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Influence of kangaroo rat burrows in the spatial organization of the San Jose Island rodent community

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ABSTRACT

Knowledge of the spatial distribution of rodents around kangaroo rat burrows may help us to understand the role that kangaroo rats play in the spatial organization of small desert rodent communities. In this study we analyzed the pattern of proximity between capture locations of desert rodents and burrows of *Dipodomys merriami insularis*, and describe the reproductive characteristics of these rodents. Captures and recaptures of individuals were carried out in an area of 79.8 ha on Isla San José in the Gulf of California, Mexico, during March to May and October to November of 2008. In order of decreasing frequency, *Chaetodipus spinatus bryanti*, *D. m. insularis*, *Peromyscus fraterculus cinereus*, and *Neotoma bryanti bryanti* were captured during both periods. The results provide evidence that the spatial distribution of these rodents around *D. m. insularis* burrows varies with sex and reproductive activity of the kangaroo rats. They suggest that female and male kangaroo rats have a different influence on the spatial organization of the rodent community on Isla San José. Furthermore, this study provides information that should improve our understanding of the island rodent community, and hence should help to improve conservation management of this endangered population of kangaroo rats.

0. Introduction

The kangaroo rats (genus *Dipodomys*) are the largest body size members of the Heteromyidae family (Vaughan et al., 2000). They have a distributional range that encompasses most arid regions of North America. Kangaroo rats (*Dipodomys*) have been argued to exert keystone effects because their burrows modify vegetation structure and diversity (Brock and Kelt, 2004). In addition, kangaroo rats modify the local spatial distribution of other rodent species because they defend aggressively their burrows against other species, and exclude those close to their burrows (Bowers and Brown, 1992; Brown and Harney, 1993). However, the behavior of kangaroo rats around their burrows often differs between sexes and reproductive activity. This could differentially affect the spatial organization of the rodent community (Vazquez et al., 2011).

Intraspecific territoriality is common in several rodent species where males often are considered to have stronger territorial behaviors than females. There are some exceptions, such as *Myodes glareolus*, whose social system is usually characterized by female territoriality (Bujalska, 1973; Koskela et al., 1997; Ostfeld, 1985). However, when the territoriality is interspecific, females can defend their territories as strongly as males (e.g. *Peromyscus leucopus*) or in some species more than males (e.g. *Peromyscus maniculatus*; Wolff et al., 1983). Territoriality in females has been explained not only from the point of view of the defence of the food, but the defense of territory to protect their young from infanticide (Ostfeld, 1990; Wolff, 1993; Wolff and Schauber, 1996). Theoretical models about interspecific territoriality suggest that there will be territorial exclusion among species with a high degree of niche overlap and when the territory holders are the dominant species in the aggressive encounters (Mikami and Kawata, 2004). Additionally, in kangaroo rats there are gender differences in reproductive activity; gestation and parental care by females, and the maintenance of territories by males, which reflect different energy demands of both sexes (Reynolds, 1960). Kangaroo rats are very active around of their burrows. They defend their burrows against conspecifics and sympatric species in order to prevent pilfering of grain reserves (Leaver and Daly, 2001). Other kangaroo rats, pocket mice, and cricetid rodents pilfer food stores of kangaroo rats (Daly et al., 1992). However, kangaroo rats such as *Dipodomys merriami* are able to aggressively dominate other species such as pocket mice to prevent seed pilfering (Leaver and Daly, 2001). This suggests that

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the proximity of rodent communities to kangaroo rat burrows may exhibit strong spatial patterns (Vazquez et al., 2011).

We show that there are differences in activity around kangaroo rat burrows that are related to sex and reproductive state of kangaroo rats that could differentially influence the spatial organization of associated rodent communities. For example, both sexes of *D. merriami* appear to differ in their tolerant to conspecifics, as suggested by the extensive home range overlap between male pairs as well as between males and females. However, only a slight home range overlap exists between adult females (Behrends et al., 1986; Jones, 1989; O'Farrell, 1980; Reynolds, 1960). Other differences between female and male kangaroo rats are found in food hoarding behavior. Males of *D. merriami* often exhibit scatter hoarding whereas the females show larder hoarding, which varies seasonally in relation to reproductive status (Jenkins, 2011). Larder hoards in burrows are an attractive target for theft but are potentially defensible by the owner, whereas scatter hoards may be subject to continuous attrition because they are plundered by other animals (Vander Wall and Jenkins, 2003), which may also have an effect on the spatial distribution of other rodents. Therefore, knowledge of spatial association between kangaroo rat burrows and sympatric rodents of other species, in relation to sex and reproductive state, may improve our understanding of the role that each sex of kangaroo rats plays in the spatial organization of associated desert rodent communities.

In a population of *Dipodomys m. insularis* distributed at Isla San José, Gulf of California (Álvarez-Castañeda et al., 2009), we found that individuals are solitaries but they use burrows which are closer among opposite-sex than same-sex individuals (Vázquez and Álvarez-Castañeda, 2011). These kangaroo rats share their habitat with rodents of *Chaetodipus spinatus*, *Peromyscus fraterculus* and *Neotoma bryanti*, all of which are listed as threatened by the Mexican government (Norma Oficial Mexicana, 2010). The spatial organization of the whole rodent community on Isla San José is still unknown. However, knowledge of the spatial proximity of sympatric rodents captured in relation to burrows of *D. m. insularis* is a first step to understand if females and males of this kangaroo rat influence differentially the spatial organization of the island rodent community.

For this study, we evaluated whether the spatial distribution of the desert rodent community found in the vicinity of burrow locations of *D. m. insularis* is differentially influenced by both sexes of burrow owners. We predicted that the spatial distribution of the rodent community is different between burrows of female and male kangaroo rats as result of differential burrow use, and that this pattern is also different between seasons as result of differential reproductive activity. Thus, we analyzed the pattern of proximity of capture locations of desert rodents to the burrows of *D. m. insularis*, and recorded the reproductive state of all rodents during two climatically different sampling periods.

1. Materials and methods

1.1. Field site and study animals

The study site was located on an area of 79.8 ha (1050 × 760 m) on eastern area of Isla San José, Gulf of California, Mexico (24° 55′ 39″ N, 110° 37′ 49″ W; described in Vázquez and Álvarez-Castañeda (2011)). Because the reproductive activity of *D. merriami* on the Peninsula mainland has been associated with rainy seasons (Álvarez-Castañeda et al., 2008), sampling periods were chosen to include both rainy and dry seasons. Therefore, individuals were live-trapped from March to May as dry season (MM) and from October to November as rainy season (ON) of the year 2008 (Salinas-Zavala et al., 1990). The vegetation at the site was desert shrub-type; the dominant plant species are chollas (*Opuntia* sp.), elephant tree (*Bursera microphylla*), saltbush (*Atriplex* sp.), mesquites (*Prosopis* sp.), cardon cactus (*Pachycereus pringlei*), and palo verde (*Cercidium microphyllum*). There is also a small region of mangroves at the southern end of the island (Lorenzo et al., 2011). The annual mean temperature varies from 21 to 23 °C, and annual mean rainfall varies from 100 to 150 mm, with the majority of precipitation occurring during the summer (Cody et al., 1983). *D. m. insularis* has been described as solitary but with clumped distribution of burrows. The spatial relationship between burrows is characterized by individuals of opposite sex being closer to each other than same-sex individuals, and this spatial relationship between nearest-neighbor burrows is influenced by their age class (Vázquez and Álvarez-Castañeda, et al., 2011). Burrows are primarily associated with elephant trees and a lower cover of fine-grained sand (Espinosa-Gayosso and Álvarez-Castañeda, 2006).

To capture all rodents, metal box traps measuring 30 × 10 × 10 cm (HB Sherman traps, Inc., Tallahassee, Florida) baited with rolled oats were set out. These were checked once a day (in the morning) during each trapping period. In total, 160 traps were used; twenty-six transect lines, separated by 30 m, were laid out and distributed so as to cover the whole study site. Traps, separated by 5 m, were set along one transect line for two or three consecutive nights during the MM or the ON period, respectively, after which they were moved to an adjacent transect line; this procedure was repeated until all 26 lines were trapped. Trapping effort was reduced to two nights during ON because we observed that individuals captured frequently (up to 15 times) during MM lost weight across successive captures. The total sampling effort corresponded to 8880 trap-nights during MM and 6240 trap-nights during ON.

For all captured individuals, sex, body weight (at 1.0 g precision), and reproductive status were recorded. Females were defined as reproductively active if macroscopic fetuses could be detected by abdominal palpation and/or milk could be expressed from the nipples; all others were classed as non-reproductive. Reproductive males were defined by presence of testes in the scrotum. All individuals were classified into two age categories (juveniles and adults). Since methods for accurately estimating the age of these living rodents are not available, we divided the captured animals into juveniles and adults based on their reproductive state and/or body weight.

In *D. m. insularis* the juveniles were defined as weighing less than 31.8 g, according to Reynolds (1960) who considers that reproduction of individuals in this species may begin to reach 70% of adult body weight, which in the present population averaged 45.5 g. Males and females in this category were all non-reproductive. In *C. spinatus* and *P. fraterculus*, all males with scrotal testis and all females with a weight equal to or greater than that of the lightest reproducing female were defined as adults. In both species, all individuals with a body weight $\geq$18 g were reproductively active. In *N. bryanti*, adult females were those with developed teats and a body weight >100 g. The one adult male captured had also a body weight >100 g.

Each *D. m. insularis* captured was individually marked with a numbered ear tag (# 1005-1, National Band and Tag Co. Newport, KY, USA) before being released at the capture point. The other rodents were marked with a permanent marker on the belly. The location of capture sites was recorded using a handheld GPS accurate to 3 m. Handling procedures conformed to the recommendations of the American Society of Mammalogists (Sikes et al., 2011).

1.2. Location of D. m. insularis burrows

Because we could not determine the exact limits of individual burrow systems, we used the location of the primary burrow