Understanding Wildlife Interactions on Ventana Ranch, CA. based on Local Rabbit Populations

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Abstract Rabbit species can be a great source providing nutrients for carnivores but can also become a pest species to agriculture and private properties. Understand the behavior patterns of the rabbit species are important for wildlife management because it provides data for wildlife interactions and pest control. The daily activity pattern of the Desert Cottontail rabbits (*Sylvilagus audubonii)* and California Jackrabbits *(Lepus californicus)* are described as crepuscular in most of the older literature. However, variability within populations due to competition and environment might be detected with modern techniques such as automated camera trapping. In this study, I compared the daily activity of the two rabbit species on Ventana Ranch, California with what has been described in the literature using camera trap data taken 24 hours per day over an eight month period in 2007. First, comparing two rabbit species' daily activity patterns showed no statistically significant difference in activity period suggesting that rabbits are not likely to display resource partitioning behavior in terms of active time periods. This information can be useful in managing rabbit species in other grassland habitats because similar behavior might be found on the habitat. Knowing the activity pattern can aid in controlling local rabbit population before it becomes a pest. Second, the results show that the peak activity is during the crepuscular period (especially dawn), but there is consistent activity throughout the night that, when summed over the longer period of night-time, is greater than the short period of dawn. This information leads to the need of future studies on wildlife interaction and behavior.

Introduction

Desert Cottontail rabbits (*Sylvilagus audubonii)* and California Jackrabbits *(Lepus californicus)* are two of the most abundant rabbits in California (Petrides, 1951, Shields, 1960). They serve an important role in the ecosystem by providing meat for higher predators such as foxes, bobcats, and coyotes (Turkowski 1975). Moreover, the rabbits can affect the diversity of the local vegetation though food selection because they prefer one type of grass over another (Zedler and Black 1992, Hoffmann et al., 1995). In many states, rabbits are also seen as pest species of agricultural crops due to their ability to graze different types of vegetation. Being able to survive in different habitats, rabbit and hare populations can be an ecosystem-level problem because they can carry and spread parasites and diseases to other species including humans (Lechleitner, 1958). For example, over grazing can become a problem in agriculture farm land (Lechleitner, 1958). Also, rabbits are known to carry parasites and ticks that might affect other species. (Smith and Cheatum, 1944, Lyons and Hansen, 1961, Monroe and Hansen, 1962). As Smith and Cheatum described in 1944, the New York State Conservation Department was concerned that the over population of rabbits on Fisher's Island of New York would seriously damage lawns and golf courses. After years of monitoring, the New York State Conservation Department found that as the population of rabbits reached a peak in 1941, many rabbits found on Fisher's Island were carrying lethal amounts of ticks and were dying of anemia and infection. Luckily in this case, the infection was not found to be lethal to other species even when others were infected. However, due to the increase of human-wildlife contact, the infection might now have an impact on the human population.

In the past few decades, there has been little research about these two rabbit species in California. In order to understand the rabbit population in Ventana Ranch, relying on the old literature alone is not enough. Many human induced changes were implemented to the area recently thus changing the local ecosystem. These changes might have impacted the behavior of several local species. For example, a recent study of the behavioral responses of bobcats and coyotes to human-induced habitat fragmentation in Southern California demonstrated that bobcats and coyotes were less active during the day in fragmented habitat. This suggests that they display some avoidance of human activities (Tigas et al., 2002). Other studies have also found activity shifts of coyotes in suburban and agriculture areas (McClennen et al., 2001). The aforementioned studies indicate that human-induced habitat fragmentation is one of the most

important factors that affect wildlife abundance, diversity, and can even lead to extinction (Wilcox and Murphy, 1985; Noss et al., 1996). Current studies at Ventana Ranch also suggest that human-induced changes in habitats might contribute to the variations in species activity.

On Ventana Ranch, in southern San Benito County, California, populations of wild animals are being monitored by camera traps set up by Professor Reginald Barrett for research purposes and monitoring wildlife diversity. Desert Cottontail rabbits and California Jackrabbits are recorded at most camera locations. The two species have many characteristics in common. As past literature describes, both rabbit species are more active around early morning and late afternoon (crepuscular). They are herbivores and their diet consists of grass, seeds, fruits and forbs. These rabbits are also able to reproduce year-round and have up to 7 offspring per litter (Ingles, 1941). Finally, they both prefer grassland and shrubs at lower elevation, and are active year round (Fitch, 1947, Marsden and Conaway, 1963, Flinders and Hansen, 1972).

To gather more data and learn more about these rabbit species, I first chose to study their general daily activity pattern. Through this first study, I hope to describe daily activity patterns of the two rabbit species and then compare that with the data from previous studies. I hypothesize that the daily activity pattern of rabbits on Ventana Ranch will be similar to the patterns described in previous literature; namely they will have a crepuscular behavior pattern. Because the two rabbit species have similar characteristics, I am also interested in how their behavior might differ from each other showing signs of resource partitioning. Resource partitioning is when two species occupy a similar niche, they will each modify their behavior to avoid competition with each other when resources are limited. In my study since food and water is supplemented as baits, I believe predator-free space and time will be the limiting resources. I hypothesize that there will be a slight difference in peak activity time in the two rabbit species due to competition over predator-free time.

This study implements a rather recent method of recording animals known as camera trapping (Figure 1). The first field survey using camera traps started in the 1920s (Chapman, 1927). Starting in the late 1950s and 60s, cameras with infrared beams were set out to record mammals that are normally hard to see (Osterberg, 1962; Pearson, 1959). As technology advanced over time, motion triggered cameras, instead of infrared beams, were set up to take a photo when it detected any action (Jennelle et al, 2002, Jacomo et al, 2004). This method has been used to effectively estimate home ranges and movements of larger mammals without

disturbing their normal activity (Trolle and Kery, 2005, Maffei and Noss, 2008). Camera trapping is one of the best ways to study wild animals because it does not disturb animals while taking pictures and it also decreases the chance of spreading disease due to handling wild animals. This study will also be observing the result of photo data collected on animals that are difficult to identify as individuals.

Fig. 1. Example photo from Ventana Ranch, CA. with 3 jackrabbits (right) and 1 cottontail (left). Field sites also included artificial water holes (middle top) and food supplementation in the form of pellets.

In this study, I use photo data collected by the motion controlled camera traps to compare and contrast activity (and abundance) patterns between Desert Cottontails and California Jackrabbits (Fig 1). Using the maximum counts of each rabbit species in a single photo, the daily activity patterns are described. Using a similar idea described in van Schaik and Griffths (1996), a typical day can be classified into 4 periods: dawn (05:00-06:59); day (7:00-18:59); dusk (19:00-20:59); and night (21:00-04:59). Seasonal variation in day light hours is not considered since the data collected are close to summertime. The results from this study will be the first step to understand more about the location and serve as an index for future development plans on the ranch.

Method

Study Site Ventana Ranch (fig. 2) is located in southern San Benito County, California, along the southern edge of the San Benito River. It is approximately 2,500 acres of grassland, chaparral, and oak woodland. It has been grazed by cattle for over 200 years, except for the last 6 years and has been fire-free for over 60 years. The current land use is primarily recreational hunting for a variety of game species. Game species found in the ranch include tule elk (*Cervus elaphus nannodes*), mule deer (*Odocoileus hemionus californicus*), wild pig (*Sus scrofa*), wild turkey (*Meleagris gallopavo*), California quail (*Callipepla californica*), morning dove (*Zenaida macroura*), coyote (*Canis latrans*), California ground squirrel (*Spermophilus beecheyi*), California jackrabbit (*Lepus californicus*), desert cottontail (*Sylvilagus audubonii*), and band-tailed pigeon (*Patagioenas fasciata*). (Barrett, Personal Conversation 2008).

Fig. 2. Bird's eye's view of Ventana Ranch, CA.

Ten sites on the ranch are set up with motion triggered cameras and baits to attract animals. The sites were chosen by Prof. Reginald Barrett to include a variety of habitats with the majority of the sites containing grasslands and shrubs; some of the sites also include water sources (Table

1). The camera takes a photo of the area whenever it detects movement. The picture storage is collected every month and pictures are sorted by species and sites. The cameras used in this study are Reconyx RM45 RapidFire Mono IR with 1.3 MegaPixel monochrome images by day and night, InstaOn Motion Sensor with 1/10 second trigger speed; RapidFire NearVideo taking one frame per second and the image capacity of 15,000 photos on a 2 GB compact flash card. The baits consist of grass and grains and were added at each site when the picture storage was gathered. Baits may impact the behavior of some species and can amplify the results, but it should not be a concern in this study since only relative abundance is analyzed. Data for each species was tabulated using the "minimum count per hour" method (Barrett, unpublished) to estimate the abundance of species and their activity patterns. This method is similar to the "mark and recapture" method. The minimum count per hour method requires counting the highest number of individuals of certain species in one photograph per hour. This method enables me to estimate the minimum number of individuals present at each site at a particular time.

Table 1. Description of Sites

Sites	Water	Vegetation	Diversity (description)
1	N	Short grass, no full ground cover	Both species of rabbit. Mostly Jackrabbits. Other species: Bobcat and coyotes. Flat ground
2	Y	Short grass, no full ground cover	Both species of rabbit. Mostly Jackrabbits Other: Bobcats and coyotes Flat ground
3	N	Mixed grass (mostly med. Height grass) mostly covered.	Both species of rabbit. Relatively even Other: Bobcat, coyote, eagle. Bit leveled
4	Y	Short grass, full ground cover	Both species of rabbit, mostly Jackrabbit Other: eagle, coyote, bobcat, fox flat
5	Y	Some long grass on side.	Only Jackrabbit. Other: eagle, coyote, bobcat Water pit.
6	N	Tree cover. Short grass	Both species. Mostly Cottontail Other: coyote, bobcat, fox Flat ground
7	Y	Some bush, other bare ground	Only Jackrabbits Other: eagle, coyote, bobcat, fox Little hilly

8	Y/N No water starting 9/1	Nothing. Bare ground	Only Jackrabbits Other: no eagle, but everything else with deer Flat
9	Y	Half short grass, half nothing	Only Jackrabbits Other: eagle, coyote, bobcat Flat
10	N	Short grass full ground cover	Only Jackrabbits Other: coyote, bobcat, fox Hilly

Analyses The activity patterns of each species are compared based on proportions because of the variability of individual counts between different species. I used the number of active individuals at each hour divided by the total active individuals through out the whole study to find out what proportion of the population is active at each hour. (Proportion of total recorded= (number of active individuals at a certain hour)/ (total number recorded)). The first part of the test plots the general activity pattern of the rabbit species as a whole and compares that with existing literature on rabbit activity patterns. In this case, crepuscular behavior can be defined as the observation of more than 90% of activity during the hours of dawn and dusk. To repeat, the time categories are as follows: dawn (05:00-06:59); day (7:00-18:59); dusk (19:00-20:59); and night (21:00-04:59). Then I plot each rabbit species separately by hour, and determine if there is a statistical significance between the two species using paired t-test. A statistically significant difference between the activity patterns of the two rabbit species will show that they might display signs of resources partitioning to avoid competition. Alternatively, if no statistical significant difference is shown, it means that the similar species are partitioning their niche in ways other than activity pattern. Also, when all the data is collected, I will use a test of confidence interval around a percentage (Fleiss, 1986) to test for significance.

Results

Daily Activity Pattern From the total of 2825 photo records, the cottontail rabbit was recorded 258 times and the jackrabbit was recorded 2321 times. Only photos with rabbits present were analyzed. The maximum number of rabbits in any photo ranged from 1 to 7 rabbits. Both rabbit species displayed a concentrated activity during dawn and night periods (cottontail: 57%; jackrabbit: 60%; fig.3) with slight variations.

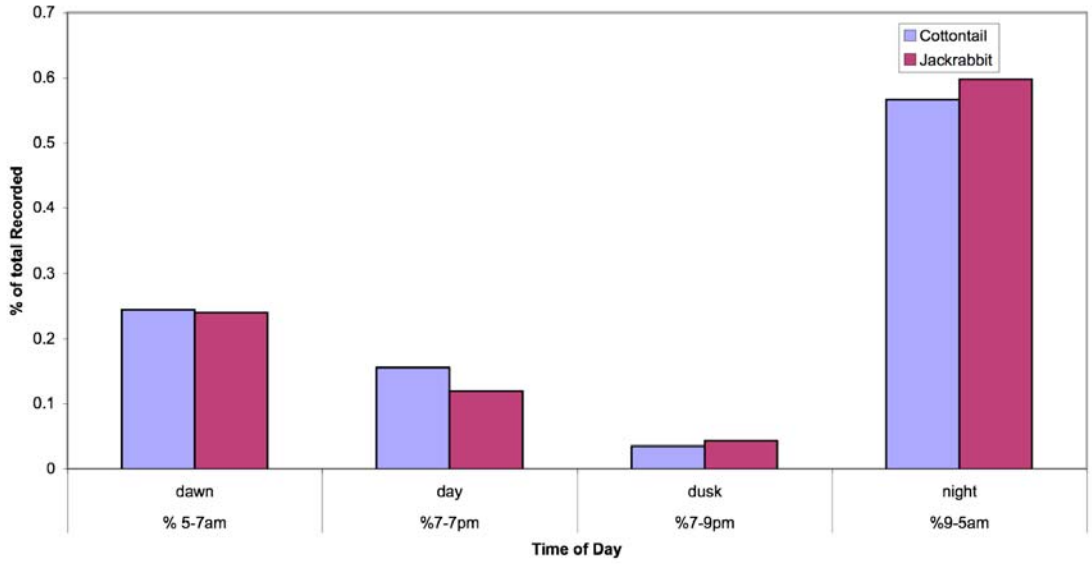

Fig. 3. Desert Cottontail Rabbit *Sylvilagus audubonii* and California Jackrabbit *Lepus californicus* daily activity pattern in Ventana Ranch, San Benito California in 2007.

The results were then normalized with the hours per time period (percent of total recorded per time period divided by the number of hours during that time period) (Fig. 4). The data shows that both rabbit species are more densely active during the dawn period (cottontail 12.2%, jackrabbit 11.9%).

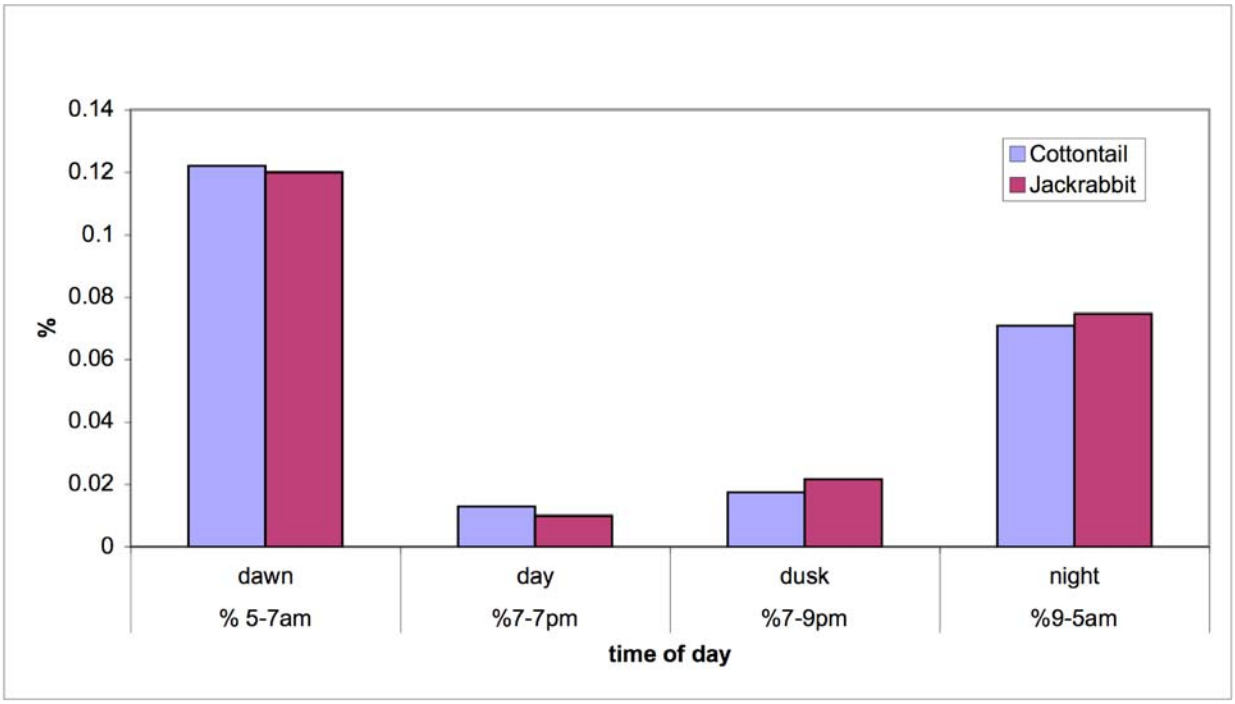

Fig. 4. Percentage of total rabbit recorded per hour during each time period of day.

Resource Partitioning Proportions calculated from the previous section was analyzed with the paired t-test (Table 2). Results showed that there is no difference between the two species' activity pattern (P=1)

Table 2. Results of the paired t-test using

	Cottontail	**Jackrabbit**
Mean	0.042	0.042
SD	0.05	0.04

Moreover, the daily activities of each rabbit species are compared throughout different sites (Table 3). It is consistent that both rabbit species are more active during the night period than any other periods despite difference in site habitats.

Table 3. Percentage of population active on each site throughout the study. (note: **Bold**=peak of activity)

Site (Habitat)		Dawn (5-7am)	Day (7-7pm)	Dusk (7-9pm)	Night (9-5am)
1	Jackrabbit	0.26	0.12	0.04	**0.61**
Short grass, no full ground cover	Cottontail	0.27	0.18	0.00	0.55
2	Jackrabbit	0.08	0.01	0.05	0.90
Short grass, no full ground cover	Cottontail	0.11	0.02	0.00	**0.88**
3	Jackrabbit	0.30	0.00	0.00	**0.70**
Mixed grass (mostly med. Height grass) mostly covered.	Cottontail	0.40	0.13	0.00	**0.47**
4	Jackrabbit	0.26	0.29	0.06	**0.43**
Short grass, full ground cover	Cottontail	0.33	0.19	0.00	**0.48**
5	Jackrabbit	**0.51**	0.02	0.00	0.47
Some long grass on side	Cottontail	0.00	0.00	0.00	0.00
6	Jackrabbit	0.20	0.13	0.13	**0.67**
Tree cover. Short grass	Cottontail	0.22	0.22	0.16	**0.52**
7	Jackrabbit	0.14	0.20	0.17	**0.65**
Some bush, other bare ground	Cottontail	0.00	0.00	0.00	0.00
8	Jackrabbit	0.32	0.01	0.03	**0.67**
Bare ground	Cottontail	0.00	0.00	0.00	0.00
9	Jackrabbit	0.42	0.09	0.01	**0.49**
Short grass, half covered	Cottontail	0.00	0.00	0.00	0.00
10	Jackrabbit	0.33	0.17	0.00	**0.50**
Short grass full ground cover	Cottontail	0.00	0.00	0.00	0.00

Lastly, since the results were compared in terms of proportions, a test of confidence limits around a percentage (Fleiss, 1986) was performed (Fig. 6).

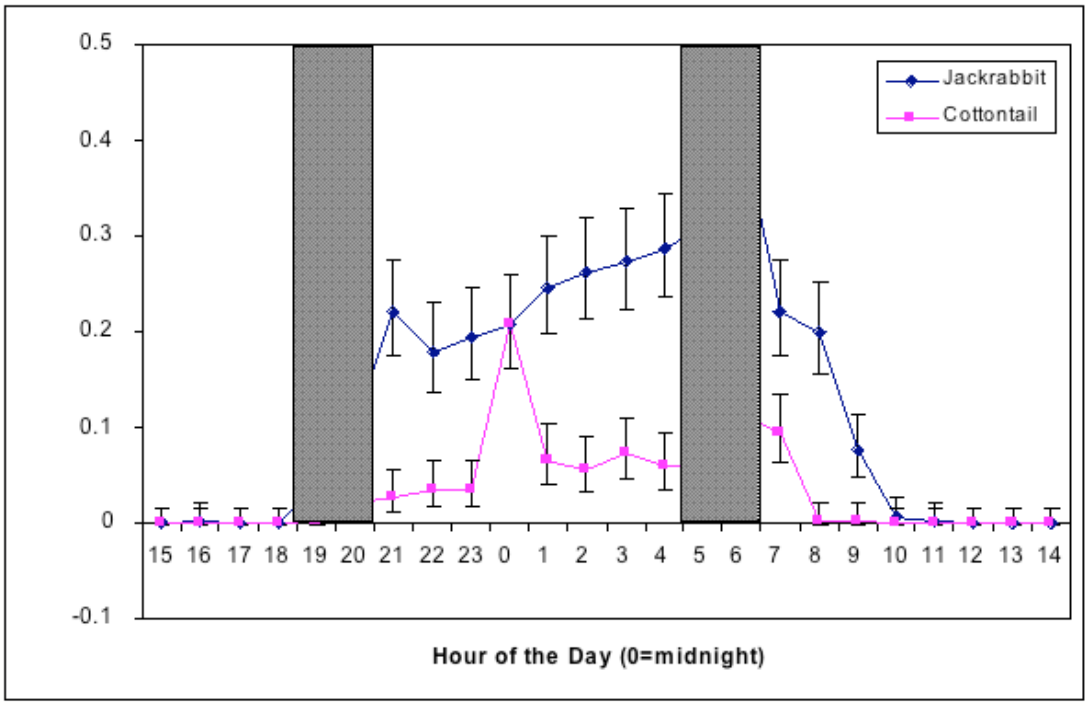

Figure 6. Desert Cottontail Rabbit *Sylvilagus audubonii* and California Jackrabbit *Lepus californicus* daily activity pattern in Ventana Ranch, San Benito California through out the year of 2007. shown with a Test of confidence limits around a percentage (Fleiss, 1986). Note: I indicates 95% CI. And the shaded area indicates dawn and dusk; and x-axis shifted to center on nighttime

Despite the difference of sample collected between the two species, both rabbit species were active through out the night period and displayed most concentrated activity at dawn period (5-7am) with exception of an outlier from 0-1am for cottontail. Less activity was found during the dusk period (7-9pm).

Discussion

Rabbits and hares are generally categorized to have a crepuscular behavior in the wild (Ingles, 1941). In this study, it is shown that rabbits and hares on this particular ranch behave in a nocturnal than crepuscular manner. In analyzing their behavior patterns, data shows that both species were most active throughout the night (cottontail: 57%; jackrabbit: 60%) (Fig. 1). Also, closer analysis demonstrates that both rabbit species are more densely active during the dawn period (cottontail: 12.2%, jackrabbit 11.9%) (Fig. 4). This might be the result of competition

with other species that occupy the same area and are active during similar times. For example, pictures of foxes were taken throughout the day and were viewed as active in the early mornings and afternoons (unpublished data). Therefore, the rabbits were forced to utilize more night time to forage.

Also, habitat differences can introduce variance into the results. For example, more rabbits might prefer short grass than longer grass. When comparing active periods, habitat differences greatly affect the number of recorded and present species (Table 1). In this case, both species seem to prefer sites with short grass and half ground cover with grass. Cottontails would also prefer some tree cover. The fact that both species are not present evenly at all the sites introduces more variance into the results. In the case of small sample size, each sample is weighted more than in a large pool of samples. For example, change in a single jackrabbit's behavior in Site 5 will shift the activity pattern proportionally more for that site than change in a single jackrabbit's behavior in Site 1 since Site 1 has a smaller sample size than Site 5. Since additional factors can also influence the habitat choice of rabbits, more samples and experiments need to be conducted to observe the preferences of rabbits.

When comparing the daily activity of each species, the two daily activity curves were not found to be different; the results were too similar to be conclusive. The difference between the total numbers recorded for each species also introduced more error. In this case, jackrabbits were recorded on an order of magnitude greater than cottontails. Therefore the curve for jackrabbits' activity is smoother than the cottontails' and more representative of their actual behavior.

Although these results contradict my hypotheses, these findings lead to more questions that may be tested using other methods. A recent study on ocelots and other animals was done using two cameras at each test site to identify an individual animal (Trolle and Kery, 2005). They were able to track down individual animals and estimate their home range and how much they traveled. It would be ideal if I could identify an individual rabbit and track its daily activity because it would increase the accuracy of my results. Also, in another recent study using camera trapping for measuring home range and density, the question of mean maximum distance moved (MMDM) was incorporated into the study (Maffei and Noss, 2007). MMDM is important to determine how big the home range of a certain animal is. In order to avoid duplicating the

number of rabbits that might be active on multiple sites, it would have been appropriate to consider this question during this study since rabbits are known to travel locally (Petrides, 1951).

The rejection of my hypotheses leads me to the following question: Do animals in the wild continue to demonstrate behaviors described in past research and literature? In Tattersall 1988, he introduced a new term "cathemeral" to help accurately characterize activity patterns. Cathemeral describes animals that are often considered as nocturnal but can also be active during other times when resources are available (Tattersall, 1988). As follow up research, it would be interesting to see if the behaviors of the two rabbit species can be categorized as cathermeral. In fact, a study conducted in the Indonesian rain forest using camera traps redefined the behavior of animals that were known to be nocturnal as cathermeral (Schaik and Griffiths, 1996). It would be interesting for future studies to look at the daily activities of wildlife in America.

The potential results of my research and follow up research can be used in wildlife management issues. It can be used to encourage owners to increase wildlife diversity in private ranches such as my current study site. Both of the rabbit species are game species and on the lower level of the food chain, and therefore maintaining the population of rabbits is important to managing other game species on the ranch since rabbits can attract predators such as bobcats and coyotes that would harm the other game species. On the other hand, increasing the rabbit population can also attract hunters which can generate revenue for the ranch.

The last important implication of my study is the usage of camera trap technology as the method to record wildlife. This promotes more technological development that will not disturb a species' natural habitat. On the other hand, implementing camera trapping can introduce biases such as site preferences, immobility, and human error. As a recent study on bobcat detecting methods pointed out, there are other methods such as detector dogs that yield more evidence for bobcats than camera trapping and hair-snares trapping (Harrison, 2006). Although my findings contradict my hypotheses, it is still important to understand that wildlife might not behave in ways we used to understand because of different environmental factors.

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