Variance of Mexican Spotted Owl Diets and Droppings with Temperature and Precipitation

Ben Miller
BIOB170 Lab, Montana State University,
Benjamin.miller12@student.montana.edu

Introduction

Mexican Spotted owls tend to roost in areas that are both high and protective, like thick, tall canopy or canyon lands in mid-western North America (Willey & van Riper, 2015). The composition of the owl diet has been studied through owl pellets, where bones, debris, and other evidence of taxonomy can be readily observed. Previous research has mainly focused on differences in diet due to location, fires, or owl type (BLOCK et al., 2005; Comay & Dayan, 2018; Ganey et al., 2014; Willey, 2013). It has been observed that fire zones create a temporary abundance of owl prey, specifically small mammals (Ganey et al., 2014, 2017). Larger owls also prey on a wider variety of animal sizes, though small mammals are still the primary food source (Comay & Dayan, 2018). Further, Owl diet tends to vary significantly between xeric and mesic climates.

So far, there has been relatively little investigation into these two questions: How does temperature affect the diets of Mexican Spotted Owls? How does rainfall affect the diets of Mexican Spotted Owls? Additionally, the data available allow us to investigate changes in the diets of Mexican Spotted Owls from 1991 to 2007 and what could have influenced the observed trends. Canyon lands tend to be much hotter and drier than forest sites, which could explain why owls eat less arthropods, less gophers, and more woodrats (Willey, 2013). Though relative abundance of the various types of prey will likely prove to be the deciding factor, climate could influence diets as well. Trends over time will likely also shed light on the subject by along with observing correlations between temperature, rainfall, and diet composition.

The response variable for this investigation is the diet composition, which is determined by the prey name variable. The Explanatory variables are site, temperature, and rainfall, where temperature and rainfall are matched with each instance from weather archives. For my hypothesis statement: If rainfall or temperature affect the diet composition of Mexican Spotted Owls, and we gather owl droppings and record their composition, the temperature, the location, and the average rainfall, then we will observe a difference in the diet composition depending on the previously mentioned variables. I predict that cooler temperatures and increased rainfall will result in a larger composition of arthropods in the owl diet.

Methods

Study Area-- The data used for this study was gathered by Dr. David Willey from 1991 to 2007. Seven sites were used throughout the Mexican Spotted Owls' primary area of distribution, southern Utah and northern Arizona. Six of the sites were located in canyons and had similar typography. They were all part of the Colorado Plateau physiographic province, had elevations between 1,345 and 2,445 m, had a total annual precipitation average of 17 cm during the study, and had temperature ranging from -1.4 and 44 degrees Celsius. They also had a variety of vegetation including desert scrubs, cacti, and several types of trees along areas of water. The seventh site was forested, had an elevation between 1,988 and 2,599 m, had an average annual rainfall of 76 cm that occurred in two seasons with the majority coming during July and August. It was largely covered in coniferous trees, mixed grasses, and ferns (Willey, 2013).

Collection Methods-- The regurgitated pellets were found by listening for owls, then finding their roost sites and opportunistically collecting them. They were collected for the forested area from "five owl pairs in the Rincons during 1996-1997. For the canyon lands, pellets were collected during 1991-1995 for seven pairs at Zion, ten pairs at Reef, five pairs at Manti, and four pairs at Canyon. In addition, pellets were collected for four pairs at Paria during 2001–2007, and eight pairs in Grand Canyon during 2004–2006" (Willey, 2013). To collect the specific temperature and rainfall data, the data was downloaded from the NOAA weather archives using the corresponding counties and date ranges (NCEI). The nearest weather station to the geographic descriptions that recorded precipitation was used. Out of the 1,261 data points recorded by Dr. Willey and his team, 100 did not match the date ranges described and were removed, leaving us with 1,161 data points. Biomass was found by consulting the appendix in Willey's paper. (Willey, 2013)

Experimental Design and Methods of Analysis-- The response variable for this investigation is the diet composition, which is either calculated by the count of each prey type, or the total biomass of each prey type. The Explanatory variables are site, temperature, and rainfall. To analyze the data, an additive general linear model will be used. Relative biomass percentage will likely be the most useful way to encode the prey name, but frequency could also be informative (Willey, 2013).

Analysis and Results

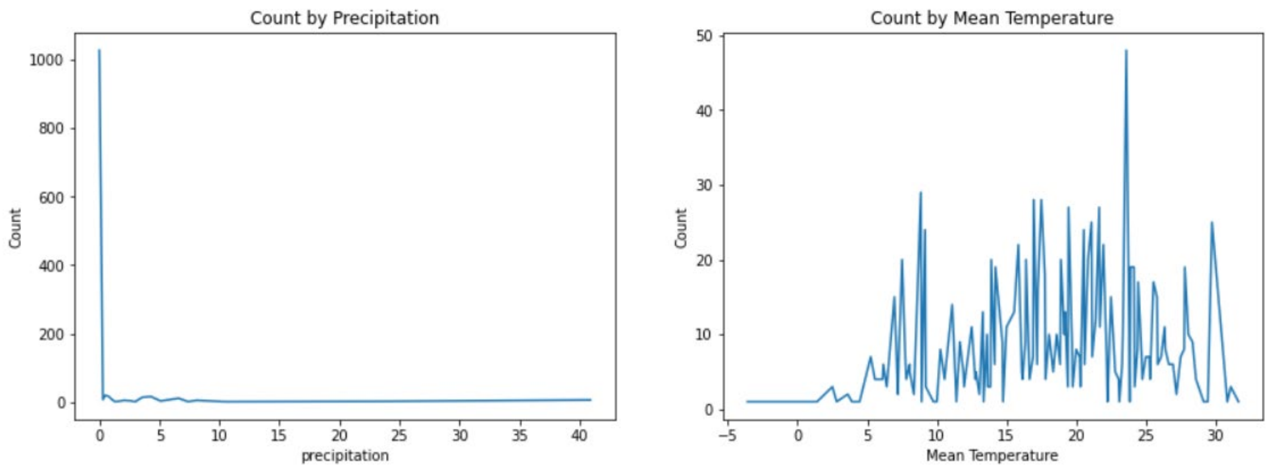

Figure 1.1 (left) Count of total animals eaten by the precipitation in cm.
Figure 1.2 (right) Count of total animals eaten by the mean temperature in Celsius over a one-day period.

Figure 1.1 shows that most of the data points were recorded on dry days, and that if it rained at all, it was likely very little. This makes sense because most of the data was recorded in deserts, and it is likely harder to find and record data on rainy days. Precipitation did not prove to be a good predictor for this study. Figure 1.2 shows the trends of counts by the average temperature that day, and it shows a roughly even distribution in the cool and warmer days. Less data was recorded during the winter, so fewer cold days were captured in the data as well.

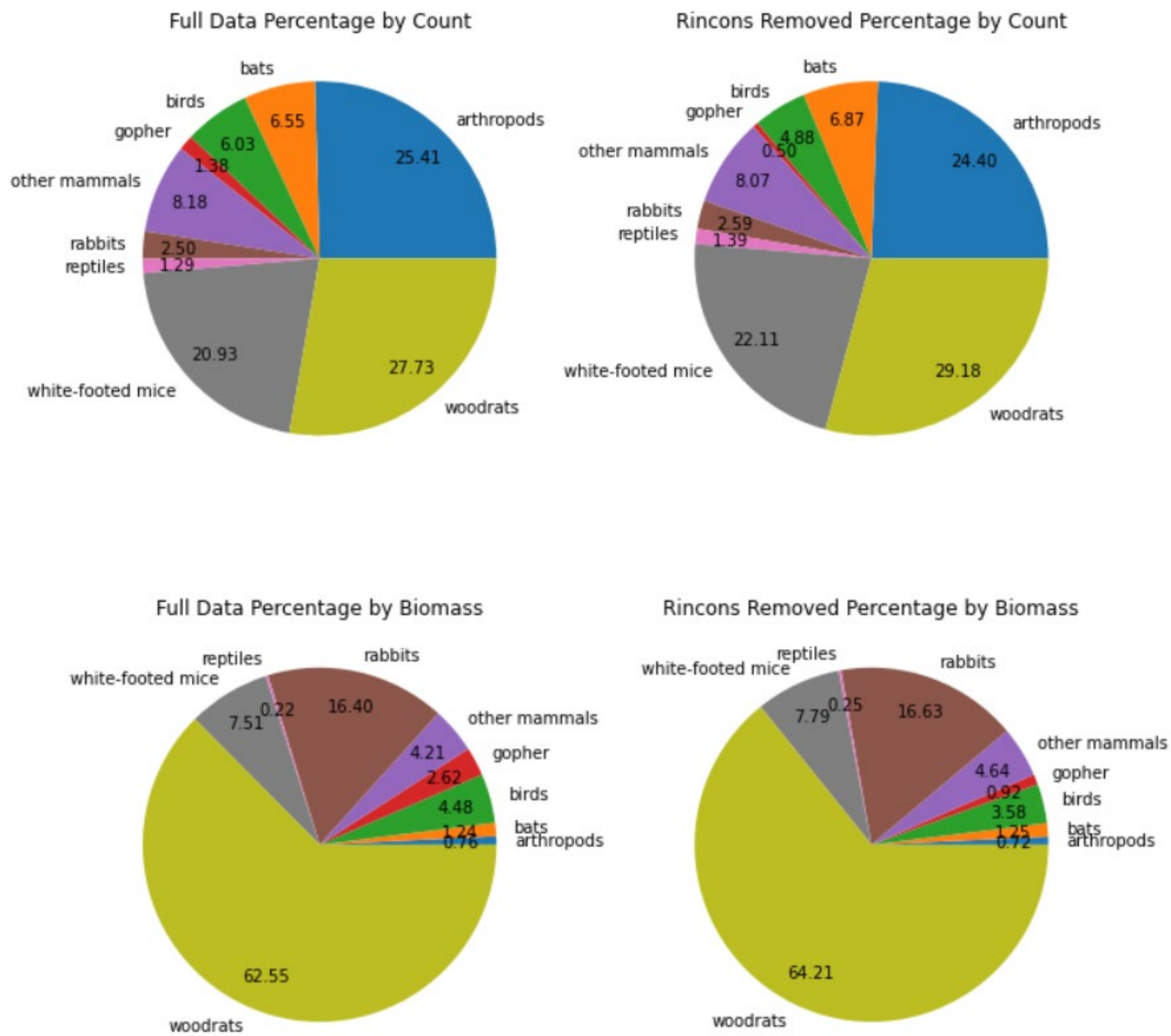

Figure 2.1 (top left) Diet composition of the full data by number of each category consumed
Figure 2.2 (top right) Diet composition of the data with the Rincon data removed by number of each category consumed
Figure 2.3 (bottom left) Diet composition of the full data by the total biomass of each category consumed
Figure 2.4 (bottom right) Diet composition of the data with the Rincon data removed by the total biomass of each category consumed

The plots in figure 2 show the diet composition using the two methods both with and without the data from the Rincons. There was some concern that the wetter and colder climate of the Rincons would change results, but the diet compositions are not significantly different from each other. The composition by count corroborates other researchers' findings that arthropods are mostly eaten as snacks and don't serve a large nutritional objective, and woodrats are the largest source of nutrients for the Mexican Spotted Owl. (Willey, 2013). More rabbits were in the data set than were reported in Willey's paper, though these rabbits could have been smaller than assumed.

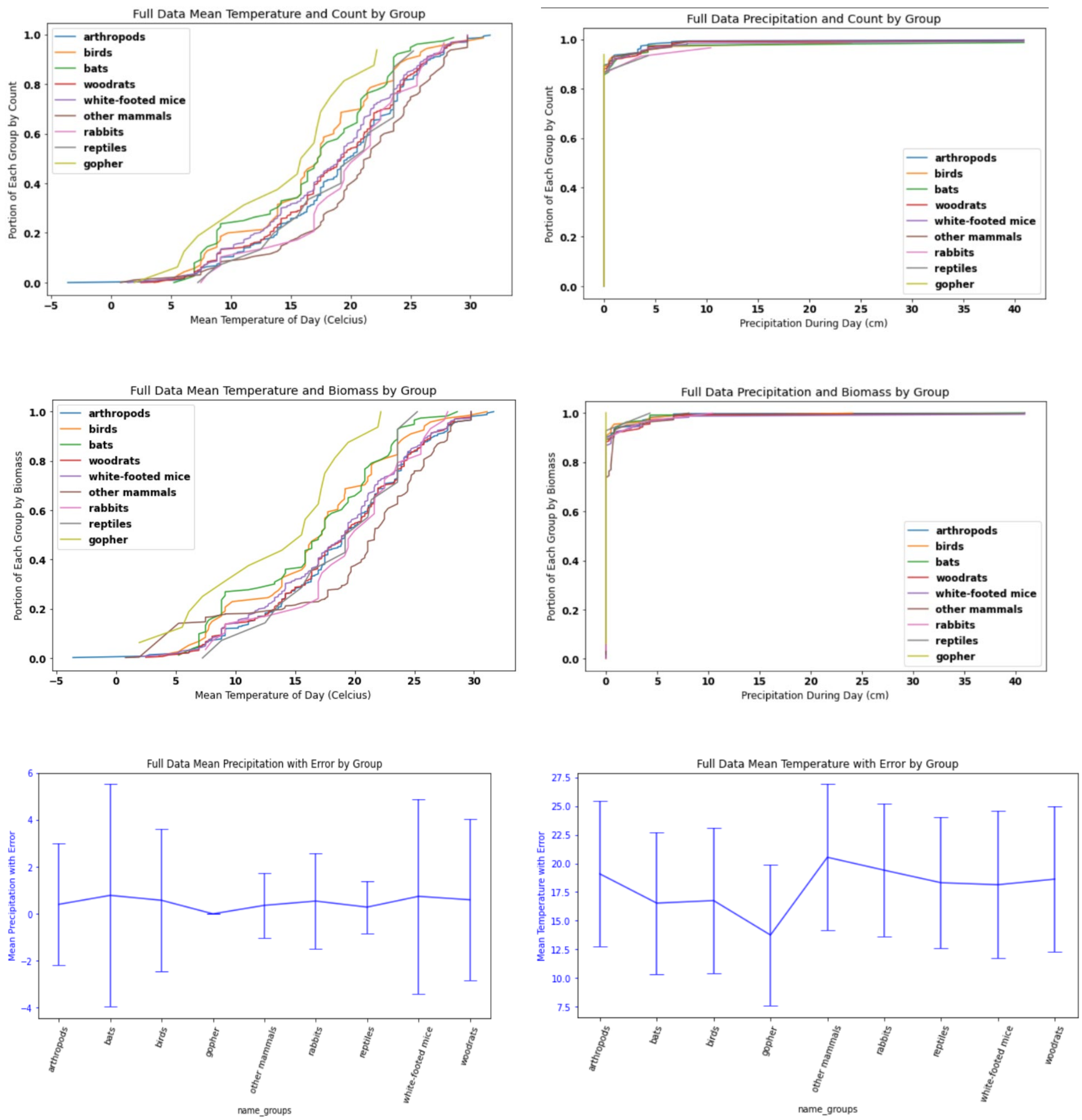

Figure 3.1 (top left) Full data mean temperature in Celsius and count by group

Figure 3.2 (top right) Full data precipitation in cm and count by group
Figure 3.3 (middle left) Full data mean temperature period in Celsius and biomass by group
Figure 3.4 (middle right) Full data precipitation in cm and biomass by group
Figure 3.5 (bottom left) Full data mean precipitation in cm with error bars by group
Figure 3.6 (bottom right) Full data mean temperature in Celsius with error bars by group

Figures 3.1 - 3.4 show the proportion of each group that was found at or below the temperature or precipitation on the x-axis. Averages were calculated from a one-day period of when the pellets were found. The temperature graphs show a fairly consistent slope for each group with "other mammals" generally having the warmest temperature and gophers generally having the coldest. The spread between the lines is a little larger and shifted to the right for some groups on the biomass temperature chart, which suggests that owls eat larger prey within each group during warmer days. No groups are significantly different than the others, especially considering how relatively few gophers and "other mammals" were eaten. The precipitation graphs show that almost all pellets were found on days with no rain. Figures 3.5 and 3.6 show that there is significant variation in the mean temperature and precipitation. In Figure 3.5, the gopher group shows that every gopher found was on a day with no precipitation.

Fitting an additive general linear model with the biomass as the response variable and precipitation, prey type, maximum temperature, minimum temperature, and mean temperature as the explanatory variables gives an intercept p-value of 0.232 on 242 degrees of freedom. The minimum temperature has a p-value of 0.066, maximum temperature has a p-value of 0.111, precipitation has a p-value of 0.574, and the rest are not significant. Fitting an additive general linear model with the number of skulls as the response variable and precipitation, prey type, maximum temperature, minimum temperature, and mean temperature as the explanatory variables gives an intercept p-value of 0.163 on 242 degrees of freedom. The minimum temperature has a p-value of 0.0003, maximum temperature has a p-value of 0.063, and precipitation has a p-value of 0.960.

Precipitation proved to be a non-factor with the data used. The intersect p-value suggests that little or very weak evidence was found to reject the null hypothesis of there being no impact from precipitation or temperature on the prey type, but the p-values of the temperature minimums and maximums suggest that they may have played a small role, though insignificant. Their small role could also be explained by experimental design and may better be explained by season.

Discussion

No conclusive result was found and there was not any statistically significant evidence against the null hypothesis. However, the data does give us some interesting information and possible areas of exploration. We know that wildfires change the landscape in such a way that owls can thrive in the short-term (Ganey et al., 2014, 2017). There could be a different composition of prey in those areas that could be like prey composition at different times of the year or under different circumstances.

Precipitation is unlikely to really affect prey composition in dry areas, which I think is because the precipitation is just not that common. Perhaps a better measure to have used would be the weekly average of precipitation, or previous weekly precipitation, which might better account for plant growth, thereby better accounting for certain types of prey. Wetter areas might also have a steadier stream of precipitation, which would balance out unevenness. It is also possible that owls don't hunt as much when it rains. Trying to gather more pellets on rainy days could give more information but would be very tough.

The temperature seemed to have the largest impact, though this is likely explained from seasons. In the winter, there are likely less bugs and colder temperatures are correlated with the season. Most of the "other animals" were found during warmer temperatures, and the few rabbits were also found during warmer temperatures. This might suggest that more exotic prey could be found during the warmer seasons. There was also a lot more data points recorded during warmer days, so an area of further research might be to find more data during the winter, which would give a better basis to draw statistical temperature conclusions from. Another interesting analysis might be to compare diet composition to season.

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