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Habitat Selection and Burrow Structure of Blanford's Jerboa, *Jaculus blanfordi* (Mammalia: Rodentia) from Central Desert of Iran

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Abstract: We investigated the habitat associations and burrow structure of Blanford's Jerboa (*Jaculus blanfordi*). Our results indicated that microhabitat vegetation types have a strong effect on the Jerboa's habitat selection for burrow sites. In addition, we identified different types of burrows, including temporary, breeding-nest and wintering burrows. The number of burrows was the highest in bare soil and *Hamada-Zygophyllum* habitat types.

Keywords: Blanford's Jerboa, burrow structure, habitat use, microhabitat types, soil chemical characteristics

Introduction

Blanford's Jerboa (*Jaculus blanfordi*) can be found in the southern and eastern desert plains of Iran, the southern and western parts of Afghanistan, and the west of Pakistan, Turkmenistan and Uzbekistan (Holden, Musser 2005, Shenbrot *et al.* 2008). It inhabits arid regions where extensive sand dunes are interspersed with gravel plains. As in other Jerboas, some behavioural mechanisms, in particular anti-predatory clues are involved in its habitat selection. It digs long burrows in hard ground, using its incisors to break substrate, forelimbs for digging and collecting the soil under the body, hind feet for kicking the soil backward, and snout for pushing and ramming the excavated soil (Naderi *et al.* 2011). This jerboa is well adapted to fast bipedal locomotion. It runs faster relative to other jerboa taxa from the study area, such as Iranian Jerboa (*Allactaga hotsoni firouzi*) and Hotson's Jerboa (*A. hotsoni*) (Naderi *et al.* 2009). Ziaei (2008) and Shenbrot *et al.* (2008) reported no food storages or excrements in the burrows, but animal fur or other soft materials may be used to line the dens during the winter. During summer, the openings are sealed with soil and gravel. Naderi *et al.* (2009) concluded that Iranian Jerboa feeds on *Peganum harmala*, *Artemisia aucheri,* and *Anabasis aphylla*. The mentioned authors found remains of that food in the burrows. The association of these small rodents with the vegetation that provides cover was previously reported (Brown 1980, Shenbrot 2004). Naderi *et al.* (2011) found that Iranian Jerboa activity is positively related to the presence of patches covered with bare soil and the major feeding plant, *Anabasis aphylla*. At the same time, they recorded a higher encounter rate of individuals in bare soil habitat type compared to other habitat types, such as *Anabasis*, *Artemisia* and *Peganum*. The underground refuges, with their relatively stable microclimate, provide protection for small animals from extreme temperatures prevailing on the surface of the desert habitats (Shenbrot *et al.* 2002). The classification of Jerboa's burrows was proposed by Naumov, Lobachev (1975) and de-

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veloped by Shenbrot *et al.* (2008). It includes: 1) breeding burrows, 2) permanent burrows of males and non-breeding females, 3) wintering burrows, 4) simple shelter burrows used during night activity, and 5) temporal burrows that were usually the first step in building of a permanent burrow. The common refuge type is the underground burrows, which usually varies in architecture from simple to complex structures (Hinz, Pillay 2006). The simple burrows comprise a single nest chamber and one or two entrance holes (Hinz, Pillay 2006), while the complex burrows include several above-ground entrance holes joined with many interconnected tunnels below the ground (Mankin, Getz 1994). The complex systems may have multiple functions, such as providing shelter from predators and gaining access to high-quality feeding sites through numerous entrance holes. Colak, Yigit (1998) found two types of summer burrows in *A. elater,* whereas Scheibler (2006) and Mohammadi *et al.* (2010) reported three types of burrows for the Mongolian gerbil (*M. unguiculatus)* and Iranian Jerboa, respectively. Considering the unknown ecology of the Blanford's Jerboa, the aims of this study include investigation of its habitat associations and burrow structure and finding the most affecting microhabitat variables in its habitat selection.

Material and Methods

Study area

The study was conducted between March 2010 and September 2012 in an arid stepped area in the south of Chupanan, Naein, Iran (33° 35'- 33° 36'N and 54° 15'- 54° 20'E). The area has an altitude of 950 m above sea level and features a very dry season between May and October (<12% of the annual precipitation). The physiognomy of the habitat presented a total woody and non-woody plant cover, such as *Atriplex* sp., *Artemisia siberi*, *Peganum harmala*, *Atraphaxis spinosa*, *Haloxylon* sp., *Calligonum comosum*, *Hamada salicornica, Zygophyllum* sp. and *Tamarix* sp. Some predator species, such as Red Fox (*Vulpes vulpes*), Jackal (*Canis aureus*), Sand Fox (*Vullpes rueppellii*) and Sand Cat (*Felis margarita*) were observed and recorded during the study.

Burrow structure

In order to investigate the burrow structure, we examined 15 active burrows in five habitat types. The burrows were carefully excavated by a spade and small shovel to maintain the original organisation of the tunnels and the associated structures. To distinguish active burrows we searched for plugged soil with different colours and humidity from ambient soil. The length of tunnels, their junctions, the number of chambers, their depth, length, width and position, as well as the number of entrances, were recorded and mapped (Mohammadi *et al*. 2010).

Burrow site selection

To estimate burrow density we traversed 25 randomly distributed strip transects in the study area (transect length = 3.5 km, strip width: 10 m). The selection of the microhabitat types was based on the dominant plant species and the bare soil cover. The microhabitat variables were measured in 35 burrows plots (presence) and in the same number of the non-burrow plots (absence). The paired plots were selected randomly in about 500 meters away from the burrow plots in a completely random direction (Naderi *et al*. 2009).

We established 10×10 m square plots surrounding the burrows and measured the following microhabitat variables: 1) bare soil percent cover (BSC). 2) pebble and cobble percent cover (PEB and COB, respectively), and 3) major vegetation species percent cover. The percentage of canopy cover at crown level was estimated with the aid of a squared hard paper frame (25 cm × 25 cm). To study the effect of soil properties on the burrow site selection a sample of one kg soil was taken from the centre of each plot for laboratory soil texture and chemical analysis.

Statistical analysis

The structural differences in the burrow systems and the significant differences in the burrow density were determined by ANOVA. Two-way ANOVA was used to compare the microhabitat variables between burrow and non-burrow plots across the whole study area within the different microhabitat types. Paired T-test was used to compare mean soil properties between presence and absence plots. The SPSS 16.0 statistical package was used for statistical analysis.

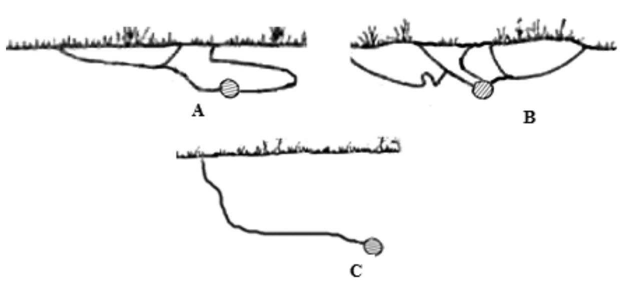

Fig. 1. Breeding-nest (A), temporary burrow (B), and wintering burrow (C) of *Jaculus blanfordi*

Results

Burrow structure

A total of 20 burrows belonging to the species were excavated in the study area. All the studied burrows represented settlement, as fresh soil had been excavated from them by the species. Three main types of burrow were identified: 1) burrows with temporary function, short length, and simple form in structure that had two or three entrances, one chamber, and several tunnels. 2) Breeding nest burrows – burrow systems that had much longer system of tunnels, a greater number of entrances and one nest chamber similar to the simple burrow. The function of this type of burrow was found to be providing safety for nesting, breeding and hibernation. We recorded plant remains, such as pieces of stem and leaves of *A. aucheri*, in these burrows. Their nest chamber was located at 30 cm from the ground surface. Tunnels were located at approximately 25 cm from the ground's surface. The number of entrance holes in the excavated burrows ranged from one to five per system and the number of tunnels ranged from two to six, depending on the burrow system (Table 1) (Fig. 1). 3) The winter burrows had one entrance and one nest chamber. Their tunnels were generally horizontal, situated at substantial depth.

Burrow site selection

A total of five major habitat types were recognised in the study area. The findings showed that there are significant differences in the burrow density between *Hamada-Zygophyllum* and bare soil type and the other habitat types (*Artemisia-Peganum*, *Atraphaxis-Haloxylon*, *Hamada-Zygophyllum* and *Tamarix-Calligonum*) (ANOVA: $F_{4.28}$=57.45, P<0.001). The highest burrow densities were recorded in *Hamada-Zygophyllum* and bare soil and the lowest in the *Tamarix-Calligonum* type. Two-way ANOVA showed that the structural characteristics of the available microhabitats varied significantly between different major habitat types (Table 2). The analysis of the chemical characteristics of soil in the burrow plots by the T-test indicated that $CaCO_3$ content was higher in burrow sites than that in the non-burrow sites but $CaSO_4$ content was lower in the burrow sites (t=56.57, P<0.001). There was no significant differences in the silt, clay and pebble content between the burrow and the non-burrow plots, while there was a difference in the sand content (t=23.14, P<0.001).

Discussion

In general, the burrow system described by Mohammadi *et al*. (2010) for Iranian Jerboa was similar with the above described types of burrows, except for the reproduction burrow. There is different classification of burrows for Jerboas including summer, reproduction and winter burrows in Mongolian gerbil (Scheibler, 2006). The summer burrows were entitled as temporary burrows with no chamber in *A. elater* (Çolak, Yigit 1998). In these studies, two types of summer burrows for *A. elater* were reported: the first had a lateral passage leading to the surface in addition to the main gallery, while the second was a burrow with a single exit. Mankin, Getz (1994) found that such temporary or escape burrows are slightly smaller than the breeding nest burrows, with numerous (2-9) entrance holes to allow for a rapid entry or exit.

Table 1. Mean ±SE values of physical characteristics of burrow systems in *J. blanfordi*

Burrow type	n	Number of entrance holes	Number of tunnels	Length of tunnels
Temporary	5	2-3	3-4	31±3.05
Breeding-nest	5	3-5	2-7	48±1.0
Wintering	5	1	1-2	75±0.8

Table 2. Two-Way ANOVA for burrow and non-burrow sites with different habitat types, including: bare soil, *Hamada-Zygophyllum* (HZ), *Artemisia-Peganum* (AP), *Atraphaxis-Haloxylon* (AH), and *Tamarix-Calligonum* (TC).

	Presence/ Absence		Interaction		Habitat types		Model		Habitat type
R^2	*P*	F	*P*	F	*P*	F	*P*	F	
0.645	<0.001	156.34	<0.001	3.54	<0.001	8.63	<0.001	57.45	Bare soil
0.634	0.001	11.43	<0.001	7.32	0.001	8.78	<0.001	56.31	HZ
0.31	0.08	3.87	0.09	6.21	<0.001	4.05	<0.001	3. 38	AP
0.13	0.023	15.50	<0.001	14.23	<0.005	5.35	<0.005	21.45	AH
0.11	0.09	9.65	<0.001	7.80	0.006	3.43	>0.005	2.05	TC

Vegetation and soil type are likely to affect *J. blanfordi* burrow site selection. Our results are in agreement with the general pattern described for most species of jerboas that use habitats characterised by hard soil and sparse vegetation (Shenbrot *et al.* 2008). For example, Brown (1980) reported that *A. hotsoni* was positively correlated with barren areas and negatively correlated with the percentage of vegetation cover. He also found a significant positive correlation between the occurrence of *A. hotsoni* and the halophytic chenopod, *Seidlitzia rosmarinus*. The investigation of habitat associations of the Hotson's jerboa (Naderi *et al.* 2009) also showed that the overall pattern of habitat selection of the species was different from the pattern of burrow site selection. This Jerboa selects *Anabasis* type for its activity out of the burrows, but bare and unvegetated areas for burrow construction. Our results are also in agreement with other studies about the habitat selection of *Pygerethmus pumilio* (Shenbrot 1992, Rogovin, Shenbrot 1995) and *A. bullata* (Rogovin, Shenbrot 1995, Shenbrot 2004). Selections of the more barren areas are probably related to the protection against the predators. Indeed, the adaptation value of preferring bare soil cover most likely results from the possibility of better and faster entering the burrows. At the same time, the amount of $CaCO_3$ mainly affects the burrow stability, which is presumed to be higher in harder soils, which seems to be especially valid for winter burrows.

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