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Habitat selection of Williams' Jerboa (*Allactaga williamsi* Thomas, 1897) in Ardabil Province, Iran

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Abstract: Investigation of habitat affinities of Williams' Jerboa in Ardabil Province showed that its activity pattern and habitat selection are positively correlated with relatively barren areas with slopes of lower than 20% covered by *Festuca ovina*, *Trifolium montanum*, and *Bromus scoparius*. Statistical analysis indicated that the *Agropyron-Stipa* vegetation type was selected more frequently by the species. This jerboa avoids plant species of the genus *Acantholimon* because of their lower adaptational value for the species' survival. The positive correlation between the Williams' Jerboa's presence and some plant species may be related to the high nutritional value of the plants, but behavioral mechanisms in avoiding or using different vegetation structures should also be considered in defining its habitat selection process.

Key words: Habitat associations, nocturnal activity, vegetation types, Williams' Jerboa

1. Introduction

One of the major bases for understanding a species' ecology and its conservation is the knowledge of its habitat affinities and associations (Huey, 1991). Habitat variables may influence several aspects, such as population dynamics (Holt, 1987) and interactions at the community level (Morris, 1988). The first step towards understanding and exploring ecological interactions between a species and its environment is to determine the selection or avoidance of one particular microhabitat in relation to its availability (Neu et al., 1974). Rodents, especially the members of the family Dipodidae, have been studied frequently as model species for investigations of habitat selection in their distributional range (Shenbrot, 1992; Rogovin and Shenbrot, 1995; Shenbrot and Rogovin, 1995; Hemami et al., 2011; Naderi et al., 2011). The results of such studies are more or less similar; for example, many of the investigations concluded that the habitat selection of many small rodents relies primarily on structural characteristics of their environment such as vegetation structure, cover, and height (Brown and Lieberman, 1973; M'Closkey, 1976; Nel, 1978; Stamp and Ohmart, 1978; Çolak and Yiğit, 1998; Yiğit et al., 2003). Jerboas select areas that facilitate entry into their burrows (for example, more barren areas with less dense vegetation cover) while providing them with sufficient food items (Shenbrot, 1995; Naderi et al., 2011).

Williams' Jerboa was described for the first time by Thomas (1897) from Turkey. Some investigations into its biology and ecology in Turkey have shown that it avoids dense vegetation and selects more barren areas (Çolak and Yiğit, 1998; Yiğit et al., 2003). Some other studies on its habitat selection have shown that Williams' Jerboa selects steppe and semisteppe areas of up to 2500 m above sea level (Ognev, 1948), or areas with sparse vegetation (Toyran and Albayrak, 2009).

The main goals of the present study were: 1) to assess preferences in microhabitat use in relation to their availability; 2) to evaluate differences in microhabitat use between studied areas; and 3) to describe the microhabitat structure required and preferred by the species.

2. Materials and methods

2.1. Study area

During a study on Dipodidae members in Iran from April to September 2012, we sampled Williams' Jerboa from Ardabil Province (Gendeshmin village: 38°12′N, 48°19′E) (Figure 1). Ardabil Province is a strip stretching from 36°50′N, 47°E to 39°40′N, 49°E. Diverse mountains, high average latitude, proximity to the Caspian Sea, and Medi-

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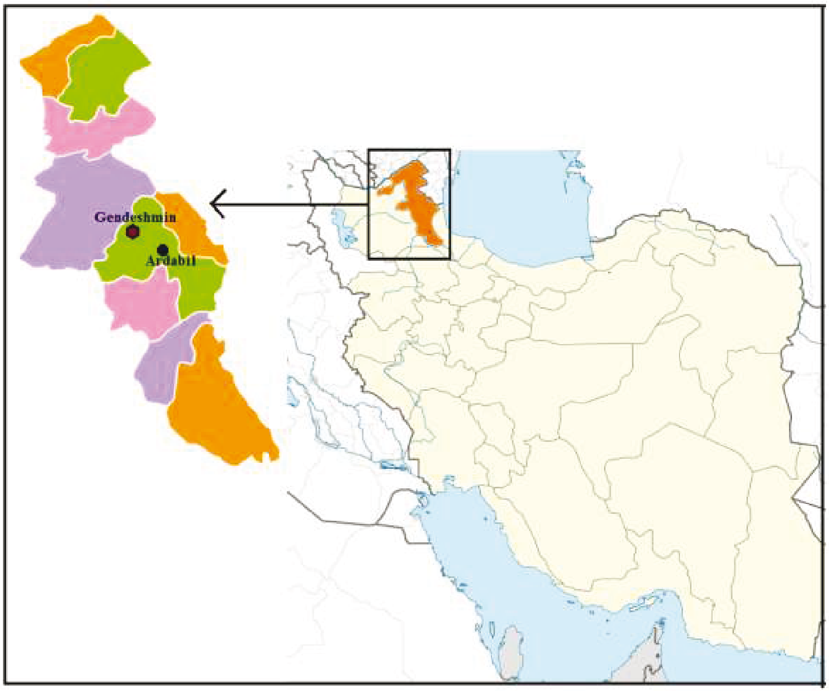

Figure 1. The study area in Ardabil Province, Iran.

terranean air flows and Siberian cold air masses all play an important role in its weather conditions (Djalilian and Tahbaz, 2006). The average altitude of the Gendeshmin area is about 1335 m above sea level, with diverse topography.

2.2. Data recording

We studied habitat preferences of *A. williamsi* in individual presence plots. In order to evaluate microhabitat availability, 40 square plots (25 m^2) were placed on line transects (n = 33; each about 2 km in length). Sampling plots along each randomly distributed transect were placed at observation (presence) points. For comparing overall structural differences between used and unused areas, we sampled the same number of completely random plots (n = 40) (Naderi et al., 2011). Microhabitat variables included vegetation percent cover (VC), vegetation species (VS), slope (SL), pebble percent cover (PB), and cobble percent cover (CB). Vegetation attributes of each plot (mainly shrubs) were characterized considering: 1) type and number of plant species, and 2) vegetation cover (total and specific). Vegetation percent cover was measured using a cardboard frame (10 × 10 cm^2) placed on top of the vegetation, and percentage cover was determined as the proportion of the frame area filled by each class. The following vegetation (shrub) cover classes were defined: 1) 0 (bare soil); 2) 1%–5%; 3) 6%–15%; 4) 16%–30%; 5) 31%–50%; 6) 51%–75%; 7) 76%–100%. For homogeneity of the sampling design for all transects, sampling was done in the same weather and lunar-light conditions (Hemami et al., 2011).

We also studied burrow site selection by the species by using 25 completely random transects (transect length = 2 km) in different vegetation types. Different methods were tried to find active burrows, such as following the individuals in the late activity period at night, searching for unfilled previous-year burrows, and finding plugged soil with different color and humidity than the ambient soil (Naderi et al., 2011). We measured the microhabitat variables in 45 burrow plots (squared plot's area = 25 m^2) (presence) and the same number of nonburrow plots (paired plots) (absence). The paired plots were selected randomly about 350 m away from burrow plots (Naderi et al., 2009). The measured variables were: 1) total vegetation percent cover (TVC); 2) pebble and cobble percent cover (PB and CB, respectively); 3) percent of slope (SL); and 4) major plant species percent cover, including *Festuca ovina* (FO), *Trifolium montanum* (TM), *Bromus scoparius* (BS), *Acantholimon senganense* (AS), *Acantholimon embergeri* (AE), *Acantholimon acerosum* (AA), and *Artemisia herba-alba* (AH).

2.3. Statistical analysis

For the study of habitat selection in different vegetation types, we analyzed our data using 2-way ANOVA. This analysis was also used to compare microhabitat variables between burrow and paired plots across the whole study area with vegetation type and presence versus absence of the burrows as fixed factors. Logistic regression analysis was used to find the most effective microhabitat variables in the species' habitat use. Paired t-test analysis was used to differentiate between microhabitat variables, measured in both burrow plots and paired plots. The assumption of our data's normality was tested using a nonparametric Kolmogorov–Smirnov test.

3. Results

Microhabitat use data for 40 individuals were recorded, and only 16 individuals were captured. Of those captured individuals from both of the study areas, 9 were adult females and 7 were adult males. All captured animals were released after some morphological measurements. In all, 3 major vegetation types were recognized in the study area, including *Acanthophylum-Euphorbia*, *Artemisia-Astragalus*, and *Agropyron-Stipa*. The highest encounter rate was recorded in the *Agropyron-Stipa* vegetation type, which was confirmed by 2-way ANOVA analysis, as well (Table 1). The t-test analysis indicated that the species' presence was positively correlated with *Festuca ovina*, *Trifolium montanum*, and *Bromus scoparius* and negatively correlated with *Acantholimon senganense, Acantholimon embergeri*, *Acantholimon acerosum*, and *Artemisia herba-alba*. The most-selected slope category was lower than 20%. In addition, mean percent cover of all variables as well as vegetation classes was significantly different between presence and absence plots (P < 0.05). Logistic regression analysis indicated that the most effective variables on the species' presence were the areas that had the lowest vegetation percent cover (class 1) and slope. The last variable was lower than 20% in all presence plots. A Hosmer–Lemeshow lack-of-fit test (χ^2 = 8.14, P = 0.51) indicated a relatively good fit of the data to the model.

We also found that there were significant differences in burrow density between the *Artemisia-Astragalus* type and the 2 other vegetation types (*Acanthophylum-Euphorbia* and *Agropyron-Stipa*) (ANOVA: $F_{2,13}$ = 54.31, P < 0.005; Figure 2). Two-way ANOVA showed that the structural characteristics of available microhabitats differed significantly between different vegetation types, and mean percent cover of all variables was significantly different

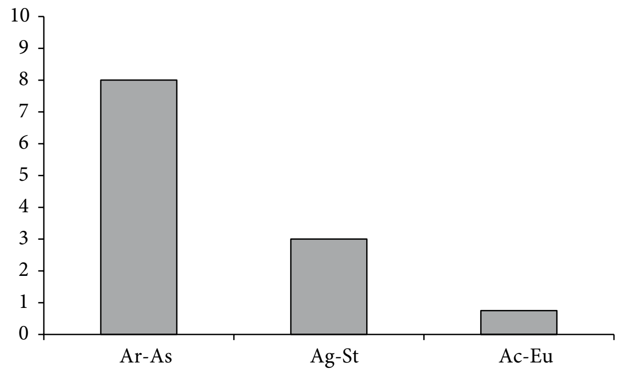

Figure 2. Burrow density per hectare in each recognized vegetation type. Ar-As, Ag-St, and Ac-Eu respectively denote *Artemisia-Astragalus*, *Agropyron-Stipa*, and *Acanthophylum-Euphorbia*.

between burrow and paired plots (P < 0.05; Table 2). Paired t-test analysis showed that the total shrub percent cover (t = 25.24; df = 44, P < 0.001), slope (SL) (t = 19.41; df = 44, P < 0.05), and cobble percent cover (CB) (t = 17.52; df = 44, P < 0.05) were the variables most affecting burrow site selection. We found that the slope value, total vegetation, and pebble percent cover in burrow plots were lower than in the paired ones. Based on these analyses, we also concluded that *A. herba-alba* percent cover in burrow plots was significantly higher than in paired plots (Figure 3).

4. Discussion

Williams' Jerboa generally selects areas with the lowest vegetation percent cover, especially on brighter nights, a conclusion that was previously confirmed for other jerboas. Our observations regarding the habitat associations of Williams' Jerboa, especially the effect of vegetation structure on its habitat use, have also been reported for some other jerboas. Naderi et al. (2011) concluded that the Iranian jerboa's activity is limited somewhat to barren areas, although some environmental factors also affect its activity patterns, such as moon phases (Hemami et al., 2011) or the presence of *Anabasis aphylla* and *Peganum harmala* as the main feeding items (Naderi et al., 2009). Yiğit et al. (2003) reported that vegetation structure,

Table 1. Two-way ANOVA for individual presence and random absence plots and their correlation with different major vegetation types including *Acanthophylum-Euphorbia* (A-E), *Artemisia-Astragalus* (A-A), and *Agropyron-Stipa* (A-S).

Vegetation types	Vegetation types		Interaction		Presence/absence		Adj. R squared
	F	P	F	P	F	P	
A-S	34.16	<0.05	7.61	0.12	57.21	<0.005	0.83
A-A	0.021	0.06	1.32	0.11	12.67	<0.005	0.29
A-E	0.16	<0.01	1.16		1.21	0.41	0.13

Table 2. Two-way ANOVA for burrow and paired (nonburrow) sites' presence/absence correlation with different distinguished vegetation types including *Acanthophylum-Euphorbia* (A-E), *Artemisia-Astragalus* (A-A), and *Agropyron-Stipa* (A-S).

	Model		Vegetation type		Interaction		Presence/absence		Adjusted R^2
	F	P	F	P	F	P	F	P	
A-A	26.23	<0.001	4.21	<0.05	6.26	0.05	58.49	<0.001	0.81
A-E	8.13	<0.05	3.35	<0.05	4.71	0.24	16.31	<0.001	0.30
A-S	13.29	<0.05	4.13	<0.05	5.20	0.12	24.56	<0.001	0.59

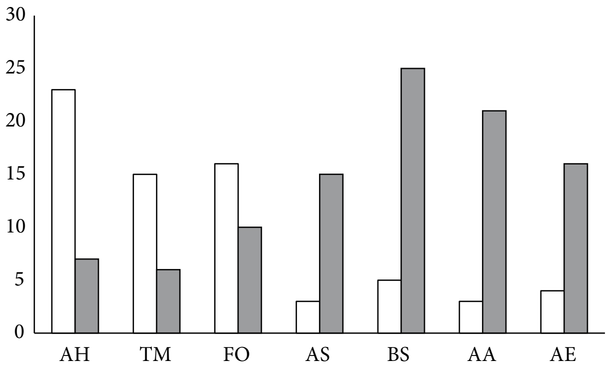

Figure 3. Percent cover of dominant plant species in burrow plots (white columns) and paired plots (dark columns). Acronyms: *Artemisia herba-alba* (AH), *Trifolium montanum* (TM), *Festuca ovina* (FO), *Acantholimon senganense* (AS), *Bromus scoparius* (BS), *Acantholimon acerosum* (AA), and *Acantholimon embergeri* (AE).

climate, and elevation are the main factors affecting rodent distribution in Turkey. The association of small rodents with vegetation variables that provide greater cover and more feeding items has also been shown in other studies (Murúa and González, 1982; Shenbrot, 2004). The positive correlation between the presence of Williams' Jerboa and some plant species such as *Festuca ovina* and *Trifolium montanum* may be related to their high nutritional value (for their crude protein content) (Ghanbari and Sahraei, 2012), but behavioral mechanisms in avoiding or using different vegetation structures should be considered. A recent investigation on Hotson's jerboa also showed that while this species selects more barren areas for activity, it selects the *Hamada salicornica* vegetation type during the new-moon periods, which indicates the role of feeding behavior in its habitat utilization (Naderi et al., 2014). Naderi et al. (2014) also showed that coverage with bare soil and the presence of *Hamada salicornica* were significantly higher in plots where the species was present than in random plots. Therefore, selecting less vegetation percent cover is an antipredatory mechanism that facilitates better and faster entrance to the burrows. Such a conclusion is also obvious from the jerboa avoiding herbal and shrub species with a broad crown and very low height, such as *Acantholimon* sp., which act as a barrier in faster bipedal locomotion and faster entrance to the burrows.

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