The Correlation between Veldt Grass (*Ehrharta calycina*) and Reproductive Condition of the Lompoc Kangaroo Rat (*Dipodomys heermanni arenae)*

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by

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Abstract: The invasive species, Veldt grass (*Ehrharta calycina*), has come to dominate coastal dune shrub vegetation along the Central Coast of California. Along with creating many land management obstacles, this grass has become dominant in the open habitat of Lompoc Kangaroo Rats (*Dipodomys heermanni arenae*). It is hypothesized that, due to a lack of suitable kangaroo rat habitat, during the breeding season months of March and April, there will be significantly fewer reproductively active females in areas of relatively high Veldt grass cover as opposed to relatively low Veldt grass cover. This study used data from a long-term demographic study on *Dipodomys heermanni arenae* trapped in the Guadalupe-Nipomo Dunes National Wildlife Refuge. Two logistic regression analyses and two chi-square analyses were performed to test for the relationship between number of reproductively active females, Veldt grass cover, and year. After finding significant effects of year on the proportion of reproductive females in each grass level, the correlation between grass level and the proportion of reproductive females was not significant (but was suggestive of a possible trend of a larger proportion of reproductive females as grass level increased from low to high). These results could be indicative of a positive correlation between kangaroo rat habitat quality and Veldt grass presence, though the relationship is confounded with annual variation.

Introduction:

The management of invasive bunchgrass species, such as Veldt grass (*Ehrharta calycina*), has been a large financial investment for California land managers (Robinson 2011). One of the many considerations during the management of these invasive grasses are the effects they have on native plant and animal species such as the Lompoc Kangaroo Rat (*Dipodomys heermanni arenae*) in the sand dune communities of California's central coast (Robinson 2011; Kelt 1988).

Dipodomys heermanni arenae is one of many subspecies of kangaroo rat in California (Figure 1). Occupying the dunes of the Central Coast south of Morro Bay, *D. heermanni arenae* is the closest in its range to the endangered Morro Bay Kangaroo Rat, *D. heermanni morroensis* whose range and abundance have declined due to many factors including changes in the vegetation composition. The rest of the species in this genus occur in California's Central Valley and coastal areas along the Monterey and East San Francisco Bays.

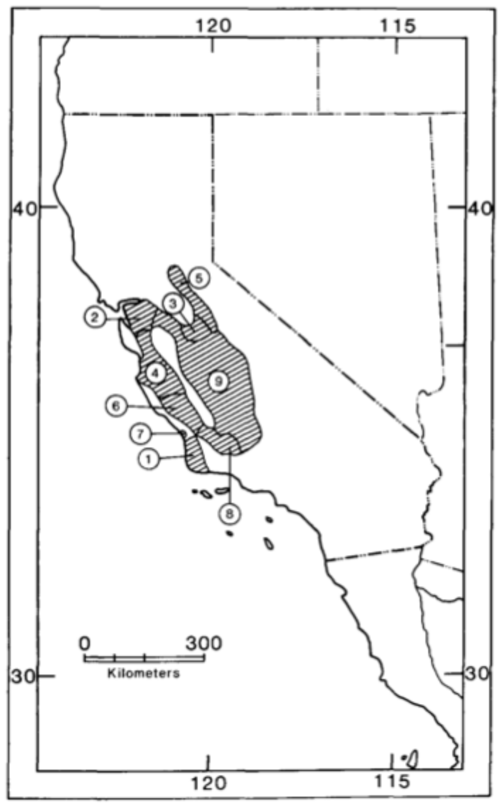

Figure 1: Distribution of *D. heermanni* in California as described by Hall (1981) and A. I. Roest (*in litt.*).
1: ***D. h. arenae***; 2: *D. h. berkeleyensis*; 3: *D. h. dixoni*; 4: *D. h.goldmani*;
5: *D. h. heermanni*; 6: *D. h. jolonensis*; 7: *D. h. morroensis*; 8: *D. h. swarthi*;
D. h. tularensis. (Kelt 1988)

Kangaroo rats such as *Dipodomys heermanni arenae*, are granivores that forage in open spaces surrounded by denser shrub habitats (Heske et al. 1993). It is commonly accepted that invasive grasses alter the native vegetation and effect the abundance and/or behavior of native animal species (Mattos and Orrock 2010). Veldt grass is pervasive in and around existing coastal dune scrub plants. It is accepted that its presence has a negative effect on *D. heermanni arenae* because it decreases the amount of open space in the plant community. Open space is important to the foraging strategy of kangaroo rats (Brown and Lieberman 1973). Unlike males, female kangaroo rats do not fight for territories and displace less fit individuals from the best quality habitats, but rather occur in higher densities in the habitat that provides the greatest fitness benefits; food resources (Kelt 1988). Therefore, high populations of females in an area is likely representative of good habitat quality and good female condition. The prediction is that a high population in an area is due to its ample food resources (Waser and Jones 1991). Additionally, reproductive activity and lactation are positively correlated with a female's condition via access to food resources (Soholt 1977). Therefore, in a comparative context, it follows that the proportion of reproductive females in a given habitat versus another is a relative indicator of habitat quality.

The reproductive status of a female kangaroo rat is determined by examination of the mammary glands (Soholt 1973). The degree to which the glands are swollen indicates her specific reproductive status. For the purpose of this study, pre-lactating, lactating, and pregnant females were considered "reproductively active", whereas, post-lactating and non-lactating females were considered "non-reproductively active". Post-lactating females, while having previously lactated, were counted as non-reproductively active because they retain their post-lactating mammary glands fairly long after being reproductively active. This would not necessarily indicate that those females were recently reproductively active with in the grass cover category they were trapped in.

To assess the implications of Veldt grass presence in the dune communities, current studies are testing multiple effects of the invasive grass species on *D. heermanni arenae* in the Guadalupe-Nipomo Dunes National Wildlife Refuge (GNDNWR). Observing habitat usage of the kangaroo rats at varying degrees of Veldt grass cover may indicate a possible relationship between Veldt grass cover and habitat quality. Using a subset of data from the study by Dr. Francis X. Villablanca Ph. D., this particular study seeks to understand if a relationship exists between the relative abundance of Veldt grass and the proportion of reproductively active *Dipodomys heermanni arenae* females in the GNDNWR. It is hypothesized that the relative abundance of Veldt grass cover negatively affects the number of reproductively active, pre-lactating and lactating, females during the breeding season (March and April). If this relationship exists, it is expected that during the months of March and April, there will be significantly less pre-lactating and lactating (reproductively active) females in areas of relatively high Veldt grass cover as opposed to relatively low Veldt grass cover.

Methods:

The data used for this study was a subset of data recorded for a long-term demographic study by Dr. Francis X. Villablanca, Ph. D.. Two Sherman live traps per station were placed at 20-meter station intervals along a 1.2 kilometer transect used for the mark-recapture study of the kangaroo rat population from December 2007 to March 2012. Each trapping period lasted 3 successive nights. The traps were baited with rolled oats at dusk and examined the following morning. The following data were recorded for each *D. heermanni arenae* captured: station number (grass cover category), animal tag number, sex, breeding condition, weight, and age class (adult or juvenile).

As this particular study focused particularly on station ranges of high, medium, and low grass levels and breeding condition of females during the breeding season (March and/or April), all other data from other months were dismissed. Little or no trapping data was collected in the spring months of 2008 and 2011. The data from April 2009, March 2010, and March 2012 were sorted in Microsoft Excel by sex to eliminate males, then by station number within the high grass cover range (stations 360-660), medium grass cover range (stations 720-1020), and low grass cover range (1240-1500) eliminating all individuals not trapped in the grass cover category ranges listed above. The data were then sorted by tag number, to avoid counting individuals more than once, and lastly by breeding condition. As previously mentioned, individuals recorded as pre-lactating, lactating, and pregnant were classified as reproductively active and individuals recorded as non-lactating and post-lactating were classified non-reproductively active. Individuals caught more than once within a trapping session and determined to have different breeding conditions within one trapping session were considered on a case-by-case basis. All individuals caught multiple times within a session with different breeding condition records across days were classified by their most frequent breeding condition. If an individual was caught twice and classified into two different breeding conditions that individual was not counted at all.

After sorting through the data, counts were recorded for individuals within the two breeding condition categories: reproductively active and non-reproductively active (Figure 2). These counts for breeding condition within the different grass levels across the three years were analyzed by two nominal logistic regressions. The first regression, Test 1, modeled the Likelihood of Grass Level Effect on Reproductive Status (regardless of year). The second logistic regression, Test 2, modeled the Likelihood of Year Effect on Reproductive Status (regardless of grass level). As differences of grass level by year were noted, the data in Figure 2 were used to conduct a contingency analysis of counts of reproductive and non-reproductive females within each grass level each year. After noting and testing for count differences between the grass levels in each year, the counts for breeding condition in each grass level across the three years was also analyzed with a contingency test to test for relationship strength. Test 3, Contingency Analysis of Trappings by Grass Level by Year, analyzed the number of trapping instances by year. Test 4, Contingency Analysis of Reproductive Status by Grass Level, analyzed the counts of reproductively active versus non-reproductively active females by grass level.

Results:

A total of seven individuals were caught multiple times within a session with different breeding condition records across days and were classified by their most frequent breeding condition. A total of four individuals were classified into two different breeding conditions within a session and not counted.

Table 1: Table of statistical tests performed. All analyses are based on counts of unique individuals per grass and year categories included in Figure 2. Test numbers 1 and 2 represent a nominal logistic regression.

Test Number	DF	Chi-square Statistic	P-value
1	2	1.14	0.5669
2	2	22.38	<0.0001
3	4	10.95	0.0271
4	2	5.22	0.0736

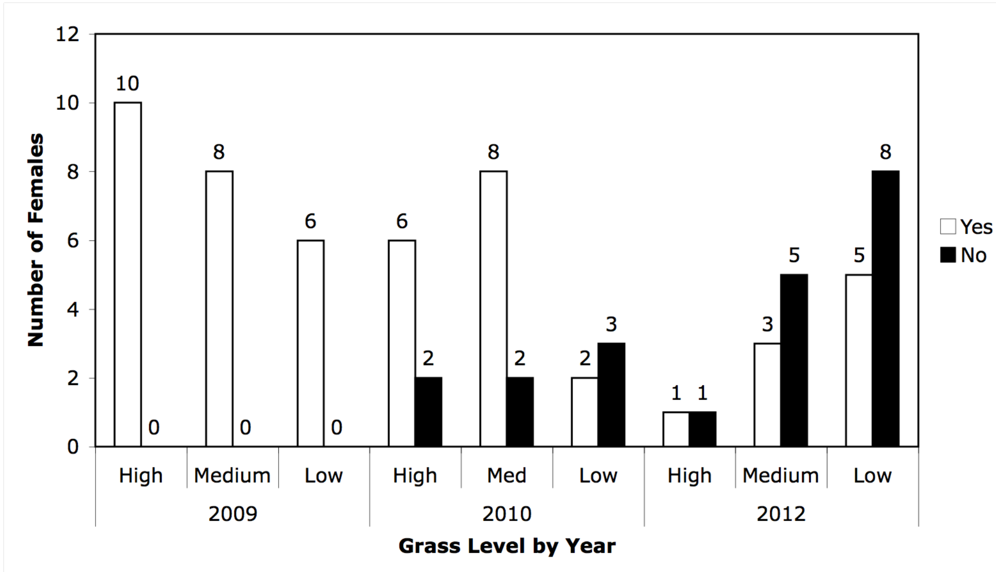

Figure 2: Counts for reproductively active (yes) and non-reproductively active (no) individuals in each grass level in each year. Individuals were only counted in one category (yes or no) based on data from each of the three trapping sessions (2009, 2010 and 2012).

Test 1, Likelihood of Grass Level Effect on Reproductive Status (regardless of year), yielded a p-value of 0.5669, which was greater than the alpha value of 0.05. This test predicted the likelihood of a statistical relationship between grass level and proportion of reproductively active females when the data was pooled across the three years. Because the p-value was greater than 0.05, the likelihood of this relationship was not statistically upheld. Test 2, Likelihood of Year Effect on Reproductive Status (regardless of grass level), yielded a p-value of <0.0001. This indicated that there was a strong correlation between year and proportion of reproductively active females. Test 3, the Contingency Analysis of Trappings by Grass Level by Year (Figure 3), allowed for an analysis of the proportions of total trapped females within each grass level in each year. A p-value of 0.0271 indicated that there was statistically significant difference between proportions of total trapped females within each grass level in each year.

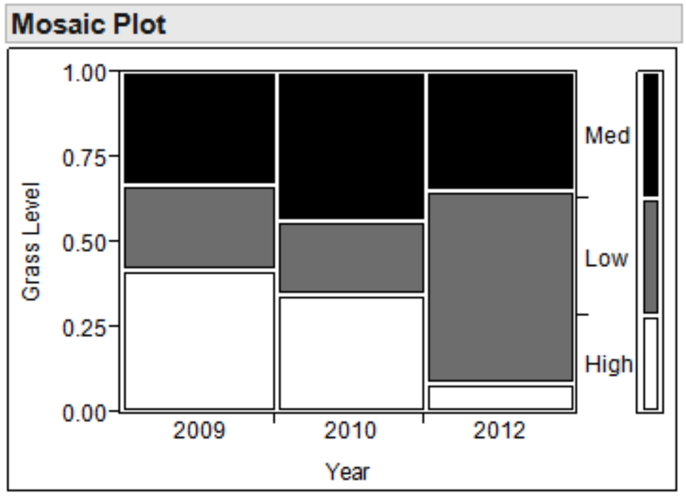

Figure 3: Mosaic plot generated by Test 3, contingency analysis of proportion of females caught (regardless of reproductive status) by grass level and by year. P-value = 0.0271 (see Table 1). P-value indicates we reject the null hypothesis that that there is no relationship between year and grass level affecting the number of females trapped.

Test 4, Contingency Analysis of Reproductive Status by Grass Level (Figure 4), was conducted to assess the strength of the possible relationship between the proportion of reproductively active females and grass level. With a p-value of 0.0736, technically the null hypothesis cannot be rejected and there is no strength to the correlation between proportion of reproductively active females and grass level.

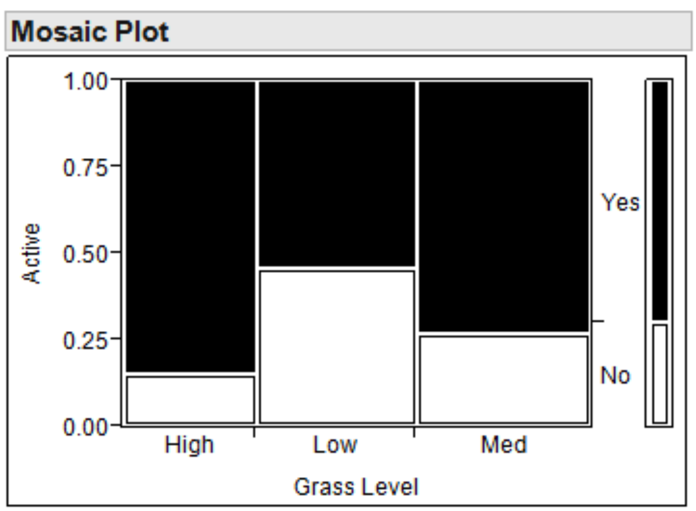

Figure 4: Mosaic plot generated by Test 4, contingency analysis of proportion of reproductive females (yes) and non-reproductive females (no) separately by grass level and pooled across all three years. P-value = 0.0736 (see Table 1). P-value indicates that we fail to reject the null hypothesis of no grass cover effect on number of reproductive females.

recapture rate could be calculated. Hypothetically, if, in 2012, the recapture rate was high for females in the low grass areas and low for females in the high grass areas, this would indicate that there are simply more kangaroo rats occupying the low grass areas and less kangaroo rats occupying the high grass areas. The difference in proportion of females caught in the high and low grass levels in 2012 could be attributed to environmental factors contributing to a change in the food resources available in a particular grass level. Possible environmental factors could be the amount of precipitation in the spring of 2012 leading to more primary growth in the low grass area and a new available food resource to exploit.

After investigating the year effect, the results of Test 4, a Contingency Analysis of Reproductive Status by Grass Level, indicated no statistical significance to the relationship between proportion of reproductively active females and grass level. However, the proportions of females trapped in each grass level (Figure 4) indicate a trend of increasing proportion of trapped females as you increase in grass level. This trend is not consistent with the hypothesis that there would be significantly less reproductively active females in areas of relatively high Veldt grass cover as opposed to relatively low Veldt grass cover. If this trend was representative of an actual dynamic in this kangaroo rat population, it may indicate that areas of high Veldt grass cover are suitable and/or high quality habitat contributing to increased fitness of the female individuals occupying those areas. It is suggested that the presence of herbaceous vegetation, grasses and their seed production play a role the initiation of reproductive activity and lactation in females (Soholt 1977). This possible trend of a higher proportion of pre-lactating, lactating, and pregnant (reproductively active) females in high Veldt grass cover would be consistent with this suggestion.

Dipodomys species can vary in their ability to adapt to changing environmental conditions such as the introduction and success of an invasive species that may or may not confer decreased habitat quality. Some species of *Dipodomys*, for example, are extreme substrate specialists and will not change substrates with habitat quality whereas other species of *Dipodomys* have been trapped in multiple habitats (Congdon 1974). More studies are currently underway to determine the effects of the Veldt grass on *Dipodomys heermanni arenae* and if these effects are conferring adaptations for possible active Veldt grass seed selection or even specialization.

Works Cited:

Congdon, Justin. Effect of Habitat Quality on Distributions of Three Sympatric Species of Desert Rodents. Journal of Mammalogy. 55.3 (1974): 659-662.

Heske, Edward J., Brown, James H., & Guo, Qinfeng. Effects of kangaroo rat exclusion on vegetation structure and plant species diversity in the Chihuahuan Desert. *Oecologica*. 95 (1993): 520-524.

Kelt, Douglas A. *Dipodomys heermanni. Mammalian Species.* The American Society of Mammalogists. 323 (1988): 1-7.

Mattos, Kaitlin J. and Orrock, John L. Behavioral consequences of plant invasion: an invasive plant alters rodent antipredator behavior. *Behavioral Ecology*. 21 (2010): 556-561.

Robinson, Ramona A. Invasive Plant Management in California State Parks. Proceedings of the California Invasive Plant Council Symposium. 15.1 (2011). Cal-IPC, Berkeley, CA.

Soholt, Lars F. Consumption of Primary Production by a Population of Kangaroo Rats (*Dipodomys heermanni*) in the Mojave Desert. *Ecological Monographs*. 43.3 (1973): 357-376.

Soholt, Lars F. Consumption of Herbaceous Vegetation and Water During Reproduction and Development of Merriam's Kangaroo Rat, *Dipodomys merriami*. *American Midland Naturalist*. 98.2 (1977): 445-457.

Villablanca, Francis X. Guadalupe-Nipomo Dunes National Wildlife Refuge, annual report

Waser, Peter M. and Jones, Thomas W. Survival and Reproductive Effort in Banner-Tailed Kangaroo Rats. Ecological Society of America. 72.3 (1991): 771-777.