Short Note

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Habitat selection by the viscacha rat (*Octomys mimax*, Rodentia: Octodontidae) in a spatially heterogeneous landscape

Abstract: The viscacha rat *Octomys mimax* is endemic to western Argentina; it inhabits lowland deserts and uses rocky crevices as resting sites. The aim of this study was to assess macrohabitat selection relative to the occurrence of rocky crevices and to evaluate seasonal variations in macrohabitats selected by this rodent in Ischigualasto Provincial Park, San Juan, Argentina. Random locations were classified as used or available based on signs recorded in rocky crevices. We confirmed the absence of the viscacha rat in macrohabitats with sandy or silty substrates. We provide new records of viscacha rat in creosote bush scrub, the most abundant macrohabitat of the Monte Desert. This result extends the known range of macrohabitat use for this species. The viscacha rat increased the number of rocky crevices used in the dry season, probably because the species increased its foraging area due to the low food resource abundance. Another possible reason is an increase in density due to new births and dispersal of young in this season. The present study highlights the importance of considering signs of presence for species with low capturability as well as of collecting data throughout multiple seasons for a better understanding of habitat selection and species distribution.

Keywords: desert rodent; endemic species; habitat selection; Monte Desert; rock-dwelling mammal; signs.

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Habitat structure strongly affects different aspects of the life of species, such as population dynamics (Seamon and Adler 1996, Covas et al. 2004), thermoregulation (Lagos et al. 1995), predation risk (Stokes 1995), social organization (Gray et al. 1998, see Lacey and Ebensperger 2007), and distribution (Di Cola and Chiaraviglio 2011). Organisms are distributed nonrandomly due to spatial and temporal heterogeneity of habitats (Stewart et al. 2000). For strict habitat specialists, the most basic limitation to distribution is the availability of suitable habitat (Walker et al. 2003).

The viscacha rat, *Octomys mimax* Lawrence 1941, inhabits lowland deserts with abundant rocks, rocky desert foothills, low scrub areas, ravines, and gorges at elevations ≤800 m (see review in Sobrero et al. 2010). This species is endemic to western Argentina and is mostly recorded in protected areas (Ojeda 2012); it is distributed in the Monte Desert and in a transition area between the Monte Desert and Arid Chaco (Sobrero et al. 2010). Because the Monte Desert has a wide range of abiotic characteristics (i.e., elevation, topography, soil type, and rainfall patterns), it bears different habitats and plant associations, such as xerophytic hillsides, forests, and woodlands mixed with grasses, shrublands, salt flats, sand dunes, bare muddy depressions, and badlands. This heterogeneous landscape (Morello 1958, Bisigato et al. 2009) offers a high variety of macrohabitats, which could be used by different species.

The viscacha rat was captured in macrohabitats dominated by hard substrates, such as sandstones (Traba et al. 2010); therefore, the occurrence of rocky crevices influences their distribution. The resting sites used by the viscacha rat are rocky crevices (Ebensperger et al. 2008); the entrance to crevices has a rock ceiling under which plant caches and feces are usually located; inside crevices, there are one or some hollows that the viscacha rat might use for different activities (Campos 2012). Previous studies may have failed to account for the presence of the viscacha rat because species associated with rocky habitats are very difficult to track or trap due to their excellent climbing abilities and low population densities, and also due to the complex topography of rocky habitat (Nutt 2007).

The viscacha rat inhabits regions with seasonal food resource abundance (Campos 2012). Populations of desert rodents are well known for undergoing drastic changes in density in response to interannual fluctuations in precipitation and food availability (Jiménez et al. 1992, Meserve et al. 1995). Hence, the macrohabitat used by the viscacha rat may exhibit changes with varying food availability and density conditions. The aim of this study was to assess macrohabitat selection relative to the occurrence of rocky crevices and to evaluate seasonal variations in macrohabitat selection.

The study was conducted in Ischigualasto Provincial Park (IPP), San Juan province, Argentina (29°55′S, 68°05′W). This protected area is located in a hyper-arid sector of the Monte biome, which corresponds to the northern Monte of hills and closed basins (Monte de Sierras y Bolsones) (Burkart et al. 1999). Temperature and precipitation are highly seasonal in IPP (Pol et al. 2005), leading to fluctuating availability of resources (e.g., food, water) (Whitford 2002). The climate is arid, with an average annual precipitation of 183 mm. It is characterized by humid summers (November–March) and dry winters (April–October), with an average precipitation of 100 mm and 8 mm, respectively (De Fina et al. 1962). Absolute maximum and minimum temperatures are 46.2°C and 12.8°C, respectively, in summer and 39.4°C and 9.9°C, respectively, in winter (Campos 2012). There are six types of macrohabitats in IPP, which are shaped by edaphic factors, distance from watercourses, and vegetation (Acebes et al. 2010):

– The barrens, a macrohabitat with irregular topography and eroded surface. It occurs in a zone away from the influence of phreatic level, so few species are adapted to these conditions of high salinity and aridity (e.g., *Sclerophylax kurtzii* Di Fulvio and *Halophytum ameghinoi* Speg).
– The saltbush has sandy-silty soils and is near ephemeral watercourses. The dominant species is zampa (*Atriplex spegazzinii* A. Soriano ex Múlgura) along with *Suaeda divaricata* Moq, *Plectrocarpa tetracantha* Gillies ex Hook. and Arn., and *Prosopis strombulifera* (Lam.) Benth.
– The mesquite woodland occurs along margins of ephemeral watercourses with sandy substrate. It is dominated by *Prosopis chilensis* (Molina) Stuntz, *Baccharis salicifolia* (Ruiz and Pav.) Pers., *Tessaria dodoneafolia* (Hook. and Arn.) Cabrera, and *Schinus polygamus* (Cav.) Cabrera.
– The creosote bush scrub has hard, coarse, and heterogeneous soils dominated by *Larrea cuneifolia* Cav. and *Zuccagnia punctata* Cav.

– The columnar cactus slopes has rocky substrate with irregular topography and frequent fissures that retain some humidity. It is dominated by a columnar cactus, *Echinopsis terscheckii* (Parm.) Friedrich and G.D. Rowley.
– The chical has rocky substrate and is dominated by *Ramorinoa girolae* Speg., a species endemic to the temperate Monte.

To evaluate macrohabitat selection, we conducted a random sampling of used and available locations for further comparison (Thomas and Taylor 1990). We used a Landsat 5 TM image with 30-m resolution of the study area stored in a geographic information system program (Quantum GIS Version 1.7.0 "Wroclaw"), which allowed us to select random locations in each type of macrohabitat (barrens n=31; saltbush n=32; mesquite woodland n=35; creosote bush scrub n=50; columnar cactus slopes n=50; chical n=50). The relative abundance of each macrohabitat in the sampled area is 10% of barrens, 10% of saltbush, 20% of mesquite woodland, 25% of creosote bush scrub, 15% of columnar cactus slopes, and 20% of chical (unpublished data). The locations were at least 100 m apart, a greater distance than that recorded for recaptures (Ebensperger et al. 2008). To evaluate selection, we applied a use-availability design, as proposed by Johnson et al. (2006) because accurate identification of unused points might be impractical or impossible. In each selected location, we searched for signs of the viscacha rat in a 900-m^2 area. We classified each location as used or available based on signs in crevices. The used crevices had signs such as fresh feces, footprints, loose soil, and caches of plant material. We considered available crevices those that had no signs, or had spider webs, leaf cover, and compacted soil. To confirm the absence of the viscacha rat in macrohabitats without rocky substrate (barrens, saltbush, and mesquite woodland), we visited all locations in one season (August 2010) because the signs in crevices are protected from adverse climatic conditions. To evaluate seasonal variations in macrohabitats with rocky substrate (creosote bush scrub, columnar cactus slopes, and chical), we visited locations in August 2010 (dry season) and January 2011 (wet season).

To obtain a resource selection function, we calculated the Manly's index, which estimates the probability that a randomly selected used resource unit would be in category i if all categories were equally frequent in the original population of available resource units (Manly et al. 2002). An index of 1/k (k=number of habitats) indicates no selection, an index >1/k indicates selection, and an index <1/k indicates avoidance. To test the reliability of the selection

index, we estimated confidence intervals of 95% of selection index by bootstrapping, taking a random sample with replacement (200 times) of used and available locations in all macrohabitats. The selection index was significantly different if the confidence interval did not contain the value 1/k. To evaluate seasonal variation, we used a generalized linear model (GLM); the response variable used (1) and available (0) crevice was fitted to a binomial distribution. All statistical analyses were carried out using R Core Team (2013). We assessed the significance of each fixed effect with Wald test (Sokal and Rohlf 2012) using the "aod" function of the language R package for R (Lesnoff and Lancelot 2012).

Based on our results, we confirmed the absence of viscacha rat in the macrohabitats without rocky substrate (barrens, saltbush, mesquite woodland), and we obtained new records for the species in creosote bush scrub, a rocky macrohabitat. This new record extends its known habitat use in the study area. The selection index revealed significant differences for all rocky macrohabitats because the confidence intervals excluded the value 1/k (1/k=0.17; Figure 1), confirming that the viscacha rat preferred rocky soils. The viscacha rat selected creosote bush scrub, chical, and columnar cactus slopes and avoided barrens, saltbush, and mesquite woodland. The chical was selected with 1.5 times the probability of columnar cactus slopes of being selected and 1.4 times that of creosote bush scrub. In the GLM proposed to evaluate seasonal variation, neither the explanatory variable macrohabitat (Wald test=1.7; df=2; p=0.42) nor the season ∗ macrohabitat interaction had an effect (Wald test <0.001; df=1; p=1.0) on the response variable (used or available crevices), whereas season did have a significant effect (Wald test=7.9; df=3; p=0.048; Figure 2).
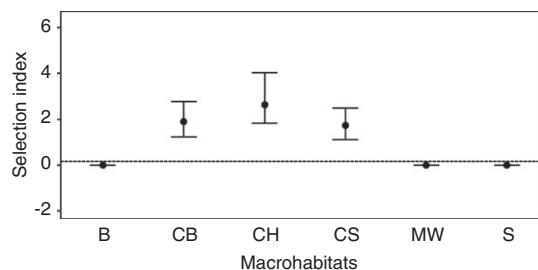

Figure 1 Selection index and 95% confidence intervals for all types of macrohabitats. B, barrens; CB, creosote bush scrub; CH, chical; CS, columnar cactus slopes; MW, mesquite woodland; S, saltbush. An index of 1/k (k=number of habitats) indicates no selection, an index >1/k indicated selection and an index <1/k means avoidance. If the confidence interval did not contain the value 1/k, then the selection index was significantly different.
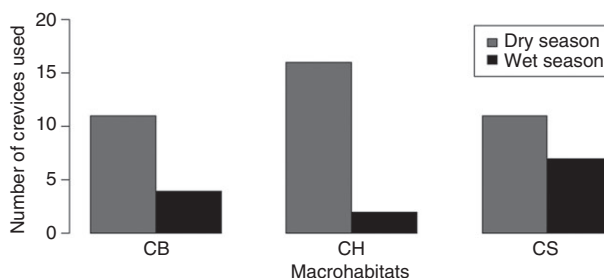

Figure 2 Number of crevices used by the viscacha rat in the dry and wet seasons, in rocky macrohabitats. CB, creosote bush scrub; CH, chical; CS, columnar cactus slopes.

The occurrence of rocky substrates in the Monte affects the distribution of the viscacha rat. The macrohabitats that were not selected by the viscacha rat (barrens, saltbush, and mesquite woodland) occur on sandy or silty substrates. Saltbush and barrens belong to Ischigualasto formation, which is a large flood plain with clays, sandstones and particularly barrens with volcanic ashes (Márquez et al. 2005). This substrate does not provide the rocky crevices that the viscacha rat uses as resting or nesting site.

The viscacha rat was captured in chical and columnar cactus slopes, two macrohabitats dominated by rocky substrate (Traba et al. 2010); however, because in that work the presence of viscacha rat was estimated only with capture data, used crevices may have been underestimated. In this work, we found used crevices in creosote bush scrub, a macrohabitat with vegetation structured in a leopard-spot pattern, situated in flat areas with hard and stony substrate (Acebes et al. 2010) and with crevices available for the viscacha rat. According to Pol et al. (2005), the creosote bush scrub is the most abundant macrohabitat of the Monte Desert and the largest in IPP (Márquez et al. 2005). Macrohabitats selected by the viscacha rat have high rock cover (columnar cactus slopes 75%, creosote bush scrub 71%, and chical 54%; Acebes et al. 2010). There is no evidence that the viscacha rat uses digging to modify its resting sites (Ebensperger et al. 2008); therefore, in the macrohabitats with rocky substrates, they do not need to build crevices, perhaps avoiding the high energetic cost that involves the excavation and construction of caves (Vleck 1979).

The availability of food resource varied in IPP throughout the seasons. Indeed, abundance of different items consumed and stored by the viscacha rat (leaves of *Zuccagnia punctata*, *Bulnesia retama* (Gillies ex Hook and Arn.) Griseb., *Lycium* spp., *Cyclolepis genistoides* Gillies ex D. Don, stems of *Bulnesia retama* and species of the

family Cactaceae, and seeds and pods of *Prosopis torquata*, *Ramorinoa girolae*, and *Maytenus* sp.) was higher in the wet season than in the dry season (Campos 2012). Our results revealed that a great number of crevices were used in the dry season in all types of macrohabitats, probably because when food resource is scarce, the viscacha rat increases its foraging area. This species can move 65 m during the day and 361 m during the night (Ebensperger et al. 2008). Another possible explanation for a higher number of crevices used in dry season could be an increase in density by new births in the wet season and dispersal of young in the dry season. In the wet season, we captured four young with Sherman traps and recorded two young inside crevices with camera traps (unpublished data); however, these data are the only ones recorded for the reproductive period on this species. The foraging behavior, reproductive period, and fluctuations in population density of the viscacha rat deserve further research.

In conclusion, it is known that the viscacha rat selects habitats with rocky substrates and crevices; however, this work provides new records of occurrence based on signs in crevices, in creosote bush scrub, the most abundant macrohabitat of the Monte Desert. These records extend the known range of macrohabitats used in the study area.

The present study highlights the importance of considering signs of presence for species with low capturability and of collecting data throughout several seasons for a better understanding of the patterns involved in habitat selection and species distribution.

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