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ORIGINAL ARTICLE

Vegetative habitat selection of Scimitar horned oryx (*Oryx dammah*) in Bouhedma National Park, Southern Tunisia

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Habitat selection;
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Abstract The present study aims to analyze the habitat selection of the Scimitar horned oryx, reintroduced in Bouhedma National Park (south Tunisia) and to identify the phytoecological factors affecting their occurrence during winter 2011 and spring 2012. Multivariate analyses of variance (MANOVA) performed by SAS package revealed that the vegetation is not the main factor in the selection of habitat by oryx in the park. It avoids glaze and mountain areas despite the presence of palatable species.

1. Introduction

The world is currently facing an unprecedented loss of biodiversity, hundreds of species already driven to extinction by anthropogenic and climatic changes, and thousands more predicted to become extinct in the next few decades (Lande, 1993). In Tunisia, animal diversity has experienced huge losses affecting several species. The most striking example is the Scimitar horned oryx (*Oryx dammah*: Class mammalian, order ungulata) which is classified as Extinct in Wild (IUCN, 2008) after the degradation of their native habitats (Kacem et al., 1994). Historically, the Scimitar horned oryx was largely distributed along the fringes of the northern and southern sub-desert (Devillers and Devillers-Terschuren, 2003), particularly in arid landscapes bordering Saharan habitats (Gilbert et al., 2012). Scimitar horned oryx can be found in a variety of habitats types including, grassy steppes, rolling dunes and wooded inter-dunal depressions (IUCN, 2008). The main reasons for the decline of this ungulate species in its native range are overhunting, droughts and habitat loss, including competition with domestic livestock (Mallon and Kinkswood, 2001; Devillers and Devillers-Terschuren, 2006).

In Tunisia, Scimitar horned oryx occurred across southern steppes, but disappeared by 1910 due to overhunting. Since its independence in 1956, the Tunisian Government has been engaged in the rehabilitation of Scimitar horned oryx population through the development of appropriate legislation, signing the convention on Migratory species (CMS) (Beudels-Jamar et al., 2006; DGF, 2001; Woodfine and

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Engel, 2005) and creation of a network of protected areas in which several operations of reintroduction of this ungulate were performed (Karem, 2001), starting with reintroduction of 10 (5 males and 5 females) Scimitar horned oryx in the Bouhedma National Park in 1985 (Wacher, 1986). The population grew to a point when ungulates exerted pressure on the canopy, especially, on grassland species. A number of questions were subsequently raised concerning the space use, the social and food behavior and the relationship of Scimitar horned oryx with environment. Furthermore, studies on habitat selection and habitat use patterns are essential for understanding the strategies of animals to fulfill their needs (Manly et al., 2002). They are also crucial for conservation and management strategies (Scott et al., 2002; Guisan and Thuiller, 2005) that can reduce the negative effects of plant damage caused by inadequate population densities (Heinzea et al., 2011).

However, information about habitat selection by oryx in Tunisian protected areas is scarce and insufficient to develop such conservation and management strategies for the animal. The present study was designed to understand the preference of Scimitar horn oryx in Bouhedma National Park with the hypothesis that occurrence of oryx depends on the vegetation type. The main objectives were: (1) to relate patterns of habitat selection by Scimitar horned oryx with vegetative cover characteristics, and (2) to identify the most attractive plants for the oryx in the park.

2. Material and methods

2.1. Study area

This research work was carried out in the protected area No. 1 (5115 hec) of Bouhedma National Park which covers a total of 16,488 hec (Fig. 1). This park is situated in the central Tunisia (34°24′–34°32′ NL; 09°23′–09°41′ E) and located along the southern Tunisian mountain ranges which are extensions of the Saharan Atlas (Abdelkebir, 2005). The altitude varies between 90 m and 814 m above sea level. The climate is arid with mild winters. The park is characterized by an extremely irregular spatiotemporal rainfall pattern with an annual average rainfall of about 150 mm.

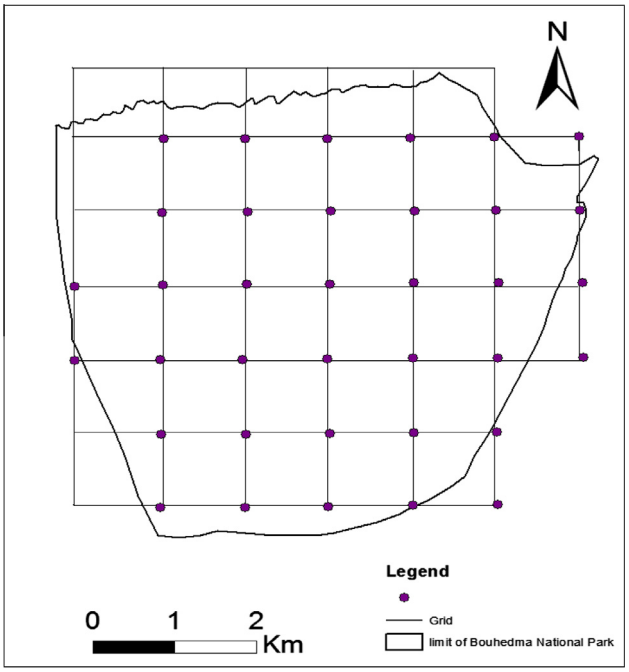


Figure 2 Sampling unit map of Bouhedma National Park.

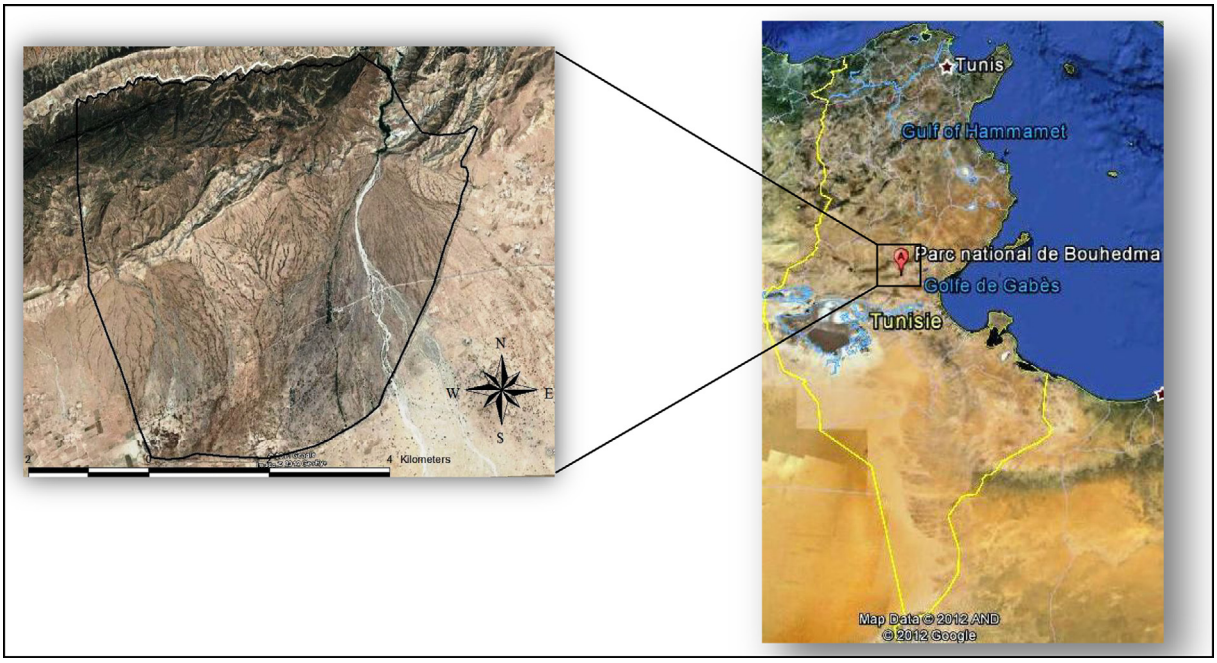
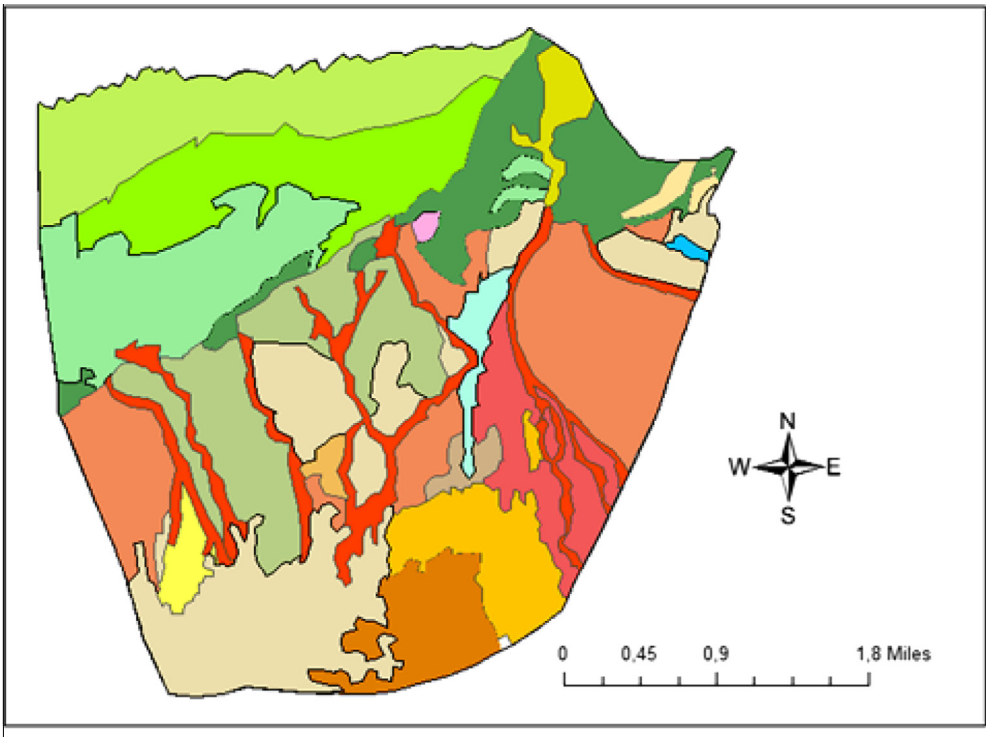


Figure 1 Geographic location of the study area.

Bouhedma National Park is considered as a transition zone which holds Mediterranean, pre-Saharan and Saharan animal species. The animal species of the park include some reintroduced species, such as, *Oryx dammah*, *Addax nasomaculatus*, and *Gazella dorcas*, and several indigenous species, like, *Ctenodactylus gundi*, *Jaculus deserti*, *Canis aureus* and *Vulpes rueppellii* (Müller, 1994). The park also houses *Sus scrofa*, *Lepus capensis*, *Rattus norvegicus* and 16 other rodent species. The total number of Scimitar horned oryx in the study area was 31 (5 males and 26 females).

On the mountainous massif, vegetation is dominated by forest species such as *Juniperus phoenicea*, *Periploca angustifolia*, *Rhus tripartitum*, *Olea europaea*, *Rosmarinus officinalis* and *Stipa tenacissima*. *Artemisia herba-alba*, *Anarrhinum*



Legend

- limit of the park
- Anarrhinum brevifolium and Moricandia suffruticosa
- Artemisia herba alba and Hamada scoparia
- Phoenix dactylifera Colony
- Eucalyptus
- Gymnocarpos decander and Atractylis serratuloides
- Gymnocarpos decander and Helianthemum kahiricum
- Hamada schmittiana and Echiochilon fruticosum
- Hamada schmittiana and Hamada scoparia
- Hamada schmittiana and Rhanterium suaveolens
- Exotic plantation
- Nursery
- Retama raetam
- Rhanterium suaveolens and Artemisia campestris
- Stipa tenacissima
- Stipa tenacissima , Periploca angustifolia and Rhus tripartitum
- Stipa tenacissima and Rosmarinus officinalis
- Stipa tenacissima, Gymnocarpos decander and Helianthemum kahiricum
- Stipa tenacissima, Jenuperus phoenicia and Olea europaea
- Ziziphus lotus and Retama raetam

Figure 3 Vegetation map of Bouhedma National Park (Tarhouni, 2003).

Table 1 MANOVA analysis of the occurrence plant groups (PG) in Scimitar horned oryx unoccupied and occupied sites in Bouhedma National Park.

Plat group	Unoccupied sites (n = 22)		Occupied sites (n = 13)		F	P
	Mean	SE	Mean	SE		
PG1	3.33	2.34	13.84	7.78	3.95	0.05
PG2	3.06	1.75	14.30	5.31	5.44	0.02*
PG3	0.14	0.14	0	0	0.62	0.4
PG4	1.3	0.86	0	0	0.71	0.4
PG5	0.08	0.08	1.15	1.02	2.11	0.15
PG6	9.02	4.68	21.83	8.24	1.91	0.17
PG7	0	0	10.26	6.63	3.94	0.05
PG8	0.38	0.38	0	0	0.61	0.43
PG9	0	0.26	9.76	6.73	3.46	0.07
PG10	0.26	0.6	0	0	0.61	0.43
PG11	0.6	1.49	0.91	0.91	1.65	0.2
PG12	4.60	3.54	7.84	2.43	1.22	0.27
PG13	3.54	6.3	3.15	2.19	0.01	0.91
PG14	21.06	5.81	4	3.29	4.28	0.04*
PG15	15.98	3.81	0	0	4.69	0.03*
PG16	12.67	3.80	0	0	5.71	0.01*
PG17	7.46	3.65	10.30	5.39	0.15	0.15
PG18	16.27	6.1	0	0	4.41	0.04*
PG19	0.09	0.09	2.59	2.22	2.07	0.16

With: PG1: *Anarrhinum brevifolium* and *Moricondia suffruticosa*, PG2: *Artemisia herba alba* and *Haloxylon scoparium*, PG3: *Phoenix dactylifera*, PG4: *Eucalyptus*, PG5: *Gymnocarpus decanter* and *Atractylis serratuloides*, PG6: *Gymnocarpus decanter*, PG7: *Haloxylon schmittianum* and *Echichilon fruticosum*, PG8: *Haloxylon schmittianum* and *Haloxylon scoparium*, PG9: *Haloxylon schmittianum* and *Rhanterium suaveolens*, PG10: *Nursery plants*, PG11: *Exotic plantation*, PG12: *Retama raetam*, PG13: *Rhanterium suaveolens* and *Artemisia campestris*, PG14: *Stipa tenacissima*, PG15: *Stipa tenacissima* and *Periploca angustifolia*, PG16: *Stipa tenacissima* and *Rosmarinus officinalis*, PG17: *Stipa tenacissima* and *Gymnocarpus decanter*, PG18: *Stipa tenacissima*, *Juniperus Phoenicea* and *Olea europa*, PG19: *Ziziphus lotus* and *Retama raetam*.

* Significant difference: $p < 0.05$.

Table 2 STEPDISC analysis of difference in occurrence of different plant groups (PG) in Scimitar horned oryx occupied and unoccupied sites of Bouhedma National Park.

Plant group	Unoccupied sites (n = 22)		Occupied sites (n = 13)		F	P
	Mean	SE	Mean	SE		
PG1	2.93	2.34	12.64	7.72	3.95	0.05
PG2	3.06	1.75	14.15	4.81	5.44	0.12
PG3	0.14	0.14	0	0	0.62	0.36
PG4	1.29	0.86	0	0	0.71	0.39
PG5	0.08	0.08	1.23	1.32	2.11	0.12
PG6	8.02	4.68	18.97	8.02	1.91	0.19
PG7	0	0	10.03	6.53	3.94	0.10
PG8	0.28	0.38	0	0	0.61	0.48
PG9	0	0.26	9.76	5.53	3.46	0.07
PG10	0.16	0.6	0	0	0.61	0.23
PG11	0.6	1.49	0.91	0.91	1.65	0.24
PG12	3.60	3.54	8.64	2.43	1.22	0.21
PG13	4.64	6.3	3.53	2.19	0.01	0.81
PG14	19.86	5.81	4	3.29	4.28	0.022*
PG15	13.78	3.81	0	0	4.69	0.017*
PG16	11.67	3.80	0	0	5.71	0.033*
PG17	7.46	3.65	9.95	5.39	0.15	0.14
PG18	15.27	6.1	0	0	4.41	0.038*
PG19	0.12	0.1	2.67	2.45	1.17	0.21

With: PG1: *Anarrhinum brevifolium* and *Moricondia suffruticosa*, PG2: *Artemisia herba alba* and *Haloxylon scoparium*, PG3: *Phoenix dactylifera*, PG4: *Eucalyptus*, PG5: *Gymnocarpus decanter* and *Atractylis serratuloides*, PG6: *Gymnocarpus decanter*, PG7: *Haloxylon schmittianum* and *Echichilon fruticosum*, PG8: *Haloxylon schmittianum* and *Haloxylon scoparium*, PG9: *Haloxylon schmittianum* and *Rhanterium suaveolens*, PG10: *Nursery plants*, PG11: *Exotic plantation*, PG12: *Retama raetam*, PG13: *Rhanterium suaveolens* and *Artemisia campestris*, PG14: *Stipa tenacissima,* PG15: *Stipa tenacissima* and *Periploca angustifolia*, PG16: *Stipa tenacissima* and *Rosmarinus officinalis*, PG17: *Stipa tenacissima* and *Gymnocarpus decanter*, PG18: *Stipa tenacissima*, *Juniperus Phoenicea* and *Olea europa*, PG19: *Ziziphus lotus* and *Retama raetam*.

* Significant difference: $p < 0.05$.

brevifolium, *Gymnocarpus decanter* and *Helianthemum kahiricum* colonize the piedmont. The flat area is dominated by pseudo-savannah vegetation with *Acacia tortilis raddiana* as the only tree species, and understorey stratum is dominated by species, like, *Rhanterium suaveolens*, *Cenchrus ciliaris*, *Haloxylon schmittianum*, *H. scoparium* and *Salvia aegyptiaca* (OuledBelgacem et al., 2013).

2.2. Measurement and data collection

Scimitar horned oryx was systematically monitored for 10 days every month between November 2011 and April 2012. The survey was conducted during morning and evening sessions. The study area was divided into a number of sampling units (1 km^2: Fig. 2) according to the stratified sampling theory (Maling, 1989), and the oryx was recorded on presence (1: tracks or droppings) and absence (0) basis in each sampling unit (Dajoz, 1996). This method seems to be effective, especially when applied on a small population (Vaucher, 1988).

Vegetation cover data were extracted from the phyto-ecological map of the park developed by Tarhouni (2003) (Fig. 3).

2.3. Statistical analysis

Multivariate analysis of variance (MANOVA) using general linear model (GLM) procedure was used for data analysis exploiting the SAS statistical package (SAS Institute, 1998). The plant communities were taken as original variables. We calculated their proportions in each sampling unit.

A canonical discriminant analysis was also performed with SAS statistical package in order to verify the results of MANOVA and to evaluate the significance of importance variables in explaining the occurrence distribution pattern of oryx.

3. Results

The effect of plant communities on the occurrence of Scimitar horned oryx is shown in Table 1.

MANOVA analysis showed a significant difference between the occupied and the unoccupied sites (Wilks' Lambda = 0.1815, $F_{14,19} = 3.32$, $P = 0.0132$). PG2 ($P = 0.02$), PG14 ($P = 0.04$), PG15 ($P = 0.03$), PG16 ($P = 0.01$) and PG18 ($P = 0.048$) plant groups were significantly associated with oryx unoccupied tracts, all holding *Stipa tenacissima*. It appears that Scimitar horned oryx doesn't use the sites having a cover of this perennial grass.

The evaluation of discriminant capacities of the different plant groups using "*STEPDISC*" analysis (Table 2) reveals that PG14 ($P = 0.022$), PG15 ($P = 0.017$), PG16 ($P = 0.033$) and PG18 ($P = 0.038$) plant groups are different between the occupied and the unoccupied sites. Following this analysis, PG2 has been excluded.

The examination of the important different variables using *DISCRIM* PROC analysis (Table 3) indicates that PG14, PG15, PG16 and PG18 are highly discriminating variables (Wilks' Lambda = 0.18, $F = 3.82$, $P = 0.004$, canonical correlation coefficient = 0.90) confirming MANOVA and STEPDISC results.

On the basis of the results obtained, the spatial distribution of oryx in Bouhedma National Park seems to be related to some plant groups. We have noted that the areas not frequented by oryx (unoccupied sites) were all marked by the presence of *Stipa tenacissima* plant. This plant appears to be rejected by the animal despite its known high palatability. This finding allowed us to reject our starting hypothesis and to consider that vegetation cover cannot be the determinant factor of habitat selection by oryx in the park. However, as this palatable plant grows generally in piedmonts and in mountains, we considered that at that stage of study elevation might be the major determinant factor in oryx distribution.

Table 3 Occurrence probability of Scimitar horned oryx according to the plant groups of Bouhedma National Park: "*DISCRIM*" analysis.

	Occupied sites ($n = 13$)		Unoccupied sites ($n = 22$)		F	P
	Mean	SE	Mean	SE		
PG14	3.71	11.46	2.06	29.56	4.36	0.04*
PG15	0	0	15.98	27.28	4.75	0.03*
PG16	0	0	11.47	17.77	5.77	0.02*
PG18	0	0	16.27	18.62	4.48	0.04*

With: PG1: *Anarrhinum brevifolium* and *Moricondia suffruticosa*, PG2: *Artemisia herba alba* and *Haloxylon scoparium*, PG3: *Phoenix dactylifera*, PG4: *Eucalyptus*, PG5: *Gymnocarpus decanter* and *Atractylis serratuloides*, PG6: *Gymnocarpus decanter*, PG7: *Haloxylon schmittianum* and *Echichilon fruticosum*, PG8: *Haloxylon schmittianum* and *Haloxylon scoparium*, PG9: *Haloxylon schmittianum* and *Rhanterium suaveolens*, PG10: *Nursery plants*, PG11: *Exotic plantation*, PG12: *Retama raetam*, PG13: *Rhanterium suaveolens* and *Artemisia campestris*, PG14: *Stipa tenacissima*, PG15: *Stipa tenacissima* and *Periploca angustifolia*, PG16: *Stipa tenacissima* and *Rosmarinus officinalis,* PG17: *Stipa tenacissima* and *Gymnocarpus decanter*, PG18: *Stipa tenacissima*, *Juniperus Phoenicea* and *Olea europa*, PG19: *Ziziphus lotus* and *Retama raetam*.
* Significant difference: $p < 0.05$.

4. Discussion

Studying habitat selection by Scimitar horned oryx is fundamental for its management and conservation of this ungulate in a protected area, such as Bouhedma National Park. The research was designed to determine the influence of plant groups on the habitat use by oryx. The present collected results show that oryx abundance is associated with vegetation type (Cooke et al., 2014). Zweifel-Schielly et al. (2009) recorded the importance of access to and/or availability of good quality forage in habitats selected by ungulates. Freitas et al. (2008) highlighted the importance of the analysis of the vegetation attribute in comparison.

However, our results suggested that vegetation is not the key factor affecting habitat selection by oryx in Bouhedma National Park. It turns out that Scimitar horned oryx population tends to use the plain of the park covering more than 2000 hectares and avoids the areas with high and medium elevation despite the presence of palatable plant, like, *Stipa tenacissima* (especially in drought periods) (Caron, 2001), and *Helianthemum sp*. Other plants, as *Retama raetam* and *Periploca angustifolia*, growing in the piedmonts and the mountain provide refuge area to Scimitar horned oryx. Kacem et al. (1994) indicated the importance of *Stipa tenacissima* and *Stipagrostis*

steppes characterizing the mountains and the glaze of Bouhedma National Park (Tarhouni, 2003) in the reintroduction of oryx in the Mediterraneo-Saharan fringe. The present results support those of Beudels-Jamar et al. (2006) who consider that Scimitar horned oryx as a typical species of steppe and grasslands bordering desert areas. It often avoids significantly mountainous areas and prefers flat deserts over hilly or stone deserts (Dolan, 1996). Abáigara et al. (2013) have also suggested the tendency of dorcas gazelle (*Gazella dorcas*) to prefer open plain areas, an adaptation for an early detection of predators (jackals). Indeed, herbivores choose generally their habitats both to maximize forage intake and to minimize their risk of predation (Riginos and Grace, 2008). It has been proved that predation can be a major obstacle to the reintroduction and the conservation of these ungulate in protected areas (Dhaoui et al., 2008; Dunham, 1997).

On the other hand, the plain area of Bouhedma National Park, marked by silty and sandy soils, is more comfortable for the displacement of Scimitar horned oryx than mountains and piedmonts (high elevation). We conclude that scimitar-horned oryx selects lower wadis and plains due to richer habitat, shade and lower predation risk rather than directly due to the effects of altitude. Further, it has been reported that the abiotic components of habitat, such as, climate and elevation, influence habitat selection at a large-scale, while the biotic factors, such as, food quantity and quality, affect habitat selection at small scales (Senft et al., 1987; Bailey et al., 1996). Finally, the measurement of habitat conditions including food availability and biological requirements of the species, as well as predators, competitors and parasites is important to determine the persistence of a reintroduced population (Amstrong and Seddon, 2008) and to be aware of the degree of success of introduction projects.

5. Conclusion

The results obtained allowed us to conclude that at a larger scale vegetation is not the determinant factor in the habitat selection of Scimitar horned oryx in Bouhedma National Park. It is mainly controlled by other factors such as elevation and predation. Therefore, a quantitatively assessment of the vegetation cover/type asses in the plain of the park could be more effective in the determination of the role of plant cover in habitat selection by Scimitar horned oryx.

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