Native Deer mice (*Peromyscus maniculatus*) use of invasive grass seed (*Ehrharta calycina*) in Coastal California

Megan Wong

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Introduction

Veldt grass (*Ehrharta calycina*), native to southern Africa (Frey, 2005), was introduced to Central California from Australia in 1929. It was planted to improve forage for grazing cattle (Frey, 2005) and help control soil erosion in California. This perennial, tussock-forming grass primarily reproduces via seeds, which can be spread by granivorous animals, but it can also reproduce vegietatively (Frey, 2005). It thrives in sandy soils (Frey, 2005) characteristic of the Guadalupe-Oceano-Pismo dunes and other areas of San Luis Obispo County including Los Osos. It does not survive well in clay soils, but the presence of deep roots allows it to use dry, sandy soils (Frey, 2005). Once it is established in a habitat, *E. calycina* can inhibit and prevent the germination of native dune shrubs and chaparral species, changing the vegetative association from coastal scrub into a non-native grassland (Frey, 2005). Because Veldt grass is a tussock-forming perennial plant, open sandy areas, characteristic of coastal dune scrub habitat, become covered with tall, dense vegetation exclusive of open space between plants. This conversion from coastal dune scrub habitat to grassland is believed to have negative impacts on the behavior of native vertebrate species (Mattos and Orrock, 2010). Multiple studies have examined the ecological relationship between *E. calycina* and *Dipodomys heermanni arenae* (Lompoc kangaroo rat) and show both negative and positive ecological responses by kangaroo rats (Boag, 2015, Trunzo, 2015), but little research has been done focusing on the effects the grass has on native deer mouse (*Peromyscus maniculatus*).

The fact that native kangaroo rats have been found to utilize Veldt grass as a food source (Trunzo, 2015) suggests that native deer mice, occurring in the same habitat, will also forage on and consume Veldt grass seed. This poses the question**,** does *P. maniculatus* consume veldt grass, contributing to seed predation or dispersal of the grass. The consumption of veldt grass

seed was assessed using artificial seed stations (seed boxes – see below). It is also important to ask how seed box foraging differs between *P. maniculatus* and *D. heermanni* in areas where *D. heermanni* are present, as this can provide insight into competitive relationships between kangaroo rats and deer mice, and may further our understanding of how to study *P. maniculatus*' relationship with Veldt grass.

The main goals of this paper include 1) observing the seed predation relationship between deer mice and invasive *E. calycina*, and 2) comparing seed box use by deer mice to that of kangaroo rats to determine if there is a significant filial or exclusionary relationship between deer mice and kangaroo rats present within or outside the seed boxes. Kangaroo rats display aggression toward deer mice, displacing deer mice to areas of cover while kangaroo rats forage in areas that have less cover (Falkenberg and Clarke, 1998). This agonistic behavior could possibly effecting deer mice presence at the seed boxes. It is hypothesized that *P. maniculatus* consumes Veldt grass seed but that they are less successful at using seed boxes than *D. heermanni*. If *P. maniculatus* consumes Veldt grass seed, the *P. maniculatus* will be present at the seed box stations but fewer will be found foraging within the boxes compared to *D. heermanni* because of interspecific competition/interactions between the two species. Seed boxes accessible to both species might provide insight into behavioral differences in *P. maniculatus* in the presence vs absence of *D. heermanni*.

Methods

Field Data Collection

Camera trap videos were used to record data for a previous Masters' thesis focusing on kangaroo rat use of Veldt grass (Trunzo, 2015). Coastal scrub habitat patches in San Luis Obispo County were chosen based on the presence or absence of Veldt grass. Five study sites were

selected (two had Veldt grass present and three lacked Veldt grass). Before any videos were recorded, trapping was done using Sherman XL small mammal traps to identify specific areas where kangaroo rats were present. Each kangaroo rat caught was given an individual hair clip marking and ear tag number. The areas where kangaroo rats were trapped were chosen as places to set up camera trap stations. At each station, a seed box constructed of aviary wire mesh, was set with 1 gram of native seed cocktail and 1 gram of Veldt grass seed, separated by an aviary wire wall, while providing just a single entry point to the station and each pile (Figure 1). Although the box was made of four sides, and a divider, it lacked a floor and a lid.

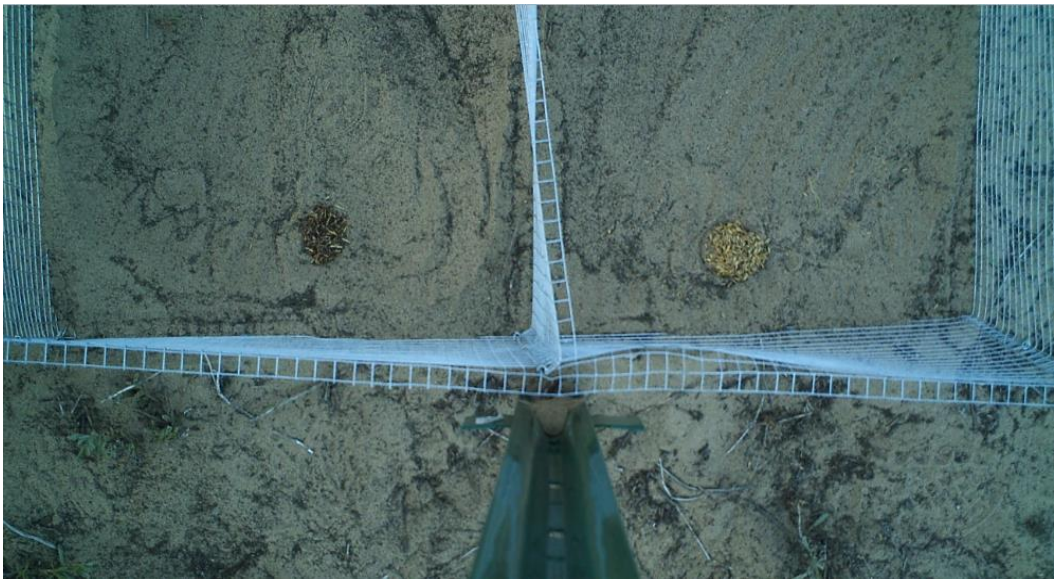

Figure 1: Aviary wire mesh seed box. 1 gram of native seed cocktail and 1 gram of Veldt grass seed separated by a wire mesh wall. A common entry into the seed box, with separate entry to each side of the box is not shown.

A total of twenty-eight seed stations were placed in the field, targeting fourteen kangaroo rats living in areas with Veldt grass, and fourteen kangaroo rats living in areas without Veldt grass. Two seed boxes were placed at each of the twenty-eight seed stations, making the total number of boxes equal to fifty-six. Each seed box was monitored with a motion activated game camera (Bushnell Trophy Camera HD 119736C) for five consecutive nights. The entire survey period

was from 13 April to 16 May, 2014. Game cameras recorded animals that entered the seed boxes and recorded activities that took place in the seed box. Once a camera was triggered, it recorded 25-seconds of video. For detail on the original study, see Trunzo, 2015.

Video Data Collection

Field videos (clips) were organized in folders by date, site, station, and seed box, making each folder a group of videos from one place and one night. Each folder was given a number and an online random number generator was used to select twenty-five folders of videos to watch. If an animal was present in a video clip, the following data were recorded: species, whether the animal was in or out of the seed box, and the side (Veldt or native seed side). A total of 220, 25-second video clips were watched. These represent randomly selected 25 seed box/location/date combinations. If the video was recorded during daylight or during set-up, the video was viewed, but the data were not included in the analysis. Some birds were present during the daytime videos and were recorded but no statistics were run for these data.

Statistics

A chi-squared test was used to determine if there was a significant discrepancy between the number of deer mice present within the seed boxes and the number present outside the seed boxes. It was assumed, that there would be an equal number in and out. The same test was used to test for a significant discrepancy between the number of kangaroo rats in the seed boxes and the number outside the boxes. With both species it was expected that the number of animals seen inside the boxes was not significantly different from the number seen outside the boxes.

Results

Of the videos watched, 42 took place during daylight or were of camera positioning and set up, therefore 178 videos were included in the analysis. Deer mice were seen in 14 of the 178

videos while 120 of the videos contained kangaroo rats. Three of the 14 deer mice were in the seed box and 50 of the 120 kangaroo rats were in the seed box. There was only one instance where a deer mouse was seen actively foraging on native seed cocktail for 10 seconds. No videos recovered deer mice consuming veldt grass seed.

Species	DF	Chi-squared statistic	P-value
P. man	1	4.57	0.0325
D. her	1	3.33	0.0679

Table 1: Table of statistical tests performed. All analyses are based on the number of animals observed inside the seed box and outside the seed box still in view of the camera.

The p-value for the chi-squared test of equal frequency in and out of the seed box for *P. maniculatus* was less than 0.05 (Table 1), meaning a there is a significant difference in the number of *P. maniculatus* observed outside the seed box compared to inside the box. The number observed outside the box was greater. The p-value for *D. heermanni* was greater than 0.05 (p=0.0679), indicating that the number of *D. heermanni* seen inside and outside the seed box was not significantly different from equality. This result has a 6.79% probability of being due to chance alone. At a cut off of 5%, we regard this result as plausibly due to chance.

Although no statistical analysis was done on videos containing daytime footage, 2 of the 15 daytime videos contained White Crowned Sparrows and 3 of the 15 videos contained California Towhees in or around the seed box. These birds were documented consuming veldt grass seed.

Discussion

Veldt grass has become an invasive plant of high priority along Coastal California (Frey, 2005). It has drastically changed the environment of the sand dunes, changing open habitat into

dense grasslands thereby affecting the native species (Mattos and Orrock, 2010). If an ecological relationship between the native species, such as deer mice, and Veldt grass has developed because of its prominence in coastal dune habitat, there is no evidence here that the relationship includes seed predation by deer mice. There is, instead, evidence that deer mice are significantly less likely to be seen within a seed box than on the periphery. Given that the veldt grass seed was provisioned within the seed box, this experiment may have been (inadvertently) biased against documenting veldt seed herbivory by deer mice. The results clearly suggest that future seed use experiments (on deer mice) should be conducted without a seed box.

It has been observed that kangaroo rats do take and feed on Veldt grass seed (Trunzo, 2015). Heteromyids, which include kangaroo rats, have been shown to forage on the seeds of the invasive weed *Salsola paulsensii* in the soil seed bank which leads to reduced seed banks and seedling establishment (Longland, 2007). Another study performed by Cushman et al. (2011) found that black-tailed jackrabbits (*Lepus californicus*) significantly reduced the height, shoot production, fecundity, and above-ground biomass of Veldt grass in a coastal dune system in northern California. In one instance, a deer mouse was observed foraging on and consuming Veldt grass seed (though this individual was outside of the seed box). The fact that a deer mouse was seen consuming Veldt grass seed indicates that *Peromyscus* may also have an impact on the seed bank of this invasive grass.

The presence of ground foraging birds foraging and consuming Veldt grass seed in the seed box also shows predation of Veldt grass seed by native species besides Heteromyids and *Peromyscus*. This also indicates that avian foraging may impact the soil seed bank of invasive plants.

Although *P. maniculatus* was not observed regularly consuming Veldt grass seed, the invasive plant still could be detrimental by changing the surrounding habitat. The change in habitat type caused by Veldt grass may also cause indirect negative effects on native vegetation via consumer-mediated apparent competition (sensu Dangremond et al., 2010). It has been shown that levels of predation by *Peromyscus maniculatus* on a native lupine has risen due to the lupine's close proximity to an invasive grass (*Ammophila arenaria*/European beachgrass) in a coastal dune system in California (Dangremond et al., 2010). Deer mice are known seed predators of the native lupine, *Lupinus tidestromii*. Beachgrass provided habitat for deer mice, contributing to an increase (growth) in mouse population (Dangremond et al., 2010). An increased number of consumers facilitated by the invasive grass has a negative effect on the survival and reproduction of the native plant (lupine) via increased herbivory (Dangremond et al., 2010). Another study done by Orrock et al. (2008) indicated that native *Nasella pulchra* plants close to exotic *Brassica nigra* were greatly affected by increased herbivory. Spatial apparent competition can be explained as exotic/invasive plants succeeding by creating an ideal biotic habitat for population growth of native plant consumers (Orrock et al., 2008). It is hypothesized that apparent competition between Veldt grass and other native plants in the Coastal dune system of San Luis Obispo County may change the vegetative community by leading to a decrease in native species and an increase in non-native or invasive species. Future work needs to be done to explore this hypothesis.

The amount of deer mice seen in the videos was lower than expected. This could be caused by many factors, the main one being that the seed boxes were set to target kangaroo rats. Each seed box was placed in proximity of a known kangaroo rat individuals. Strong interspecific competition has been shown between kangaroo rats and deer mice (Falkenberg and Clarke,

1998). In every instance of aggression observed by Falkenberg and Clarke (1998), deer mice never reciprocated aggressiveness towards kangaroo rats, but instead fled from the kangaroo rat. Deer mice "completely avoided open areas in the presence of kangaroo rats…" (Falkenberg and Clarke, 1998). Interspecific competition leads to deer mice spending a greater percentage of foraging time in covered habitat relative to open habitat in the presence of kangaroo rats (Falkenberg and Clarke, 1998). Kangaroo rats are also adapted to utilize open microhabitats during foraging. Highly inflated auditory bulla and bipedal locomotion allow easy detection of and evasion of predators, such as owls (Kotler, 1984), allowing them to utilize open microhabitats. Relative to kangaroo rats, deer mice have small auditory bullae. They have been found to spend the majority of foraging time under cover and in dense habitat (Kotler, 1984). The placement of the seed boxes in known kangaroo rat territory, and in open habitat away from cover, are likely causes for the low numbers of deer mice observed in the videos. To get an accurate representation of deer mice usage of Veldt grass as forage, seed boxes and camera traps should be placed in areas with more coverage and away from kangaroo rats.

The majority of deer mice observed were in view of the camera but not inside the seed box. Many mice were seen running back and forth along the back wall of the seed box. This begs the question as to whether seed boxes are the proper method to study deer mouse foraging habits and usage of Veldt grass seed. If seed boxes are built targeting the foraging habits of deer mice, more data on *Peromyscus maniculatus* use of Veldt grass will be available. The single incidence of a deer mouse foraging on Veldt grass indicates that there is reason to keep researching interactions between Veldt grass and *Peromyscus maniculatus*.

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