIET.csv", header=T)
head(mammalDIET.data)

##                  Species      Diet
## 1   Abrocoma bennettii Herbivore
## 2 Abrocoma boliviensis Herbivore
## 3      Abrocoma budini Herbivore
## 4     Abrocoma cinerea Herbivore
## 5    Abrocoma famatina Herbivore
## 6   Abrocoma shistacea Herbivore
```

The necessary packages, tidyverse and dplyr, were installed in order to be able to count how many of each diet group there are in each dataset.

```
#install.packages("tidyverse")

#install.packages("dplyr")
```

The proportions of the observed and expected vector were calculated using the count() function.

```
library(tidyverse)

## Warning: package 'tidyr' was built under R version 4.2.3

## Warning: package 'readr' was built under R version 4.2.3

## Warning: package 'dplyr' was built under R version 4.2.3

## Warning: package 'stringr' was built under R version 4.2.3

## ── Attaching core tidyverse packages ──────────────────────── tidyverse 
2.0.0 ──
## ✔ dplyr     1.1.4     ✔ readr     2.1.5
## ✔ forcats   1.0.0     ✔ stringr   1.5.1
## ✔ lubridate 1.9.3     ✔ tibble    3.2.1
## ✔ purrr     1.0.2     ✔ tidyr     1.3.1
## ── Conflicts ──────────────────────────────────────────
```

```
tidyverse_conflicts() ──
## ✖ dplyr::filter() masks stats::filter()
## ✖ dplyr::lag()    masks stats::lag()
## ℹ Use the conflicted package (<http://conflicted.r-lib.org/>) to force
all conflicts to become errors
```

```r
ADWdiet.data %>% count(Diet)
```

```
##        Diet   n
## 1 Carnivore 200
## 2 Herbivore 310
## 3  Omnivore  98
```

```r
mammalDIET.data %>% count(Diet)
```

```
##        Diet    n
## 1 Carnivore 1637
## 2 Herbivore 1926
## 3  Omnivore 1788
```

From this we see that the following proportions for the observed (ADW = 608) and the expected (MammalDIET = 5351). C=Carnivore, O=Omnivore, and H=Herbivore.

ADW:

C=0.32 O=0.16 H=0.50

MammalDIET:

C=0.31 O=0.36 H=0.33

Chi-Square Goodness of Fit Test

The Chi-Square Goodness of Fit Test was conducted to determine if the observed proportions matched the expected proportions.

Below, the values needed to calculate the chi-square test were assigned variables and the results were visually represented in a table with with frequency, diet, and group, as the variables.

```r
# Observed and expected counts
observed <- c(200, 98, 310)  # Carnivores, Omnivores, Herbivores
expected <- c(1637, 1788, 1926)

# Perform Chi-squared test
chi.results <- chisq.test(observed, p = expected / sum(expected))
print(chi.results)
```

```
##
##  Chi-squared test for given probabilities
##
```

```
## data:  observed
## X-squared = 93.46, df = 2, p-value < 2.2e-16
```

Table

```
# Observed and expected frequencies
observed_freq <-c(0.32,0.16,0.50)
expected_freq<- c(0.31, 0.36, 0.33)

#Creating a dataframe with the values
mammalpropDATA <- data.frame(frequency = c(observed_freq, expected_freq))
mammalpropDATA$Diet <- c("Carnivore", "Omnivore",
"Herbivore","Carnivore","Omnivore", "Herbivore")
mammalpropDATA$Group <- c("Observed", "Observed", "Observed","Expected",
"Expected", "Expected")
print(mammalpropDATA)
```

```
##   frequency      Diet    Group
## 1      0.32 Carnivore Observed
## 2      0.16  Omnivore Observed
## 3      0.50 Herbivore Observed
## 4      0.31 Carnivore Expected
## 5      0.36  Omnivore Expected
## 6      0.33 Herbivore Expected
```

A group bar plot was created to visually represent the difference in frequencies between groups categorized by diet.

Group Bar Plot

```
library(ggplot2)
ggplot()+
geom_bar(data=mammalpropDATA, aes(x=Diet, y=frequency, fill=Group),
stat="identity", position="dodge")+
theme_bw(base_size=16)+
ylab("Frequency")
```

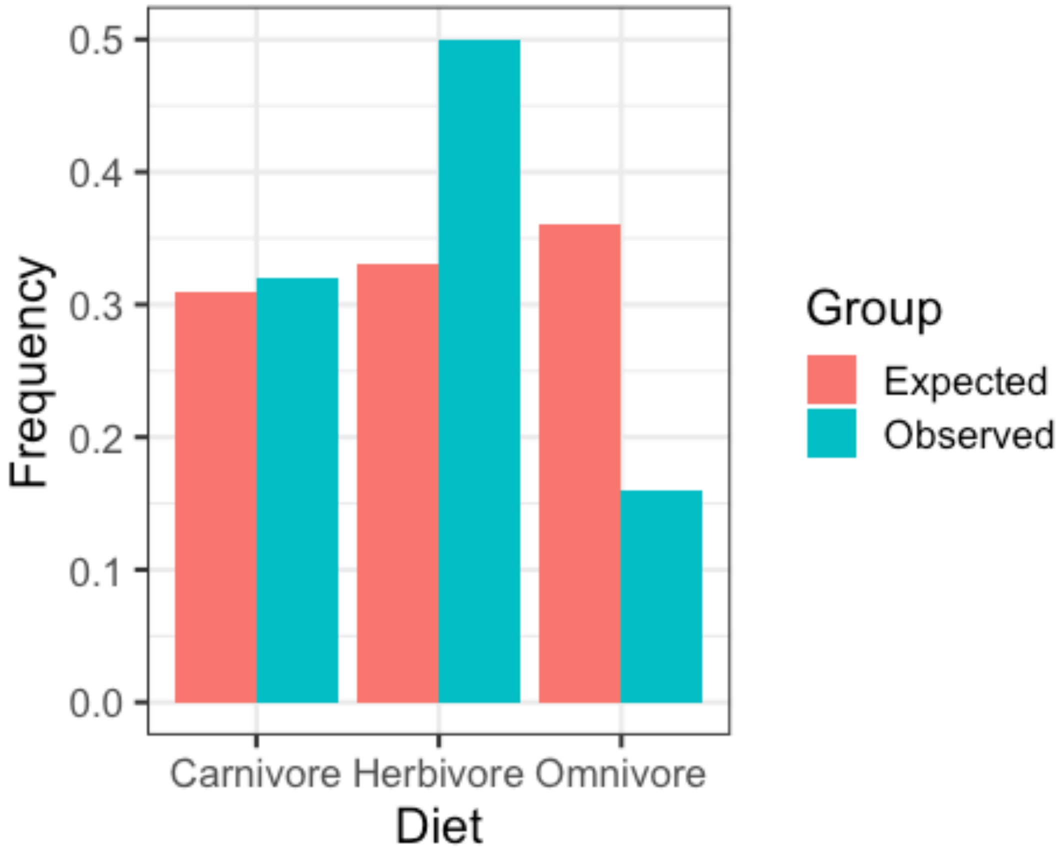


Figure 2. Group Bar Graph comparing the frequency of each diet group (Carnivore, Omnivore, Herbivore) between the observed ADW data values and the expected ADW data values if the proportions matched the MammalDIET data proportions. Data provided by Animal Diversity Web and Kissling, W.D. et al.

In the second analysis, the Chi-Square Goodness of Fit test indicates that the observed proportions in the ADW data differ significantly from the expected proportions based on the MammalDIET data ($\chi^2 = 93.46$, df = 2, p-value = 2.2e-16). This discrepancy suggests that the proportions of diet categories in the ADW data are not as expected: the proportion of herbivores is much higher than predicted, while the proportion of omnivores is much lower (Table 1, Figure 5). It is also important to note that the critical χ^2 value for df = 2 is 5.99, and the observed χ^2 value far exceeds this threshold, resulting in a very small p-value.

Conclusion

My general linear model supported my biological hypothesis, indicating that average body mass and diet significantly impact mammal lifespan, explaining 42.57% of the variability. However, the assumptions for the GLM were not met, and the Animal Diversity Web (ADW) dataset, which was not proportionate to the larger MammalDIET dataset, might not be a representative sample. The ADW dataset's overrepresentation of herbivores could have skewed results, as herbivores showed the longest lifespans, but the significant difference between datasets suggests that the ADW data may not accurately reflect mammalian diets (Figures 4 & 5, Table 1).

Despite the GLM's significant results, the data did not meet the assumptions for normality and equal variance, which could affect the conclusions. The ADW dataset's smaller sample size and non-representative nature, coupled with potential biases, highlight limitations. Future research should consider using more balanced datasets and exploring factors beyond body mass and diet, including predation and environmental influences. This study could inform conservation efforts and animal care practices by providing insights into factors affecting longevity, challenging media claims about weight and diet, and suggesting directions for broader research, including non-mammalian vertebrates and specific dietary components.

Bibliography

Animal Diversity Web. Quaardvark. 2013. University of Michigan Museum of Zoology. https://animaldiversity.ummz.umich.edu/quaardvark/search/1E37C501-393E-0001-32B7-2A6014F113B8/?start=1.

Ebert T. 2008. Longevity and lack of senescence in the red sea urchin Strongylocentrotus franciscanus. Exp Gerontol: 43(8):734-8.

Kissling WD, Dalby L, Fløjgaard C, Lenoir J, Sandel B, Sandom C, Trøjelsgaard K, Svenning J-C. 2014. Establishing macroecological trait datasets: digitalization, extrapolation, and validation of diet preferences in terrestrial mammals worldwide. Dryad Digital Repository. doi: 10.5061/dryad.6cd0v. Price S, Hopkins S. 2015. The macroevolutionary relationship between diet and body mass across mammals. Biological Journal of the Linnean Society: 115(1):173–184. https://doi.org/10.1111/bij.12495.

Speakman J. 2005. Body size, energy metabolism and lifespan. Lifespan, Reproduction And Ecology. J Exp Biol 208 (9): 1717–1730.

Wilder M, Le Couteur D, Simpson S. 2013. Diet mediates the relationship between longevity and reproduction in mammals. Age (Dordr),: 35(3): 921–927.