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RESEARCH ARTICLE

Microhabitat selection by *Octomys mimax* (Rodentia: Octodontidae) in the Monte Desert is affected by attributes and thermal properties of crevices

La selección de microhábitat por *Octomys mimax* (Rodentia: Octodontidae) en el Desierto del Monte es afectada por los atributos y propiedades térmicas de las grietas

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ABSTRACT

The viscacha rat (*Octomys mimax*; Rodentia, Octodontidae) belongs to a monotypic genus endemic to western Argentina and inhabits lowland deserts with abundant rocks and ravines. Our objectives were 1) to determine the attributes of crevices (depth, height, width, entrance orientation, and rock color) that influence selection by the viscacha rat; 2) to compare the range and variance of temperature inside and outside crevices, at the soil surface, at the rock surface and in the air; and 3) to evaluate if there is a thermal gradient inside crevices, comparing range and variance of temperature at the soil surface at different depths (0, 30 and 50 cm). The viscacha rat did not use microhabitats in proportion to availability; the species selected deep and narrow crevices with restricted access that might be used as refuge from predation and extreme climate conditions. The temperature at the soil surface and at the rock surface inside crevices was more stable (smaller ranges and variances) than the corresponding external temperatures in summer and winter. The range and variance of temperature in the air were different only in summer. Moreover, in summer the range and variance at the soil surface inside crevices were more stable with increasing depth. In winter, only temperature range showed a gradient. The insulating effect of rocks might benefit the viscacha rat by providing a thermally stable environment, especially in summer. The present study provides quantitative evidence about the thermal behavior of rock crevices, which contributes with the traditional hypothesis proposed to explain the benefits of living in rock crevices.

Key words: desert, rock dwelling mammal, suitable habitat, viscacha rat.

RESUMEN

La rata vizcacha (*Octomys mimax*) pertenece a un género monotípico endémico del oeste de Argentina; habita en zonas desérticas con abundantes rocas y barrancos. Los objetivos de este trabajo fueron: 1) determinar los atributos de las grietas (profundidad, altura, ancho, orientación de la entrada y color de la roca) que influyen en la selección de grietas por parte de la rata vizcacha; 2) comparar el rango y la varianza de temperatura adentro y afuera de las grietas, en la superficie del suelo, en la superficie de la roca y en el aire y 3) evaluar si existe un gradiente térmico adentro de las grietas, comparando para ello el rango y varianza de temperatura en la superficie del suelo a diferentes profundidades (0, 30 y 50 cm). La rata vizcacha no usó los microhábitats en proporción a su disponibilidad; esta especie seleccionó grietas profundas y estrechas con accesos restringidos que pueden ser consideradas como refugio tanto del clima extremo como de los depredadores. Las temperaturas en la superficie del suelo y de la roca dentro de las grietas fueron más estables (menores rangos y varianzas) en comparación con las correspondientes temperaturas externas, tanto en verano como en invierno. El rango y la varianza de temperatura en el aire fueron diferentes sólo en el verano. Además, en verano, el rango y la varianza de temperatura en la superficie del suelo resultaron ser más estables a mayores profundidades dentro de las grietas. En invierno solo el rango de temperatura mostró un gradiente. El efecto aislante de las rocas beneficiaría a la rata vizcacha, ya que le provee un ambiente térmicamente estable, especialmente durante el verano. El presente estudio proporciona evidencia cuantitativa sobre el comportamiento térmico de las grietas, que contribuye con la hipótesis tradicional propuesta para explicar los beneficios de vivir en grietas.

Palabras clave: desierto, hábitat adecuado, mamífero de roquedal, rata vizcacha.

INTRODUCTION

A rocky habitat, in its broadest sense, may be described as any locality that contains boulders, rocks, scree, pebbles, outcrops, cliffs, or caves (Nutt 2007). These habitats have a highly complex structure and a particular microclimate; they may offer sites for shelter, which mammals may use as nesting sites or dens to raise their young in a stable microclimate that is relatively secure from predators (Mares 1997, Nutt 2007). Hence, rocky habitats are important, especially in deserts (Mares 1997), because these are extreme environments for animals due to pronounced daily and seasonal temperature fluctuations, and low availability of resources (e.g., food, water; Costa 1995). Despite the recognized importance of rocky habitats and their strong influence on the biota of a region (Mares 1997, Nutt 2007), knowledge on habitat requirements by rock-dwelling mammals is scarce, except for bats (see review in Chruszcz & Barclay 2002).

The viscacha rat (*Octomys mimax* Lawrence, 1941, Rodentia, Octodontidae) is a rodent endemic to western Argentina. It occurs in the temperate Monte Desert and in a transition area between the Monte and Chaco Seco. Information on the ecology of the viscacha rat is scarce; the population from Ischigualasto Provincial Park, the one occurring in the most arid portion of the Monte Desert, has received the greatest attention so far (see review in Sobrero et al. 2010). The viscacha rat was captured in habitats dominated by hard substrates (Traba et al. 2010) and was found to typically use rock crevices with relatively low vegetation cover as resting places (Ebensperger et al. 2008), suggesting that it would behave as a species associated with coarse-grained selection. Although some studies have described habitat use by the viscacha rat, none of them have measured microhabitat scale variables in the crevices used by the species or compared them to random crevices to identify variables that increase crevice suitability for the viscacha rat use.

After describing the basic habitat affinities of a species, a logical step toward understanding its habitat ecology is to investigate factors influencing the habitat selection process. These factors, in turn, affect the degree to which important habitat features explain habitat use. Several non-mutually exclusive hypotheses have been proposed to explain why many rodents live in rocky habitats (see review in Nutt 2007). One of them addresses the insulating effect of rocks in moderating temperature fluctuations, which can help rodents to properly thermoregulate (see review in Nutt 2007). Studies have shown that rocks store heat, thus modifying the microclimate of shelters during cold periods by keeping temperatures above those of the cold desert air (Mares & Lacher 1987). Rocks cool down and heat up slowly because temperatures inside crevices are generally cooler than external temperature during the heat of the day and warmer at night. Hence, temperatures inside crevices are also generally much more stable than external temperature, which can undergo pronounced fluctuations in desert environments (Mares 1997, Nutt 2007). It has also been reported that environmental temperature has a daily cycle, but remains stable inside crevices (Huey et al. 1989) and is dominated by depth (Gates 1980). This traditional hypothesis about the thermal stability of rocky crevices was tested only in some species of bats, snakes and geckos that live in quite structurally different crevices in temperate environment, information on the thermal behavior of crevices used by rock-dwelling rodents, however, is scarce and anecdotal, despite the harsh desert environments they have to cope with.

Other hypotheses that attempt to explain why many rodents live in rocky habitats consider high predation risk of desert areas and postulate that rocky substrate might enhance the ability of rodents to protect from predation using rocks as lookout posts to detect predators; moreover, rodents would be able to avoid predation through camouflage (see review in Nutt 2007). Another hypothesis formulates that the complex topography of rocky habitats, including the presence of water catchment sites, can generate unique microenvironments throughout rocky substrate with increased richness of plant species that remain green for longer periods due to increased water availability afforded by the rocks (Mares 1997, Nutt 2007).

Identifying and characterizing the habitat requirements of a species are essential steps in determining its distribution and proposing conservation strategies, particularly in an endemic, habitat specialist species of a monotypic genus like the viscacha rat. For that purpose, it is necessary to evaluate the characteristics of crevices selected by the viscacha rat and to test the traditional generalizations about the thermal behavior of rocky crevices. We postulated that the viscacha rat would use crevices with particular attributes; accordingly, hence our objectives were 1) to determine the attributes of crevices that influence crevice selection by the viscacha rat, by comparing structural attributes between used crevices and crevices available in the surrounding environment; 2) to compare the thermal properties of used crevices with the external environment, by analyzing range and variance of temperature inside and outside crevices, at the soil surface (T_s), at the rock surface (T_r), and in the air (T_a); and 3) to evaluate if there is a thermal gradient inside crevices, comparing T_s range and variance at different depths (0, 30 and 50 cm).

METHODS

Study area

The study was conducted in Ischigualasto Provincial Park, San Juan province, Argentina (29º 55′ S, 68º 05′ W). This protected area is located in a hyper-arid sector of the Monte Desert biome, which corresponds to the northern Monte of hills and closed basins (Monte de Sierras y Bolsones, Burkart et al. 1999). Mean annual precipitation ranges from 80 to 140 mm, concentrated in late spring and summer, with interannual variations (Márquez 1999, Cortez et al. 2005). This subregion is characterized by a wide temperature range throughout the year; mean annual temperature is 22ºC, with a maximum of 45ºC and a minimum of -10 °C (Márquez 1999, Cortez et al. 2005). Temperature is characterized by considerable day/night variations (Abraham & Martínez 2000). The vegetation is xerophytic due to the low rainfall and high temperatures that characterize the desert climate of the region (Márquez 1999). Plant cover is about 15 % (Márquez et al. 2005) and is characterized by open scrublands dominated by shrubs (*Larrea cuneifolia* Cavanilles, *Zuccagnia punctata* Cavanilles , *Prosopis torquata* Cavanilles ex Lagasca), cacti (*Echinopsis terschesckii* Britton & Rose), and bromeliads, such as *Deuterocohnia longipetala* (Baker), and *Tillandsia* sp. (Márquez et al. 2005, Acebes et al. 2010).

The study population was located in Los Rastros area (30°05'S; 67°56'W; 1,260 m a.s.l.) within Ischigualasto Provincial Park. In this area, we used telemetry techniques to monitor activity patterns, resting places, and range areas of the viscacha rat (Ebensperger et al. 2008). This population occurs in the "Columnar cactus slopes" plant community, which is situated on rocky substrate with irregular topography and frequent fissures that retain some humidity. This site is characterized by a great plant cover compared with other sites within Ischigualasto Provincial Park, producing a concentration of water and nutrients beneath canopies as well as shielding from intense solar radiation (Acebes et al. 2010).

Structural characteristics of crevices

We characterized all crevices present in an area of approximately 14 ha, in December 2008. For the study of crevice selection, we applied a use–availability design, as proposed by Johnson et al. (2006) because identifying unused points might be impractical or impossible. We considered that crevices were either used by the viscacha rat or available to them; the former were identified by signs, such as presence of feces, footprints and caches of plant material (both new and old), whereas the latter had no signs at the moment of sampling.

The entrance to crevices had a rock ceiling where caches of plant and feces were usually located. Inside crevices there were one or more hollows that the viscacha rat might use for different activities (Campos 2012). We obtained values for the following variables at each one of used and available crevices: 1) depth: measured as the distance from the entrance (below the rock ceiling) to the bottom; 2) height: measured at the entrance, from the ground or rock bottom to the rock ceiling; 3) width: maximum length of crevice entrance; 4) orientation to magnetic north: crevice entrance orientation was assigned to four quadrants (north, east, west and south), following the method proposed by Torres et al. (2003); 5) color of rocks: according to the table of Munsell, we considered crevices of dark-colored rocks (10YR 3/1, very dark gray) and crevices of light-colored rocks (10YR 7/1, light gray). Color of rocks affects their ability to absorb heat (Trenhaile 1998); dark-colored rocks (low albedo) can absorb more incident solar energy, resulting in higher surface temperature than light-colored rocks (high albedo) under the same conditions (Warke & Smith 1998; see review in Hall et al. 2005). We considered this variable in crevice selection because in a preliminary study we observed that crevices used by the viscacha rat are composed of sedimentary rocks of different color (R Trozzo, pers. comm. 2009). To consider the irregularity of crevices we measured depth and height 3 to 5 times, and for the analysis we used their mean value.

Temperature inside and outside crevices

To compare the thermal properties of crevices with the external temperatures, we recorded T_s, T_r and T_a inside and outside crevices. We recorded T_s and T_r with a non-contact infrared thermometer (resolution: 0.1° C from -50 °C to + 200 °C; accuracy ± 2 °C); and T_a with a digital thermometer (resolution: 0.1 °C from -20 °C to + 200 °C; accuracy ± 1 °C).

Thermal gradient inside crevices

To explore if there is a thermal gradient inside crevices, we measured T_s at different depths: 0 cm (at the entrance), 30 cm and 50 cm. For both objectives, we recorded temperature every 3 h for 3 consecutive days and nights, in summer (January 2009) and winter (August 2009) to obtain representative extreme values.

Statistical analysis

We used the information-theoretic approach described by Burnham & Anderson (2002) to model the data, based on the second-order Akaike Information Criterion corrected for small sample size (AICc). As a rule of thumb, models with ΔAICc (Δ = AICc – minimum AICc) ≤ 2 have substantial support. We considered an Akaike weight (w_i) as it represents the weight of evidence in favor of a candidate model being the best model out of the set of models considered (Burnham & Anderson 2002).

We applied a use–availability design for estimating models using logistic regression. The models provided an estimate of the odds of the viscacha rat selecting a crevice based on their structural characteristics. We previously performed a correlation analysis to identify multicollinearity in order to remove correlated variables (Neter et al. 1990). However, we included all variables in the analysis because the coefficients were $r < 0.8$. We tested the effect of the following fixed factors on crevice selection: depth, height, width, crevice entrance orientation and color of rocks. The analysis was performed using generalized linear models (GLM) and the response variable (used: 1, available: 0 crevices) was fitted to a Binomial distribution (link = logit).

To determine the thermal properties of crevices, we assessed temperature range and variance for a better understanding of thermal variability and stability of crevices. The analysis was performed using GLM and the continuous response variable was fitted to a Gamma distribution (link = inverse). We analyzed the seasons separately and also considered time of the day as covariate for all models.

To compare the thermal stability of crevices with the external environment, we included ambient as fixed factor with two levels (inside and outside crevices) and the response variables were temperature range and variance of T_s, T_r and T_a. To explore the possible occurrence of thermal gradient inside crevices, we considered gradient as fixed factor with three depth levels (0 cm, 30 cm and 50 cm), with temperature range and variance of T_s as the response variables. Due to the structure and complexity of the crevice, 50 cm was the greatest depth at which we could record temperature.

Temperature is expressed in Celsius degrees. All statistical analyses were carried out using R Core Team (2013). We assessed the significance of each fixed effect with Wald test (Sokal & Rohlf 1995) using the "aod" function of the language R package for R (Lesnoff et al. 2012).

RESULTS

Structural characteristics of crevices

We measured variables of 51 crevices used by the viscacha rat and 146 crevices available for the study population. We ran 28 models with different combinations of the explanatory variables. Table 1 shows the AICc values for the four best models, which are ranked according to their AICc differences (Δ_i) from best to worst, as well as the number of estimated parameters (K) and Akaike weights (w_i). The w_i of the first four models only differed by 0.43, 1.52 and 1.66 units, respectively; however, we argue that the best model was the model that included the lowest number of parameters, i.e. the most parsimonious one (Burnham et al. 2011).

The best approximation model of crevices selection by the viscacha rat included crevice depth and width attributes (model 2), both with a significant effect (Wald test = 14.4; df = 1; P = 0.0002 and Wald test = 15.4; df = 2; P = 0.0005, respectively). The logistic regression equation of the selected model was:

$$Y = -1.302 + 0.017\,(\text{depth}) - 0.003\,(\text{width})$$

TABLE 1

The four best models of crevice selection by the viscacha rat. AICc values for each candidate model; differences between the model with the lowest AICc value and each candidate model (Δ_i) from best to worst; number of estimated parameters (K), and Akaike weight (w_i). The fixed factors included in these models were depth, height, width and color of rocks.

Los mejores cuatro modelos para la selección de grietas por la rata vizcacha. Valores de AICc de cada modelo candidato; diferencias entre el modelo con el menor valor de AICc y cada modelo candidato (Δ_i) ordenados desde el modelo que mejor ajusta hasta el peor; número estimado de parámetros (K), y Akaike weight (w_i). Los factores fijos incluidos en estos modelos fueron profundidad, altura, ancho y color de las rocas.

Model	AICc	Δ_i	K	w_i
depth + width + color	209.12	0.00	5	0.31
depth + width	209.55	0.43	3	0.25
depth + height + width	210.64	1.52	4	0.14
depth + height + width + color	210.78	1.66	6	0.13

Based on this model, the odds of selection increased by exp (0.017) = 1.017, or 1.7 % , for every 1cm increase in depth of crevice (Fig. 1). Furthermore, the odds of selection decreased by exp (-0.003) = 0.997, or -0.3 % , for every 1cm increase in crevice width (Fig. 1). The depth and width of crevices were the variables included in the best model for habitat selection; therefore, we considered them as covariates in the next analysis.

Temperature inside and outside crevices

The models selected for winter revealed that T_s range and variance were different inside and outside crevices (Wald test = 14.4; df = 2; P = 0.0007; and Wald test = 15.2; df = 2; P = 0.0005; respectively) being higher outside crevices (Fig. 2). We found a similar response for T_r range and variance (Wald test = 5.8; df = 2; P = 0.054; and Wald test = 6.0; df = 2; P = 0.05; respectively), both variables being higher outside crevices (Fig. 2). T_a range and variance were not different between inside and outside of crevices (Wald test = 1.9; df = 2; P = 0.38; and Wald test = 1.6; df = 2; P = 0.44, respectively).

In summer, T_s range and variance were different inside and outside crevices, being higher outside them (Wald test = 14.7; df = 2; P = 0.001; and Wald test = 12.7; df = 2; P = 0.002;

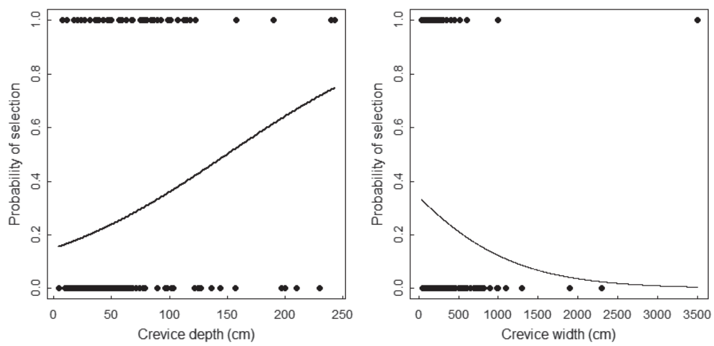

Fig. 1: Probability of crevices selected by the viscacha rat according to predictor variables included in the best model. Both variables are expressed in centimeters.

Probabilidad de selección de grietas por la rata vizcacha en función de las variables incluidas en el mejor modelo. Ambas variables están expresadas en centímetros.

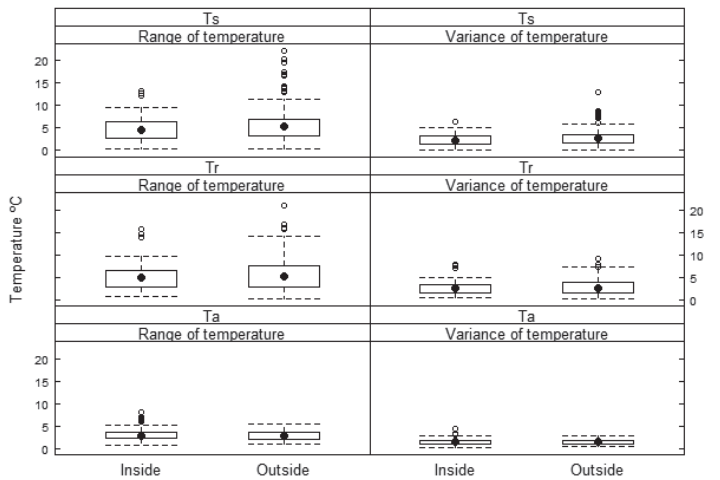

Fig. 2: Range and variance of temperature inside and outside crevices, at the soil surface (T_s), at the rock surface (T_r) and in the air (T_a) in winter.

Rango y varianza de temperatura adentro y afuera de las grietas, en la superficie del suelo (T_s), en la superficie de la roca (T_r) y en el aire (T_a) en invierno.

respectively; Fig. 3). T_r range and variance were different inside and outside crevices (Wald test = 60.9; df = 2; P < 0.0001; and Wald test = 61.0; df = 2; P < 0.0001; respectively). T_a range and variance showed a similar response (Wald test = 36.6; df = 2; P < 0.0001; and Wald test = 51.3; df = 2; P < 0.0001, respectively). T_r and T_a range and variance were higher outside than inside crevices (Fig. 3).

Absolute minimum temperatures outside crevices were recorded at 9:00 a.m. in winter (T_s: -3.7 °C and T_r: -6.00 °C) and at 6:00 a.m. in summer (T_s: 10.2 °C and T_r: 8.4 °C). Absolute maximum temperature outside crevices were recorded at 3:00 p.m. in winter (T_s: 61.5 °C and T_r: 53.2 °C); in summer, maximum temperatures were T_s 65.2 °C at 12:00 p.m. and T_r 57.2 °C at 3:00 p.m.

Thermal gradient inside crevices

The selected models for winter revealed that temperature range showed a gradient inside crevices (Wald test = 6.1; df = 2; P = 0.046), with the lowest values at the greatest depth; however, temperature variance inside crevices did not show a gradient (Wald test = 4.7; df = 2; P = 0.093). In summer, temperature range and variance inside crevices showed a gradient (Wald test = 8.3; df = 2; P = 0.015; and Wald test = 9.3; df = 2; P = 0.009, respectively). In this season, temperature range and variance decreased with increasing depth (Fig. 4).

DISCUSSION

Our results show that the viscacha rat did not use microhabitats in proportion to availability, suggesting a preference for certain characteristics of the crevices occupied. We found a positive association between species presence and depth of crevices; however, there was a negative association with width of crevices. Regarding thermal properties of crevices used by the viscacha rat, we found thermal stability inside crevices compared with the external environment and a thermal gradient inside them, with temperature being more stable with increasing depth.

Selecting appropriate crevices can provide the viscacha rat with multiple benefits, because crevices are an important resource for reproduction; they provide shelter against predators and escape from the harsh aridity of the desert, as well as sites for handling fruits, stems, leaves and for storing food caches for periods of scarce food resource availability (Campos 2012). Thus, the availability of

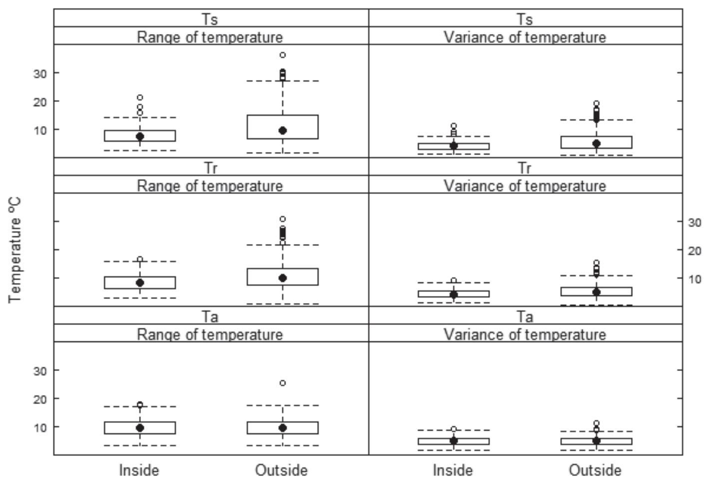

Fig. 3: Range and variance of temperature inside and outside crevices, at the soil surface (T_s), at the rock surface (T_r) and in the air (T_a) in summer.

Rango y varianza de temperatura adentro y afuera de las grietas, en la superficie del suelo (T_s), en la superficie de la roca (T_r) y en el aire (T_a) en verano.

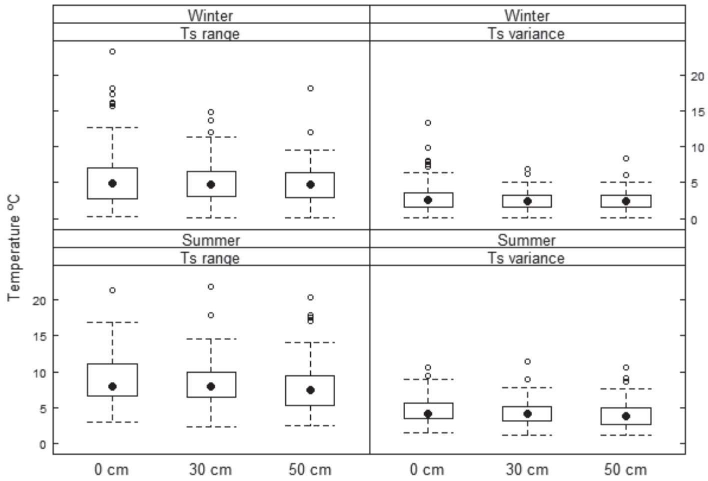

Fig. 4: Range and variance of temperature at the soil surface (T_S) at different depths inside crevices (0, 30 and 50 cm) in winter and summer.

Rango y varianza de temperatura en la superficie del suelo (T_S) a diferentes profundidades adentro de las grietas (0, 30 and 50 cm) en invierno y en verano.

suitable retreat sites may have strong effects on individual fitness as well as population viability (Huey et al. 1989). In general, crevices, holes or burrows with restricted access can be considered important refuge for several animals. These refuges may provide shelter before detection or attack by the predator or can be used for withdrawal after an encounter with the predator (Sundell & Ylönen 2004). In addition, the attributes of rock crevices selected by animals likely enhance the ability to survive under several climatic desert conditions. In the Appalachian Mountains, the Allegheny woodrat (*Neotoma magister* Baird, 1857) and the eastern woodrat (*N. floridana haematoreia* Howell, 1934) selected crevices of large dimensions (height, width, depth), suggesting that these crevices enhance protection against predators and severe climatic conditions (Rossell et al. 2009).

The color of crevices was not an important variable in the selection of microhabitat by the viscacha rat, probably because the absorption of heat and the radiation emitted by a body is also a function of its surface area (Siegel & Howell 1992). Thus, the structural characteristics of crevices may have greater influence on its thermal behavior than rock color.

Our results show that crevices had more stable temperatures (smaller ranges and variances) than external temperatures in both seasons. Our findings agree with some works conducted research in other species from temperate environment and different types of burrow. For example, Brown (1968) reported that temperature of burrows constructed in rock crevices by the bushy-tailed woodrat (*Neotoma cinerea* Ord, 1815) fluctuates by only a few degrees Celsius daily, whereas ambient temperature may fluctuate between 15 °C and 20 °C daily. The oldfield mouse (*Peromyscus polionotus* Wagner, 1843) finds thermoneutral temperature (about 31 °C) in its burrow when soil surface temperatures rise to 40-50 °C or higher at midday (Smith & Criss 1967). Likewise, the garden dormice (*Eliomys quercinus* Linnaeus, 1766) was found to be attracted by rocky areas that may act as a heat source during the night; this was very important in the earliest months of the active period, when animals emerged from hibernation and started the mating season (Bertolino 2007).

Food abundance and climatic conditions in nature influence the rates at which animals can acquire and expend energy (Costa 1995). In an evaluation of the thermoregulatory capabilities of the viscacha rat under laboratory conditions, Bozinovic & Contreras (1990) found that this rodent maintained body temperature at 36.7 ± 0.6 °C when exposed to ambient temperatures of 5-35 °C, indicating that the species is an effective thermoregulator. However, the thermoregulatory capabilities of this rodent at extreme environment temperatures typical of the desert, where minimum temperature in winter is below 0 ºC and maximum temperature in winter and summer is above 50 ºC, are still unknown. Furthermore, the energy costs for thermoregulation would be greater in winter due to the greater difference between maximum and minimum temperatures. The lowest limit of the thermoneutral zone found for the viscacha rat was 22.2 °C; below this temperature, the metabolic rate increases significantly to maintain body temperature (Bozinovic & Contreras 1990). Despite our lack of data on body temperature of the viscacha rat, we assume that this rodent would be able to avoid extreme temperatures by using rock crevices.

We found that T_a variance in winter was similar inside and outside crevices, probably due to a limitation imposed by the crevice structure and complexity, which allowed us to record the temperature only up to 50 cm, or by a relationship between burrow architecture and abiotic factors (e.g. air and soil temperature, surface-wind velocity, relative humidity, precipitation and direction of sunlight) as suggest by some studies (Kay & Whitford 1978, Best 1982, 1988, Baumgardner 1991, Torres et al. 2003). The viscacha rat lives in crevices with numerous entrances (mean ± SE: 4.63 ± 0.42) facing different directions (Campos 2012); hence, air may flow inside crevices due to their complex structure, leading to similar temperature fluctuations in the air inside and outside crevices. A similar burrow complexity was found for another octodontid desert rodent, the sister taxon *Tympanoctomys barrerae* (Yepes, 1942), which inhabits large mounds with at least three different gallery levels and several entrances (Ojeda et al. 1996). A factor that is likely to decrease the variability of air temperature inside crevices in winter is the zonda, a wind typical of the Monte Desert. Under zonda conditions, the temperature in winter can rise up to 17 °C and the atmospheric humidity can drop to 5 % (Norte 1988, Seluchi et al. 2003, Le Houérou et al. 2006). An evaluation of crevice architecture and estimation of the spaces used inside crevices by the viscacha rat could help understand patterns and benefits of habitat selected.

The thermal properties of crevices used by the viscacha rat might facilitate the species thermoregulation through a stable microclimate, by which different depths would offer thermal benefits to meet the needs of the moment. In the present study, range and variance were higher at the entrance (0 cm) than at 30 cm and 50 cm in depth in summer, whereas in winter, only temperature range was higher at the entrance than at greater depths. However, although the thermal gradient inside crevices was less pronounced in winter than in summer, with differences according to depth found only for temperature range, the minimum temperatures inside crevices were always lower than those recorded outside them. The viscacha rat displayed temporal variation in activity (Ebenserger et al. 2008). Camera traps placed at the entrance of crevices showed that viscacha rat activity in winter was markedly higher inside crevices between 8:00 p.m. and 9:00 a.m. which corresponds with minimum temperatures recorded in the soil outside them (5.4 °C at 12:00 a.m.; 0.00 °C at 3:00 a.m.; -3.3 °C at 6:00 a.m. and -3.7 °C at 9:00 a.m.). In summer, the viscacha rat is more active inside crevices at times of maximum temperatures recorded outside (47.8 °C at 9:00 a.m. and 64.8 °C at 3:00 p.m.; V. Campos & S. Giannoni unpublished results). Animals avoid uncomfortable extremes, the total time available for surface activity or foraging may readily be made up at another more suitable time of day (Kenagy et al. 2002).

We also recorded high temperatures outside crevices at 12:00 p.m. and 6:00 p.m. in summer (65.2 °C and 59.8 °C respectively; V. Campos & S. Giannoni unpublished results). Although we have no data about behavior of this rodent inside crevices, under laboratory conditions the viscacha rat did not display torpor (Bozinovic & Contreras 1990); hence, the species might use different crevice depths according to thermoregulatory costs. This strategy was found for other species (*Myotis evotis* Allen, 1864, *Procavia capensis* Pallas, 1766, *Jaculus jaculus* Linnaeus, 1758, *Thamnophis elegans*

Baird & Girard, 1853), which may take advantage of different parts of roosts, crevices and burrows for behavioral thermoregulation (Sale 1966, Ghobrial & Nour 1975, Huey et al. 1989, Chruszcz & Barclay 2002). However, further studies on movements inside crevices related to temperature are necessary to confirm this assumption. Moreover, the viscacha rat would display behavioral patterns that contribute to body temperature control. All these assumptions deserve future research because this knowledge can contribute to the conservation of this habitat specialist and endemic species.

The present study provides quantitative evidence about the thermal behavior of rock crevices, which contributes with the traditional hypothesis proposed to explain the benefits of living in rock crevices.

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