A Closer Look at the Breeding Season of the Kangaroo Rat *Dipodomys heermanni*

Brianna R. Lavelle
Senior Project for the College of Science and Math
Biological Sciences Department, California Polytechnic State University, San Luis Obispo
March 17, 2013

Abstract. The breeding season of kangaroo rats has not been a widely studied topic, and therefore is not very well known. *Dipodomys heermanni* is the species of interest for this study and is thought to breed from February to October (Kelt, 1988). The purpose of this study is to take this broad time period and narrow it down to prime breeding activity months. I hypothesized the prime breeding season of *Dipodomys heermanni arenae* to be between March and June. Mark-recapture methods were applied to the kangaroo rats at our study site in the Guadalupe Nipomo Dunes National Wildlife Refuge during the months of March, June, September, and December. Data collected included gender as well as the breeding condition, or reproductive state. Two separate Chi-squared tests were performed on contingency tables, one for males, and the other for females. The results demonstrated breeding condition for both genders is dependent on time of year; there was a significantly greater proportion of reproductive males and females during March and June, and a significantly greater proportion of males and females not in reproductive breeding condition during September and December.

Introduction

Kangaroo rats are a keystone species, playing a crucial role in maintenance of the ecosystem. However, for being such an important part of the community, their life history has not been actively studied. In particular, the breeding season of kangaroo rats has not been widely or recently studied. The vast majority of knowledge obtained on this subject was collected many years ago, and the data varies greatly. For instance, a study on *Dipodomys ordii* depicted their breeding season to span between the last two weeks of February and the first two weeks of June (Johnston, 1956). This can be compared to another study showing *Dipodomys ordii* to have two distinct breeding seasons from January to March and from September through October (Duke, 1944). Both of these studies took place over fifty years ago, with results that don't agree, yet this topic still remains minimally studied.

With more knowledge on kangaroo rats breeding season, captive breeding efforts for these species could be improved. There are currently a few species of kangaroo rats that are listed as endangered, such as *Dipodomys ingens* and *Dipodomys heermanni morroensis*. They are highly aggressive in nature, meaning that females will usually only tolerate males when in estrous (Roest, 1991). This results in captives fighting with other individuals in their cage. So expanding our comprehension of when kangaroo rats are more inclined to breed rather than fight would result in more successful captive breeding.

The kangaroo rat of interest for this study is *Dipodomys heermanni arenae*, which is closely related to the endangered subspecies, *Dipodomys heermanni morroensis*. *Dipodomys heermanni* occur roughly in the box of Suisun Bay Lake Tahoe, southern Sierra Nevada foothills, and Point Conception (Kelt, 1988). According to Kelt (1988), *Dipodomys heermanni* primarily

breed from February to October with peak activity in April, and decreasing after July. Their gestation period was also recorded as 30 to 32 days with an average litter size of 3.33 in San Luis Obispo County (Roest, 1991).

The purpose of this study is to enhance our understanding of the breeding season of *Dipodomys heermanni*. The current information on their breeding season is very broad, so narrowing it down to prime activity months will set the old information in a new light. With that said, my hypothesis is that the prime breeding season of *Dipodomys heermanni arenae* is between March and June. This means that in March and June there would be a greater proportion of females who are pre lactating or lactating and a greater proportion of males who have descended testes. In addition, during September and December there would be a greater proportion of females who are not lactating or post lactating and a greater proportion of males who do not have descended testes.

Methods

Over the course of the last five years, mark recapture methods have been used on *Dipodomys heermanni arenae* at various locations in the Guadalupe Nipomo Dunes National Wildlife Refuge in San Luis Obispo County. Half of the locations for the field study had high densities of invasive veldt grass, while the other half lacked any veldt grass. A wide range of topography was also incorporated in the locations in the form of rolling sand dunes. The experimental sites were set up using a 1200 meter line. The starting point was marked with a stake and from there a compass and rangefinder were used to place the next stake 20 meters away. This was repeated until we had a 1200 meter line. Every night at around 4:30 pm, two Sherman small mammal traps were set up near each stake and baited with oats. Early the next morning traps were checked.

As each kangaroo rat was caught, its breeding condition would be recorded. Males were recorded as either testes not descended (TND), testes partially descended (TPD), or testes descended (TD). Females were recorded as not lactating (N), pre lactating (Pre), lactating (L), or post lactating (Post). For males, the data was gathered by visually inspecting and discerning by touch to determine if their testes were descended. For the females, the shape of their nipples was used to access breeding condition. When they are not lactating, their nipples are very small, round, and inconspicuous. Pre lactating nipples are slightly elongated, lactating nipples are the most elongated, and sometimes swollen or irritated. Post lactating females also have nipples that are slightly elongated, but with a slight hook at the end.

The field work and subsequent data was collected from 2009 to 2012 in the months of March, June, September, and December, with the exception of 2009 where early April was sampled instead of March. The data has been collected by Dr. Villablanca, his graduate students, and students who took his extended field biology class.

Once the data was compiled, the breeding condition information on males and females was merged together by possible breeding season months (March and June), and possible non breeding season months (September and December). In this study, breeding season is defined by

certain breeding conditions. Males were considered able to breed when their testes were descended, and not able to breed when their testes were not descended. Females were considered to be breeding when they were pre lactating or lactating, and not breeding when they are not lactating or post lactating.

A contingency table for each gender was then used to compare the expected and observed frequencies of breeding condition in relation to time. The expected values were determined by multiplying the total number of kangaroo rats caught during a specific time frame by the total number in a specific breeding condition, then divided by the overall total. Further analysis of the data sets involved Chi squared tests to examine the probability that the distribution of the breeding conditions among each time period is due to random chance. A P-value of .05 was used to indicate significance. For both male and female kangaroo rats, the null hypothesis is that the proportion of *Dipodomys heermanni* breeding is independent of time of year. The alternate hypothesis for both genders is that the proportion of *Dipodomys heermanni* breeding is dependent on time of year.

Results

Males

There were a total of 429 male kangaroo rats captured and positively identified for breeding condition during the course of the field study. Of these, 213 were caught in March and June, of which 146 were *observed* to be breeding, while only 80 were *expected* to be breeding. During March and June there were also 67 males *observed* not breeding, and an *expected* value of 133. Likewise, 216 male kangaroo rats were caught in September and December with 16 breeding males *observed*, and 82 *expected* to be breeding. 200 of the 216 captured males during September and December were *observed* not breeding with an *expected* value of 134. The resulting Chi squared statistic of 172.83 with 1 degree of freedom is greater than 6.635 with a corresponding probability of P=.01. This is less than the accepted significant level of P=.05, so we can reject the null hypothesis that the proportion of male kangaroo rats breeding is independent of time of year. Thus the data supports the hypothesis that the proportion of male kangaroo rats breeding is dependent on time of year, or in other words, there is a breeding season for males.

Time		Breeding Condition (Male) Breeding (TD)	Not Breeding (TND)	Total
	Mar/Jun	146	67	213
	Sep/Dec	16	200	216
	Total	162	267	429

Table 1. The number of male *Dipodomys heermanni* caught in the Guadalupe Nipomo Dunes National Wildlife Refuge from 2009 to 2012.

	Observed	Expected	(O-E)^2/E
Mar/Jun Breeding	146	80	54.45
Mar/Jun Not Breeding	67	133	53.12
Sep/Dec Breeding	16	82	32.75
Sep/Dec Not Breeding	200	134	32.51
			$X^2 = 172.83$

Table 2. A Chi squared test and comparison between observed and expected values of male *Dipodomys heermanni* during specific months, and in specific breeding conditions. Degree of freedom used was 1.

Females

Over the years of the field study, 618 female kangaroo rats have been caught and identified for breeding condition. Of this total, 276 were caught in March and June with 126 individuals *observed* to be breeding and 88 *expected* to be breeding. There were 150 females caught and *observed* not breeding during March and June, and 188 *expected* to not be breeding. Of the 618 total females caught, 342 were in September and December. During these months, 70 were *observed* to be breeding, and 108 were *expected* to be breeding. Also, 272 were *observed* to be not breeding while 234 were *expected* to not be breeding. The calculated Chi squared statistic of 43.63 with 1 degree of freedom is greater than 6.635 with a corresponding probability of P=.01. This is less than the accepted significant level of P=.05, so we can reject the null hypothesis that the proportion of female kangaroo rats breeding is independent of time of year. This supports the alternative hypothesis in that the proportion of female kangaroo rats breeding is dependent on time of year; there is a set breeding season for female kangaroo rats.

Time		Breeding Condition (Female) Breeding (Pre) (L)	Not Breeding (N) (Post)	Total
	Mar/Jun	126	150	276
	Sep/Dec	70	272	342
	Total	196	422	618

Table 3. The number of female *Dipodomys heermanni* caught in the Guadalupe Nipomo Dunes National Wildlife Refuge from 2009 to 2012.

	Observed	Expected	(O-E)^2/E
Mar/Jun Breeding	126	88	16.41
Mar/Jun Not Breeding	150	188	13.37
Sep/Dec Breeding	70	108	7.68
Sep/Dec Not Breeding	272	234	6.17
			$X^2 = 43.63$

Table 4. A Chi squared test and comparison between observed and expected values of female *Dipodomys heermanni* during specific months, and in specific breeding conditions. Degree of freedom used was 1.

Discussion

The data supports the hypothesis that there is a prime breeding season between March and June for *Dipodomys heermanni arenae*. Conducting Chi squared tests for each gender based on the corresponding contingency table resulted in significance for both males and females. This indicates that breeding condition and time of year are dependent on each other

Males

The Chi squared statistic and corresponding P-value of less than .05 signifies that the proportion of male kangaroo rats breeding are dependent on time of year. There are a significantly greater proportion of male kangaroo rats with their testes descended in March and June when compared to September and December. Also, there are a significantly greater proportion of males with their testes not descended in September and December when compared to March and June. This indicates male kangaroo rats have higher breeding activity in March and June.

Females

Performing a Chi squared test on the data for female kangaroo rats resulted in a P-value of less than .05. This implies that the proportion of female kangaroo rats breeding are dependent on time of year. There are a significantly greater proportion of female kangaroo rats pre lactating or lactating in March and June when compared to September and December. In addition, the

proportion of female kangaroo rats not lactating or post lactating is significantly greater in September and December when compared to March and June. Thus indicating the breeding activity for females peaks in March and June.

Males and Females

Analysis on Male and Female data sets shows that both genders have significantly higher breeding activities in March and June, and significantly lower breeding activities in September and December. However, when comparing the genders there are some interesting findings. During the prime breeding season months of March and June, 69% of males are able to breed and 46% of females are breeding. During non breeding months of September and December, 7% of males are still able to breed while 20% of females are seen to be breeding. So, more males are essentially coming into reproductive breeding conditions sooner than females, but the females maintain their reproductive breeding conditions longer than males (fig. 1). This trend could be the result of males noticeably coming into reproductive breeding condition prior to females since copulation has to occur before females can get pregnant. In the same manner, females may stay in reproductive breeding conditions longer than males as a result of providing nutrients for their young. Fundamentally, the breeding season for *Dipodomys heermanni* is slightly different between males and females when considering breeding conditions; there is a lag from the time males are seen with their testes descended to when females are seen pre lactating or lactating.

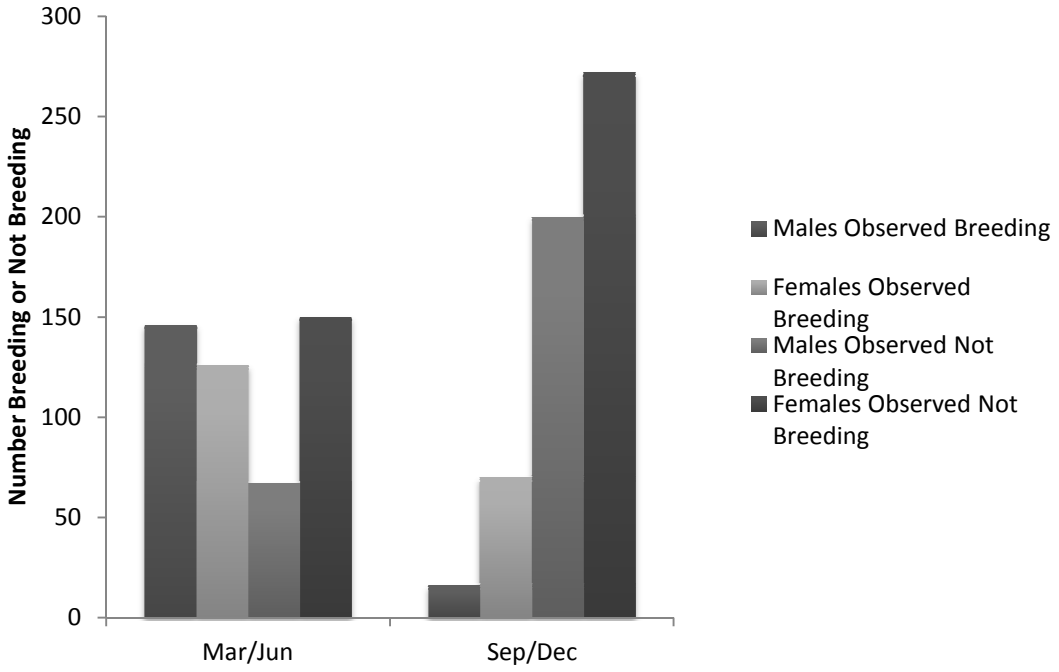

Figure 1. A comparison between the number of female and male *Dipodomys heermanni* that are breeding and not breeding during the months of March and June, and the months of September and December.

Applying this knowledge to further studies could prove to be an important component. For example, knowing the peak times in breeding season for any species is the foundation for captive breeding success. The breeding season for *Dipodomys heermanni* was previously recorded to be between February and October (Kelt, 1988) which is a very broad time period, so narrowing it down will prove to increase knowledge and empower future studies. A captive breeding experiment on *Dipodomys heermanni* performed by Roest in 1991, had some difficulties producing successful mating attempts. He stated that the lack of success could be attributed to the kangaroo rats aggressive nature toward each other and that not every copulation lead to a pregnancy. In his experiment he paired kangaroo rats together based on when the female was in estrous, which she is capable of year round. Having knowledge of the peak months in reproductive activity of *Dipodomys heermanni* may have increased the breeding success rate if it was taken into account. For future captive breeding experiments, kangaroo rats can be paired based on when the female in estrous as well as during their breeding season. This information could be beneficial to captive breeding attempts of *Dipodomys heermanni*'s closely related endangered relatives such as *Dipodomys heermanni morroensis* and *Dipodomys ingens*.

References

Kelt, Douglas A. "*Dipodomys heermanni.*" *Mammalian Species* No 323 (1988): 1-7.

Roest, Aryan I. " Captive Reproduction in Heermann's Kangaroo Rat, *Dipodomys heermanni.*" *Zoo Biology* 10.2 (1991): 127-137.

Thompson, Katerina V; Roberts, Miles; Rall, Willem F. "Factors Affecting Pair Comptibility in Captive Kangaroo Rats, *Dipodomys heermanni.*" *Zoo Biology* 14.4 (1995): 317-330.

Johnston, Richard F. "Breeding of the Ord Kangaroo Rat (*Dipodomys ordii*) in Southern New Mexico." *The Southwestern Naturalist* 1.4 (1956): 190-193.

Duke, Kenneth L. "The Breeding Season in Two Species of *Dipodomys*." *Journal of Mammalogy* 25.2 (1944): 155-160.

Yoerg, Sonja. "Solitary is not Asocial: Effects of Social Contact in Kangaroo Rats (Heteromyidae: *Dipodomys heermanni*)." *Ethology* 105.4 (1999): 317-333.

Randall, Jan; Hekkala, Evon; Cooper, Loni; Barfield, Julia. "Familiarity and Flexible Mating Strategies of a Solitary Rodent, *Dipodomys ingens*." *Animal Behaviour* 64.1 (2002): 11-21

Shier, Debra; Randall, Jan. "Use of Different Signaling Modalities to Communicate Status by Dominant and Subordinate Heermann's Kangaroo Rats (*Dipodomys heermanni*)." *Behavioral Ecology and Sociobiology* 61.7 (2007): 1023-1032.