Rodent road ecology in south Texas and the potential bottom-up effects on rodent predators

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Abstract:

In the field of road ecology, rodents are a taxonomic group which is understudied and could potentially be influential for the road ecology of other species. In the south Texas region rodents could be particularly influential due to the important and threatened rodent predators in the region. This project addresses aspects of the road ecology of rodents and their potential impacts on the interactions of rodent predators with roads and wildlife crossings on Laguna Atascosa NWR. Diel activity pattern figures were generated for rodents in different road and undisturbed habitat categories and statistically analyzed to show any differences in rodent temporal activity. Direct comparisons between predator and rodent activity at sample sites will consist of linear regressions to discover potential correlations between rodent activity and predator abundance.

Introduction:

The native rodent species community is a vital components of south Texas ecosystems, they not only play important roles as herbivores, scavengers, and predators (Dickman 1999), but they are also the primary prey for many species in the region, including bobcats (*Lynx rufus*), coyotes (*Canis latrans*), and federally endangered ocelots (*Leopardus pardalis*) (Booth-Binczik, Bradley et al. 2013). Due to their importance and potential effects on other species, the effect of increased urbanization and human development on rodents needs to be assessed to most effectively manage and conserve native wildlife. The effect of roads and wildlife crossing structures in particular on rodents has been understudied or completely disregarded, but much of the literature which is available indicates notable effects on some rodent species linked to roads (Kozel and Fleharty 1979). In south Texas, this gap in knowledge leads to an incomplete understanding of not only how rodent populations are changing because of these roads and structures, but also whether rodents could function as drivers for how rodent predators interact with roads and crossings.

One important way that rodent communities could be affected by roads and crossing structures is that the noise, light, and disturbed habitat around roads could change the diel patterns of rodents which live near roads and/or crossing structures(Shilling, Collins et al. 2018). This diel pattern could in turn affect the activity of rodent predators as they look for prey. If increases in activity of crepuscular rodents such as hispid cotton rats (*Sigmodon hispidus*) are observed for example, there is the potential for a shift in predator activity to periods where there are higher volumes of road traffic.

Another road effect that could cause shifts in predator activity and presence is the potentially altered activity and availability of rodents around road mortality mitigation structures (Godbois, Conner et al. 2004). Rodent availability potentially being a factor driving rodent predator use of crossing structures is not inherently counter to the goals of installing road mortality mitigation structures, but more research would be necessary to determine if any of the bottom-up effects on predators are changing the level of conservation success of the crossings at the population level.

Methods:

Rodent data was gathered utilizing photobooths which has also been used to effectively survey for rodents on surveys in other regions (McCleery, Zweig et al. 2014). Data for predator species will be taken from a long-running monitoring project of SH 100 and FM 106. The study area will be limited to the monitored sections of SH 100 and FM 106, which are both in Cameron county in south Texas primarily on Laguna Atascosa NWR property.

Data from the photobooths was manually sorted to the species level and then processed using R code which outputted a .csv file with independent occurrences calculated based on a 30-minute interval of independence. Predator data from the monitoring project was manually sorted to the species level as well, but independent occurrences was based on both a 30-minute interval of independence and by observed behavior in the photos.

The rodent dataset constitutes approximately 5% of the total dataset which will be utilized in the final version of this research in my thesis, therefore much of the results will function as proof of concepts for generating figures and statistics which will be useful in my thesis rather than results which answer my objective questions.

The compiled data was processed using the Pandas, NumPy, and Matplotlib packages in Python. The number of independent interactions was plotted in a stacked bar plot with each bar showing an hour of the day with each bar further divided by rodent species. A proof of concept for predators was also generated utilizing this same code after slight modifications reflecting the different species, but due to the current dataset for predators not including reference/control data, no conclusions could be reached using this analysis.

The Activity library in R was then used to statistically analyze the rodent diel activity patterns. Figures were generated which showed a single unstacked category of wildlife's pattern and with a non-linear regression and 95% confidence intervals. Activity was also used to compare diel patterns for different categories to determine if there were any significant differences.

Linear regressions were then run to compare prey activity with predator abundance. The predators used were bobcats and coyotes, and ocelots were excluded due to the low number of sightings. In addition to rodents, lagomorphs were also compared to predators due to their importance as coyote prey in other road ecology studies (Caldwell and Klip 2020). The lagomorph data was taken from the same dataset as the predator data. These regressions were generated in Python using the Pandas, NumPy, and Matplotlib packages.

Results:

The rodent diel pattern data processed in Python successfully showed rodent activity patterns over a 24-hour period for wildlife crossing site and reference site categories. These were an effective way of visually comparing the diel patterns between the two site categories and show that there are differences in the data, but the data is shown just descriptively, and significance cannot be determined in these figures. Fig 1 and Fig 2 are included to show examples of these figures.

The Activity library in R generated diel pattern figures which allowed better visual comparisons due to the inclusion of confidence intervals and showed that all species with sufficient sample sizes had mostly overlapping confidence intervals. Additionally, the total rodent community showed no significant difference when crossing and reference sites were compared (p value = .2749). An example of rodent diel patterns generated utilizing Activity can be seen in Fig 3.

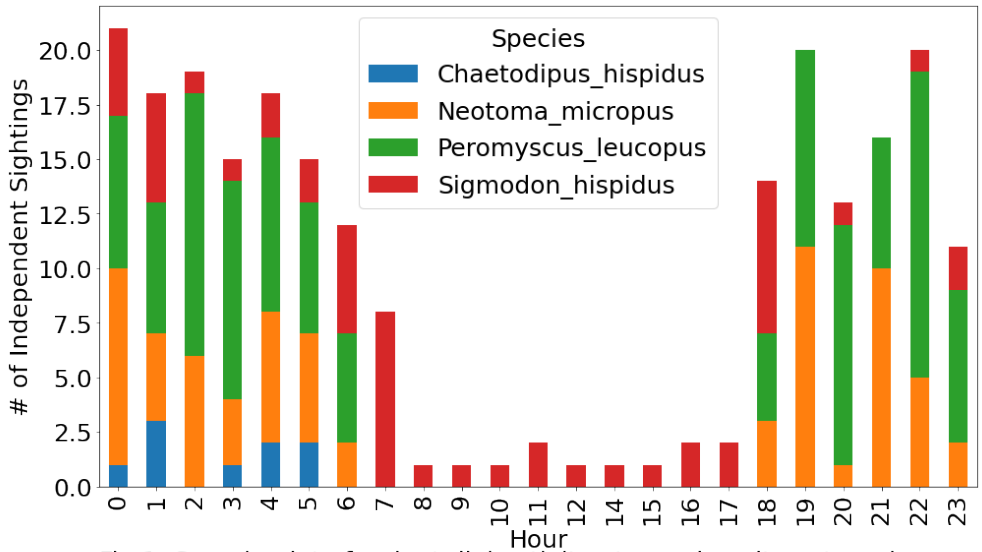

Fig 1: Sample plot of rodent diel activity at crossing site categories

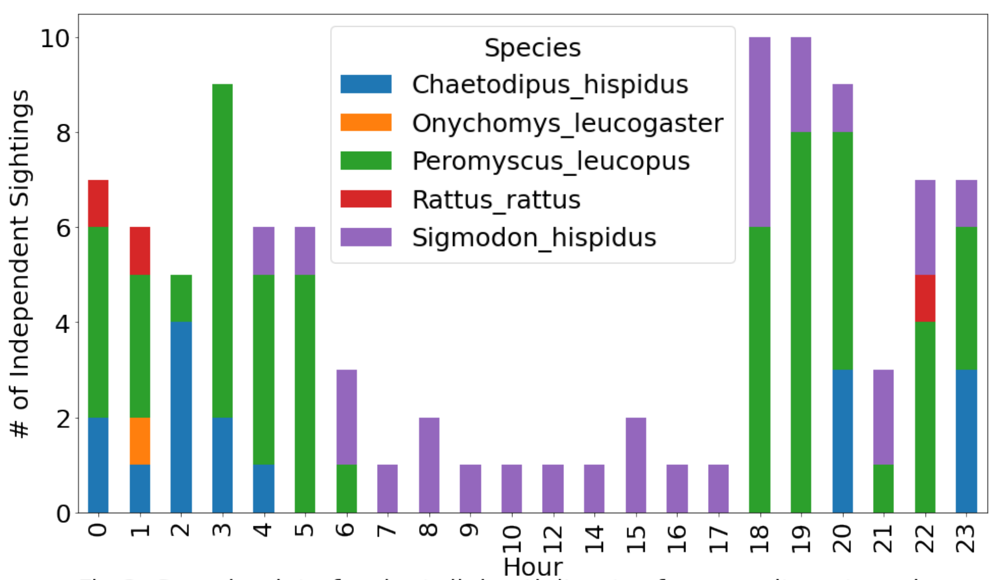

Fig 2: Sample plot of rodent diel activity at reference site categories

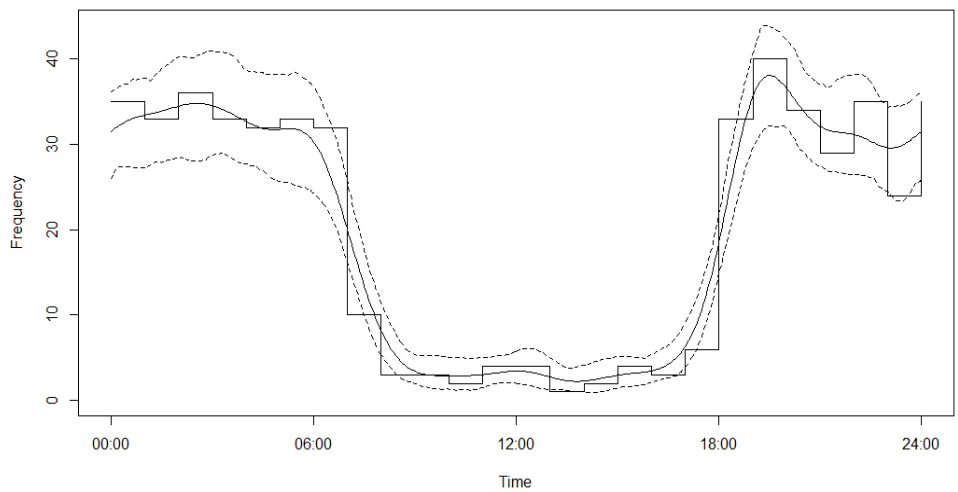

Fig 3: Sample plot of rodent diel activity with nonlinear regression and 95% confidence intervals for all sites generated in Activity

The linear regressions for predators and prey showed a significant positive correlation between rodents and bobcats (Fig 4), a nonsignificant positive correlation between rodents and coyotes (Fig 5), no correlation between bobcats and lagomorphs (Fig 6), and a nonsignificant negative correlation between coyotes and lagomorphs (Fig 7).

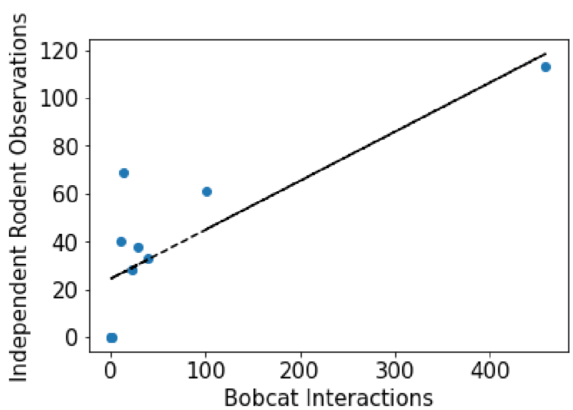

Fig 4: R value = .805, P value = .0049

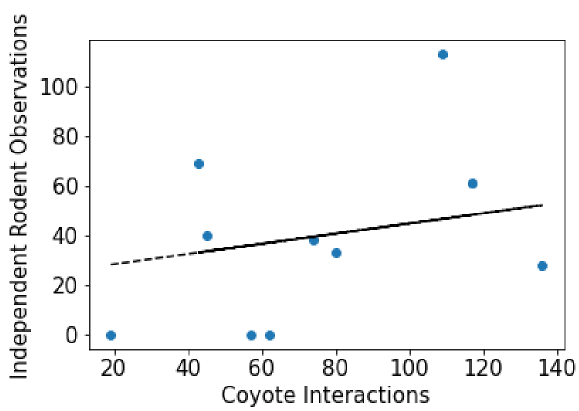

Fig 5: R value = .432, P value = .2125

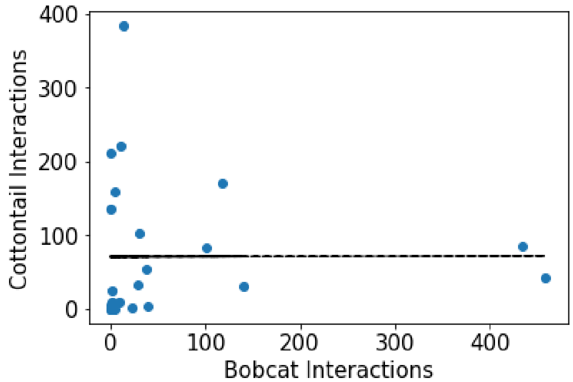

Fig 6: R value = .0032, P value = .988

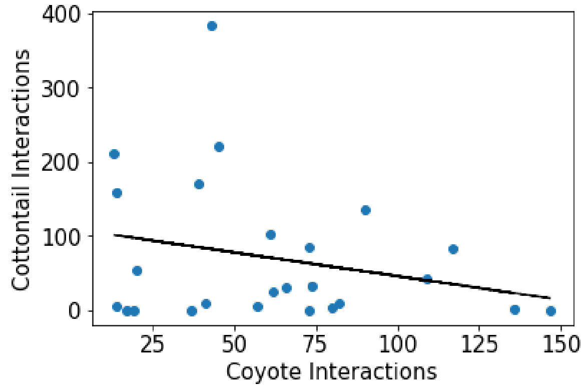

Fig 7: R value = -.253, P value = .222

Discussion:

The diel pattern comparisons generated no significant results but some nonsignificant differences in the data was visible. Since the sample size looked at in these analyses was a small fraction of what the total dataset will be there is still a benefit of further study when the larger dataset is completed. The methodology and quality of the figures was also potentially useful for laying the groundwork for any further analysis of this type of data. The figures generated in Python would be useful as a method of showing results which breaks down the data by species while showing the whole community and in a way which is more visually appealing for the purpose of presentations. The figures generated using Activity were better for running statistical comparisons and the outputted p-value would be a requirement for any scientific comparison of diel patterns.

The primary correlation of interest shown by the linear regressions was the strong positive correlation between bobcat and rodent activity. This correlation may not be indicative of any direct relationship between the two species, but habitat variables driving the activity of both species. With more data and survey sites becoming available as the project progresses the primary driving variables involving habitat can potentially be identified and the context of the bobcat-rodent relationship can be better determined. This relationship is also of particular interest because typically ocelots in south Texas do not interact with roads in high enough numbers to generate results which would be statistically significant, but bobcats are suitable surrogates for ocelots in examining crossing interactions and overall road ecology.

Bibliography:

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Dickman, C. R. (1999). "Rodent-ecosystem relationships: a review." Ecologically-based management of rodent pests. ACIAR Monograph **59**: 113-133.

Godbois, I. A., et al. (2004). "SPACE-USE PATTERNS OF BOBCATS RELATIVE TO SUPPLEMENTAL FEEDING OF NORTHERN BOBWHITES." Journal of Wildlife Management **68**(3): 514-518.

Kozel, R. M. and E. D. Fleharty (1979). "Movements of Rodents across Roads." The Southwestern Naturalist **24**(2): 239.

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Python Sample Code Supplemental Material:

#Creating diel activity pattern

#data must have an ‘Hour’ column for time and a ‘Species’ column in .csv format

1st filter for rodents, update with any new target species

rodents=data[data['Species'].isin(['Chaetodipus_hispidus','Sigmodon_hispidus','Peromyscus_leucopus',' Onychomys_leucogaster', 'Rattus_rattus', 'Neotoma_micropus','Reithrodontomys_fulvous'])]

#select relevant data for figure

rodents_time = rodents.groupby(['Hour','Species'])['# of Individuals'].sum()

#Personal preference font size for figure

plt.rcParams.update({'font.size': 20})

#Creates plot in correct format with species stacked for each hour

rodents_time.unstack().plot.bar(ylabel='# of Independent Sightings', stacked=True, figsize=(16,9))

#creates annotation positioned properly for font size and fig size

plt.annotate('Fig 1: Sample plot of rodent diel activity at all site categories', (0,0), (0, -55), xycoords='axes fraction', textcoords='offset points', va='top')

#Create predator-prey linear regression

#import data, columns will be Species, rows will be sample sites, values will be activity or abundance index. Easiest to prep data is by using a pivot table.

pred_prey = pd.read_csv('data.csv')

#fill na values with 0’s

pred_prey=pred_prey.fillna(0)

#generate stats for regression

slope, intercept, r_value, p_value, std_err = stats.linregress(pred_prey['bobcat'],pred_prey['Rodent'])

#plot scatterplot with regression line

plt.plot(pred_prey['bobcat'], slope*pred_prey['bobcat']+intercept, 'k--')

plt.scatter(pred_prey['bobcat'],pred_prey['Rodent'])

R Sample Code Supplemental Materials:

#plotting diel activity patterns using Activity library in R

activity <- read.csv(file.choose()) # make sure time of day is in radian format, easiest way is to get total number of seconds for time by converting hours and minutes, then converting to radians

#Fit without confidence limits

data(activity)

tm <- 2*pi*subset(activity)$time

mod1 <- fitact(tm)

plot(mod1) #basic plot with regression

#Fit with 95% confidence limits,

mod2 <- fitact(tm, sample="data", reps=100)

plot(mod2)

#Comparison between crossing and reference site diel patterns

#select first category to compare, in this situation species was replaced with site categories in the .csv, but I initially used this code to compare species to each other

tCross <- 2*pi*activity$time[activity$species=="crossing"]

#select second category

tRef <- 2*pi*activity$time[activity$species=="reference"]

#fewer reps are faster, but accuracy increases as more reps are added. Diminishing returns eventually so no need to go too high.

fCross <- fitact(tCross, sample="data", reps=10)

fRef <- fitact(tRef, sample="data", reps=10)

fCross@act

fRef@act

#outputs the stats, w=wald statistics, p= p value

compareAct(list(fCross,fRef))