Acta Theriologica 50 (3): 405–415, 2005.
PL ISSN 0001–7051

Evaluation of habitat use of a semi-captive population of Cuvier's gazelles *Gazella cuvieri* following release in Boukornine National Park, Tunisia

Teresa ABAIGAR, Mar CANO and Mounir SAKKOUHI

Abaigar T., Cano M. and Sakkouhi M. 2005. Evaluation of habitat use of a semi-captive population of Cuvier's gazelles *Gazella cuvieri* following release in Boukornine National Park, Tunisia. Acta Theriologica 50: 405–415.

Thirteen Cuvier's gazelles were relocated to a 6-ha acclimatization enclosure in Boukornine National Park (Boukornine NP) in Tunisia, where they are part of a reintroduction project. To determine the degree of adaptation and habitat use under the new conditions, the acclimatization enclosure was divided into 6 sections according to topography, plant cover and plant species in the area. Signs of gazelle activity were coded as feeding site, paths, passages, feces and resting places. Sampling was done in spring, summer and autumn from September 2000 to July 2001. Multivariate analysis using PATN analysis and χ^2 distribution tests were used to analyze the data. Multivariate analysis yielded 5 groups of biotopes according to the above variables. The χ^2 distribution test showed the significant effect of each variable on the presence of signs of gazelles. Cuvier's gazelles prefer areas with low and west to north facing slopes and scant plant cover; animals are attracted to the proximity of the fence as the limit of their territory and even though the presence of humans does not represent a disturbance, gazelles select areas far (> 50 m) from the supplementary feeding and water supply for their activities.

Estación Experimental de Zonas Áridas, Consejo Superior de Investigaciones Científicas, C/ General Segura 1, 04001-Almería, Spain, e-mail: abaigar@eeza.csic.es (TA); Estación Experimental de Zonas Áridas, Consejo Superior de Investigaciones Científicas, C/ General Segura 1, 04001-Almería, Spain (MC); Direction Général des Fôrets Ministére de la Agriculture, 30 Rue Alain Savary, 1002-Tunis, Tunisie (MS)

Key words: *Gazella cuvieri*, habitat use, reintroduction, Tunisia

Introduction

The Cuvier's gazelle *Gazella cuvieri* (Ogilby, 1840) is a medium-sized ungulate living in the mountain and hilly areas of the Atlas Mountains of Morocco, Algeria and Tunisia. *G. cuvieri* were widely spread across their historical range (Beudels--Jamar *et al*. 1998) until the middle of the 20th century, when numbers began to decline dramatically and the total population became fragmented (De Smet 1988, 1991, Kacem *et al*. 1994, Cuzin 1996). As with other species of endangered, even extinct, north African ungulates, decline during the last century was due mainly to over-hunting and to the degradation of habitat generated by human activities of farming, livestock and deforestation. The conservation status of the Cuvier's gazelle is "Endangered" (IUCN 1996).

The knowledge of wild populations of Cuvier's gazelles is scarce and limited to the general distribution and conservation status of the species (De Smet 1988, 1991, Sellami *et al*. 1990, Loggers *et al*. 1992, Aulagnier *et al*. 2001) biology and ecology in reduced areas of their range such as the Mergueb Reserve in Algeria (Sellami 1998) and southern Morocco (Cuzin 2003). This lack of studies is due in part to the strong effort needed to monitor this very rare and elusive species which lives in mountainous areas in small family groups. Direct observation of individuals is very difficult and costly, and the use of indirect methods may be the only realistic alternative for study of this species.

Most animals leave a repertory of signs (tracks, resting places, fecal deposits, etc.), which reveal the majority of activities (movement, resting, territoriality, scent communication, etc.) within the habitat. By systematically monitoring these signs and combining them with descriptions and characterization of the habitat, considerably little effort is required for their ecological study.

Until the 1930's, Cuvier's gazelles in Tunisia were distributed throughout most of the mountainous areas from the north (Atlas Tellien), through the Atlas Mountains (Djebel Tamesmida, Dj. Chambi, Dj. Semmana) to the area of Gafsa and Djebel Orbata-Bou Hedma, and even penetrated as far as the hills around the southern chotts (Djebel Tebaga and adjacent areas) (Sclater and Thomas 1894–1900, Joleaud 1929). Cuvier's gazelles disappeared from Djebel Boukornine near Tunis in 1936 (Lavauden 1932, Kacem *et al*. 1994) and since the 1960's, the only stable populations are those around Djebel Tamesmida-Châmbi-Semmana (Kasserine region) in the center of Tunisia near the Algerian border. The total number of animals is uncertain but estimates place populations at between 30 and 300 individuals (M.N. Forester, pers. comm., Kacem *et al*. 1994). To avoid their complete extinction, as well as that of other species, the National Parks of Châmbi and Boukornine were created in 1980 and 1987.

A captive breeding group of Cuvier's gazelles is maintained in the Rescue Park for Saharan Fauna (RPSF), a center belonging to the Arid Zones Experimental Station (AZES) (Spanish Research Council) in Almería, Spain. The RPSF was created in 1971 for the purpose of preserving several endangered North African ungulates, Mohor gazelles *Gazella dama mhorr*, Cuvier's gazelles *G. cuvieri*, Dorcas gazelles *G. dorcas neglecta* and the Saharan Barbary sheep *Ammotragus lervia sahariensis* from extinction. The RPSF founder population of Cuvier's gazelles originally came from the north of Western Sahara (ex-Spanish colony), south of the Oued Draa Valley (see Alados *et al*. 1988 and Escós 1993 for history of this species). In December 2001 the global captive population of Cuvier's gazelles was 239 of which 78 were in the RPSF, 5 in the Tabernas Desert Thematic Park (Almería, Spain), 10 in the Rabat-Temara Zoo (Morocco) and the remainder, 146 gazelles, in several North American zoos (Abáigar and Cano, in press). Except for those in Morocco, the founders of this global captive population are 2 males and 2 females captured in the Western Sahara in 1975 (Escós 1993).

The General Director of Forestry, Ministry of Agriculture of Tunisia, contacted the AZES in 1998 concerning the initiation of a reintroduction program for this species in Boukornine NP. This contact followed a series of previous successful relations between the institutions that began with the reintroduction of Mohor gazelles in Bou-Hedma National Park in 1994 (Abáigar *et al.* 1997). In December 1999, seventeen (5 male and 12 female) Cuvier's gazelles from the RPSF in Almería (Cano and Abáigar 2000), representing 22.6% of the captive population of the Cuvier's gazelle in Spain, were reintroduced in Boukornine National Park.

The main reproductive herd was initially relocated to an acclimatization enclosure (AE) in Boukornine N.P. to control their familiarization with the new habitat. Even though the AE is only 6 ha and cannot be considered a large range, it was still a significant change from their original small 300–800 m^2 enclosures, in which there was no natural vegetation for food and intense human manipulation. These new conditions of semi-captivity are essential to ensure the future acclimation of the animals to the wild. The AE location includes representative and proportional biotopes found in Boukornine NP and its size is appropriate for secure monitoring of the animals in a mountainous area. Our research has two purposes: (1) to describe the acclimation response of a reestablished population of Cuvier's gazelles to a new habitat and their use of that habitat, and (2) to show how an indirect method of sampling along with pattern analysis of habitat heterogeneity could be employed to study habitat use in gazelles.

Study area

The study was conducted in Boukornine National Park, officially created in 1987. Djebel Boukornine (36°38'–36°44'N; 10°17'–10°25'E) is an isolated massif located in the eastern part of the Tunisian Dorsal (Atlas Tellien) 17 km from Tunis; it occupies 1939 ha and the maximum altitude is 576 m. The climate is subhumid Mediterranean with mild winters and, depending on the altitude, an average rainfall of 400–600 mm (D.G.F. 1985, Sakkohui 1986). Dominant vegetation is a natural Thuya forest (*Tetraclini articulata*), wild olive bushwood *Olea europaea* and *Pistacia lentiscus* with some areas reforested with *Pinus halepensis*. Up to 48 species of trees and shrubs have been described in Boukornine National Park (D.G.F. 1985, Sakkohui 1986) including *Callicotum villosum*, *Rosmarinus officinalis*, *Globularia alypum*, *Cystus albiflorus*, *Cystus monspelliensis*, *Erica arborea*, *Erica multiflora*, *Thymus*, *Helianthemum*, and *Cyclamen persicum*, a well-protected endemic. Large mammals in the study area are wild boar *Sus scrofa*, jackal *Canis aureus*, red fox *Vulpes vulpes atlantica*, African wild cat *Felis silvestris libyca* and hare *Lepus capensis kabylicus*, as well as a small population of reestablished Barbary sheep *Ammotragus lervia*.

Material and methods

The animals

Seventeen Cuvier's gazelles (5 males, 12 females) were transported by plane from Almería (Spain) to Tunis (Tunisia) in December 1999. The selection of animals was based on inbreeding criteria, sex-ratio, age and social stability; age varied from several-months-old to 4-year-old males and females up to 8 years old. A pair of gazelles was placed in an enclosure in the Aďn Zerga exhibition area, and two other males were placed in isolated enclosures for future reproduction. The remainder (2 males, 11 females) were released in the AE. Ages of the group in the AE varied from fifteen months to 8 years old in females, and 2 males were 20 months and 5 years old. Natural food in the form of local plants (*Oxalis*, *Senecio*, *Rumex*, *Stelaria*, *Tripholium*, *Acacia*, *Avena*, *Malva*, *Vicia*, *Medicago* and several species of grasses) was supplemented twice a day. The feeding area was located directly in front of the AE gate; water and mineral salts were also provided *ad libitum* at 2 different places within the AE (Fig. 1).

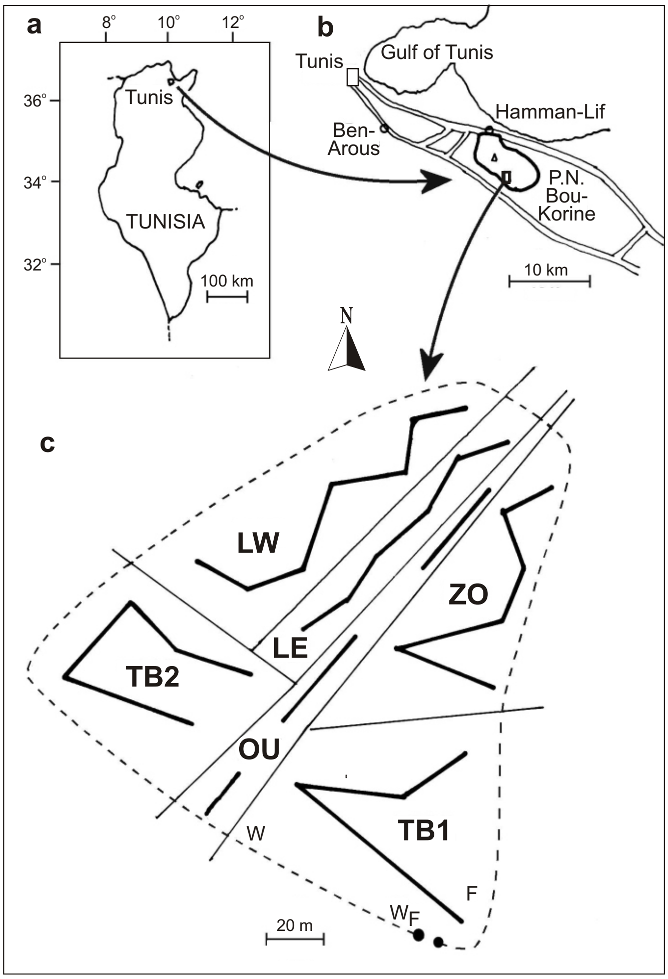

Fig. 1. The study area: (a) Tunisia, (b) location of Boukornine National Park, (c) scheme of the acclimatization enclosure; dashed line: fence, thin lines: separation of the six sections (TB1, TB2, ZO, LE, LW, OU), thick lines: transects surveyed inside each section, W – water points, F – supplementary feeding points.

The acclimatization enclosure

A 6-ha acclimatization enclosure (AE) was built with a 2-m-high wire fence to hold the animals in the "Abab" zone of Boukornine NP near a post-control point. All the various biotopes found within the Park were represented in the enclosure. Inside the AE, there was a shelter, feeding area, several watering areas, salt licks, and a small capture enclosure. No other species of large mammals were present in the AE where use of habitat by reestablished Cuvier's gazelles was studied. The enclosure was divided into 6 sections according to physiographic characteristics and vegetation in order to monitor the gazelle's use of habitat within the AE. Proximity of gazelles to the *ad libitum* food feeding and water supply and the fence were also assessed. The 6 sections were as follows: TB1: flat area that included the feeding area and water supply; natural vegetation with reforested pine; TB2: similar to TB1 but far from the feeding area; ZO: northwest, facing the "oued" (dry river), with high slopes; dominant vegetation was thuya trees over 3 meters high with dense cover; LE: southeast, facing the "oued", with high slopes and stony area with thuya trees less than 2 meters high and shrubs (*Erica arborea*, *Genista*, *Rosmarinus officinalis* and *Globularia alypum)*; LW: similar to LE but facing west; OU: "oued" bottom area, connecting the rest (Fig. 1).

Observations

Habitat preference of gazelles was assessed by recording signs of activity such as tracks, fecal deposits, resting places and paths in each of the six transects, one per sector. Feeding activity and food selection was also observed. To avoid double counting in subsequent samplings, tracks and resting places were destroyed and fecal deposits were removed after sampling. The transects were selected so as to cover all the physical and vegetation characteristics present within the study area representatively and proportionally. The total transect length was 750 m and the area sampled was 3750 m^2 (6.25% of the total area of the AE); all signs present within 2.5 m on each side were recorded. Each transect was divided into 5 × 5 m plots in which the presence or absence of signs of the gazelles was recorded. This method of indirect sampling had previously been proven effective in the study of habitat preference in other species (Abáigar *et al*. 1994). Seasonal data (spring = May; summer = July and September; autumn = November) were the following variables for each area occupied (1) slope (low < 30°, high > 30°), orientation (north: 315°–45°, east: 45°–135, south: 135°–225°, west: 225°–315°), (3) proximity to the fence, food and water supply (< 50 m >) and (4) vegetation cover estimated subjectively by a score of 1–5 (scant < 3, dense > 3). Additional specific information was obtained on habitat use relative to specific species of trees, shrubs and grasses.

Data analysis

The subset of plots showing signs of activity of Cuvier's gazelles was determined by the multivariate space used by them. A multivariate analysis was performed on this subset of plots showing gazelle activity to examine their habitat preference. The variables were recorded in a binary format resulting in a data matrix of 406 observations (sighting of gazelle signs) by 34 variables. The analysis was carried out in three steps using the PATN software package (Belbin 1991): (1) a non-hierarchical classification (NH) of observations with the ALOC ("allocation") algorithm (Belbin 1987). In this procedure the first observation in the matrix was arbitrarily chosen as the only seed and the objects (observations) are allocated to groups according to the weights of their descriptors. Later, the group centroids were fused using the Sequential-Agglomerative-Hierarchical-Combinatorial (SAHN) flexible (UPGMA) classification (Belbin 1991). A reduced set was defined from that hierarchy, in which the clustered objects actually refer to groups, not to observations. Group definitions were then expanded to present a final summary of groups of observations. (2) Principal Coordinates Analysis (PCoA) of observations to test the agreement between classification and ordination of observations, and (3) Principal Coordinates Analysis of variables, to define the main orthogonal gradients controlling the presence of gazelles. Habitat use was also tested for availability using an χ^2 test or a two-dimensional contingency table with the Statistic for Windows (Statsoft UK, Letchworth) software package.

Results

The non-hierarchical classification of the 409 observations yielded 22 groups; these 22 groups were later reduced to 5 by clipping the SAHN clustering dendrogram at the appropriate level; the 5 groups define different biotopes according to their attributes as follows: Group 1 had the highest proportion of observations (48.7%) throughout the year. This group defined a biotope with low slopes, less vegetation cover, near a fence but far from food and water supply. In this biotope, paths were the main sign of gazelles and the dominant plant species were thuya and wild olive trees; foraging in this biotope was also an important activity. This group was identified with the sections labeled TB1 and TB2 as the only sections having reforested pines. Moreover, these sections showed heavy gazelle activity, all the different signs of their presence having been recorded there. The effect of browsing was very noticeable in thuya and wild olive trees and also, but less so, in *Pistacia lentiscus*, as confirmed after 1.5 years since their reestablishment.

Group 2 had 11.5% of the observations and was recorded mainly in autumn. The biotope defined by this group had lower slopes and a western orientation, cover vegetation was scant and proximity to the fence was not significant. The majority of signs were found far from the food and water supply. Thuya and wild olive trees were the dominant species of vegetation. The presence of pine in this biotope identifies it as sections TB1 and TB2, but the difference between it and those defined by Group 1 was that in Group 2 the signs identified were collected in autumn when the presence of annual plants and moss was important in the gazelle's food selection.

Group 3 had 28.1% of the observations which corresponded with signs collected all year long, but mainly in autumn on northern slopes. This group defined a biotope characterized by low slopes and little vegetation cover. It was located far from the fence and from the food and water supply. The dominant vegetation was thuya, *Rosmarinus officinalis*, *Erica arborea*, *Globularia alypum* and moss. The presence and abundance of these plants identified sections LE and LW, with no pine and scarce presence of wild olive trees. These areas showed frequent signs of activity as *Globularia alypum* was one of the plants most commonly consumed by gazelles.

Group 4 had only 6.1% of the signs of gazelle activities. This group included signs found in the summer in northern and western orientations. The slope was low with little vegetation cover. All the signs were found close to the fence and near the food and water supply. These characteristics, combined with the presence of pines in the area, defined sections as TB1 and TB2. The presence of thuya and wild olive trees was also important. Paths were the most important signs of gazelle activity.

Group 5 also had few signs (5.4%) of gazelle activities. This group included signs found in the summer in an area with low slope and dense vegetation cover, near the fence and far from the food and water supply. This area was identified as a passage from ZO to "oued" and LW, which was the area where plant cover was densest, since 62% of observations were paths.

The ordination of the 5 groups after the PCoA demonstrates that Groups 3, 4 and 5 are clearly independent and isolated from each other; Groups 1 and 2 overlap with the two sectors having the highest number of gazelle signs throughout the year and were distinguished only by the proximity to the food and water supply.

Factor loading of variables (PCoA analysis) on the first three axes accounts for 57.6% of variance. The values along the first axis ("x") explain 24.4 % of the variance. The first axis is associated with the different species of plants in the AE; on the right-hand side of the axis, plants are characteristic of sunny, exposed areas, *Erica arborea*, *Globularia* and *Callicotum*, and at the other end (left) pines are the characteristic species; proximity to the fence and orientation (north *vs.* west) are other important variables loading variability, but are less important than plant species. Values along the second axis ("y") explain 19.5% of the variance; this axis is associated with slope, high at the top and low at the bottom. Cover vegetation and some of the plant species (*Helianthemun* and thuya) account for some of the variability on this axis. The values along the "z" axis account for 13.7% of the variance and are mainly associated with season.

Habitat preference and activity of Cuvier's gazelle

Habitat preference of Cuvier's gazelle was assessed by observing how animals responded to variations in topography, season, plant cover and human activities (Table 1).

The presence of feeding sites resulted in significant differences depending on slope; the effect of this variable on the rest of the signs could not be tested because the frequency was <3; nearly 100% of signs were found in sites with low to moderate slopes. Orientation was a variable showing differences statistically

Table 1. Habitat preference (χ^2 distribution test) calculated for Cuvier's gazelle in Boukornine National Park (Tunisia) from September 2000 to July 2001 (χ^2 value, df degree freedom, p probability significance, ns ($p > 0.05$).

Variable	Natural feeding sites			Tracks			Paths			Feces			Resting places		
	χ^2	df	p	χ^2	df	p	χ^2	df	p	χ^2	df	p	χ^2	df	p
Slope	4.05	1	0.044												
Orientation	11.8	2	0.008	71.8	2	0.000	ns			16.5	2	0.001	49.2	2	0.000
Season	10.2	2	0.006	ns			16.9	2	0.000	27.9	2	0.000	31.5	2	0.000
Plant cover	44.8	1	0.000	13.6	1	0.000	4.7	1	0.03	18.7	1	0.000	28.6	1	0.000
Fence proximity	ns			15.8	1	0.000	ns			ns			21.5	1	0.000
Food-water suppl.	ns			4.7	1	0.03	ns			ns			10.3	1	0.001

significant for all signs except for the paths. All signs were found on the preferred west face: feeding sites, 40.4%; tracks, 54.2%; paths, 39.1%; feces, 43.5% and resting places 59.1%; northern orientation followed in the rank and southern orientation was the least used. The nearly non-existent use of the southern sides for resting was significant.

Significant seasonal differences were found in the presence of all signs of gazelle activity except for tracks; summer was the season with the highest proportion of signs (feeding sites, 47.5%; tracks, 48.6; paths, 51.1%; feces, 52.8% and resting places 61.3%) followed by spring.

Presence of gazelle activity was significantly different depending on plant cover. The highest proportions of gazelle signs were found where vegetation was scant: feeding sites 90.7%, tracks 91%, paths 86.3%, feces 92.1% and resting places 98.5%. The absence of resting places in dense or compact areas was noticeable, but did not seem important for paths.

Proximity to the fence and to the food and water supply points was considered as a sign of human presence in the AE. Both variables showed significant differences but only for the presence of tracks and resting places (see Table 1). Proximity to the fence attracted gazelles (feeding sites 61.1%, tracks 70.3%, paths 61.7%, feces 65. 9%, and resting places 77.3%), whereas the distance to the food and water supply attracted gazelle activity: feeding sites 81.8%, tracks 78.3%, paths 81.4%, feces 82.2%, and resting places 73.5%.

Discussion

The reestablishment of a species requires the initial acclimation step in which animals are kept in enclosures. This practice has been used previously for the reestablishment of several ungulate species (Stanley-Price 1988, Gordon and Gill 1993, Cano *et al*. 1993, Abáigar *et al*. 1997). The objective is to monitor the acclimatization of the species to new environmental conditions, and the degree of their acclimatization is measured in terms of social behaviour, food habits, natural reproduction and use of habitat. This practice is fundamental to ensure the survival of the species reintroduced. The area of the acclimatization enclosures and the time the animals spend there depends on the design of the reintroduction program. For example, the Arabian oryx *Oryx leucoryx* reintroduced in Oman were kept in enclosures from 2 to 24 months (Stanley-Price 1988), the Scimitar-horned oryx *Oryx dammah* were kept in a 10-ha acclimatization enclosure in Bou Hedma National Park, Tunisia for 18 months (Gordon and Gill 1993). The same enclosure was used for acclimatization of Mohor gazelles *Gazella dama mhorr,* but the animals were there only 5 months (Abáigar *et al*. 1997). In this study, 13 Cuvier's gazelles were placed in a 6-ha acclimatization enclosure. Bearing in mind the 300–800 m^2 area of the enclosures they occupied during captivity in the PRFS (Almería), these may be considered semi-captive conditions.

Even though observation of gazelles in the AE was quite easy, an indirect method was chosen for monitoring habitat use for two main reasons: first, to avoid disturbing the animals, and second, to show the validity of an indirect method of studying habitat use by an elusive species that lives in forested areas. Furthermore, the method that we employed required few facilities and minimal training and allowed recording and analysis of data for long periods of time. Both the indirect method of sampling and the multivariate statistical analysis had been successfully used in previous studies (Abáigar *et al*. 1994).

Multivariate analysis showed the environmental tendencies in the gazelles' use of habitat; the 5 groups obtained after data classification show the habitat variables which best define the presence of gazelles, and the kind of signs recorded there define how they used that habitat. Low slopes were crucial to them, although generally known as "a mountain species". This was also confirmed by a χ^2 distribution test, indicating that the largest proportion of signs were found on sites with moderate slopes (Table 1). These results were not contradictory to their being a mountain species, but provide additional information. While they could use available habitat, low slopes were more convenient for daily use, even for a species adapted to mountainous environments that can be found at elevations ranging from 60 to 2600 m (Cuzin 2003).

Multivariate analysis also showed the importance of orientation and season in habitat use by the gazelles. As indicated by the signs, the western side was more frequently used for all activities, followed by the northern orientation, while the southern orientation was scarcely used for any activity, and not at all for resting. These results agree with previous observations of Cuvier's gazelles in the same area, where they prefered high altitudes and northern orientation in spring--summer seasons, to escape the high temperatures (Kacem *et al.* 1994).

Vegetation cover was also a fundamental variable for habitat selection of gazelles in the AE. Gazelles selected areas where vegetation was not very dense for all their activities; only in the section labeled ZO (Fig. 1) was the vegetation cover dense (see Group 5 of multivariate analysis), however, the presence in and use of this section was very low (5.4% of the signs). These results suggest that Cuvier's gazelles avoid dense areas where visibility is limited, preferring clearings where they are able to look out for danger (De Smet 1991, pers. obs.). This fact was also supported by the results of the χ^2 test, in which nearly 90% of the feeding sites, tracks, paths and feces were found in areas with scant vegetation cover, increasing up to 98.5% for resting places.

Human influence in the AE, as defined by proximity of the gazelles to artificial structures (fence, feeding site and water supply), had no negative effect on presence and habitat use. On the contrary, the proximity of a fence (< 50 m) attracted gazelles and the presence of signs of gazelle activity was always high there. This behaviour could be explained by the fact that all of the animals were born in captivity where their territorial reference was the fence, which also marked the limit of human presence. Moreover, in previous experience with reintroduction

(Cano *et al*. 1993, Abáigar *et al*. 1997), it was observed that immediately following release from the holding crates, the first thing the animals did was to identify the fence and run the entire perimeter of the new enclosure. In the case of the distance to food and water supply, most signs are found more than 50 m away from such objects. Since no visitors were allowed to approach either the entrance gate or the fence, the animals were at ease, and the presence of the technical staff did not disturb them. To the contrary, Cuvier's gazelles seem to tolerate relatively frequent human presence in their habitat (Cuzin 2003) and it was not unusual for them to visit open fields of crops for feeding, although they found shelter from human disturbance in the surrounding forest and hills (De Smet 1991).

Our study confirms the validity of an indirect sampling method for monitoring habitat use of the Cuvier's gazelles. It can also be used for many other species of mammals in which direct observation is difficult either because of their scant numbers or where the habitat impedes surveillance. This indirect sampling method was ideal for collecting data over long periods of time without sophisticated materials and without disturbing the animals. It also had the added value of making long-term studies possible. Even though Cuvier's gazelles reintroduced in Boukornine NP are still in the confines of the AE, the results of this work demonstrate how this species used and selected habitat and how it was able to adapt to new conditions. The degree of its adaptation in terms of habitat use is essential for the survival of this species in the area, into which they are to be reintroduced and provide the key for future selection of new reintroduction sites throughout the original distribution area of the gazelles. This methodology, along with research on the remaining wild populations, is crucial for the restoration and conservation of Cuvier's gazelle.

Acknowledgements: The authors are grateful for the support of the Director General of Forestry and the Regional Center of Agricultural Development of Ben Arous (Ministry of Agriculture, Tunisia), and the Estación Experimental de Zonas Áridas (CSIC-Spain); to the technical staff working in Boukornine National Park; to Carmen Herance and Eduardo Marín for helping to collect data. This work is part of a project funded by the Agencia Española de Cooperación Internacional (Ministerio de Asuntos Exteriores, Spain), 1999TN001.

References

Abáigar T., Cano M., Espeso G. and Ortiz J. 1997. Introduction of Mhorr Gazelle (*Gazella dama mhorr*) in Bou Hedma National Park, Tunisia. International Zoo Yearbook 35: 311–316.

Abáigar T., del Barrio G. and Vericad J. R. 1994. Habitat preference of wild boar (*Sus scrofa* L., 1758) in a mediterranean environment. Indirect evaluation by signs. Mammalia 58: 201–210.

Abáigar T. and Cano M. (in press). Management and conservation of Cuvier's gazelle (*Gazella cuvieri*, Ogilby 1841) in captivity. International Studbook: 1–102.

Alados C. L., Escos J. and Vericad J. R. 1988. Captive populations of northwest african antilopinae and caprinae at the Estación Experimental de Zonas Áridas. [In: Conservation and Biology of Desert Antelopes. A. Dixon and D. Jones, eds]. Christopher Helm, Bromley: 199–211.

Aulagnier S., Cuzin F., Loggers C.O. and Thévenot. 2001. Chapter 3. Morocco. [In: Global survey and regional action plans: antelopes. No. 4: North Africa, the Middle East and Asia. D. P. Mallon and S. C. Kingswood, eds]. IUCN, Gland: 13–21.

Belbin L. 1987. The use of non-hierarchical allocation methods for clustering large sets of data. Australian Computer Journal 19: 31–41.
Belbin L. 1991. PATN Technical Reference. CSIRO Division of Wildlife and Ecology, Canberra: 1–167.
Beudels-Jamar R. C., Devillers P. and Lafontaine R. M. 1998. Rapport sur l'état et les perspectives d'une espčce *Gazella cuvieri*. Séminaire sur la conservation et la restauration des antilopes sahélo-sahariennes. 19–23 Février 1998, Djerba, Tunisie: 1–13.
Cano M. and Abáigar T. 2000. Espańa y Túnez cooperan para evitar que la Gacela de Cuvier se extinga. Quercus, Cuaderno 168: 6.
Cano M., Abáigar T. and Vericad J. R. 1993. Establishment of a group of Dama gazelles, *Gazella* (= *Nanger*) *dama* for reintroduction in Senegal. International Zoo Yearbook 32: 98–107.
Cuzin S. 1996. Repartition actuelle et status des grands mammiféres sauvages du Maroc (Primates, Carnivores, Artiodactyles). Mammalia 60: 101–124.
Cuzin F. 2003. Les grands mammiféres du Maroc meridional (Haut Atlas, Anti Atlas et Sahara): distribution, écologie et conservation. Thése de Doctorat, Université Montpellier II, Montpellier: 1–350.
De Smet K. 1988. [Distribution and habitat choice of the larger mammals in Algeria with special interest towards nature conservation]. PhD thesis, Gent University, Gent: 1–357. [In Dutch]
De Smet K. 1991. Cuvier's gazelle in Algeria. Oryx 25: 99–104.
Direction Générale des Forêts, Ministère de l'Agriculture, République Tunisienne (1985). Avant projet de creation et d'amenagement du Parc National de Boukornine. Internal report: 1–9.
Escós J. 1993. *Gazella cuvieri* Studbook. Cuadernos monográficos 20. Instituto de Estudios Almerienses, Diputación Provincial de Almería, Almería: 1–75.
Gordon I. J. and Gill J. P. 1993. Reintroduction of Scimitar-horned oryx, *Oryx dammah*, to Bou Hedma National Park, Tunisia. International Zoo Yearbook 32: 69–73.
Joleaud L. 1929. Études de géographie zoologiques sur la Berbérie. Les ruminants, V. Les Gazelles. Bulletin Societé Zoologic Française 54: 438–457.
IUCN 1996. IUCN red list of threatened animals. IUCN, Gland, Switzerland: 1–368.
Kacem S. B. H., Müller H-P. and Wiesner W. (eds) 1994. Gestion de la faune sauvage et des parcs nationaux en Tunisie: reintroduction, gestion et amenagement. Eschborn, Germany Federal Republic: 1–305.
Lavauden L. 1932. La chasse et la faune cynégétique en Tunisie. Direction des Forêts. Tunis. Imprimerie central: 1–45.
Loggers C. O., Thévenot M. and Aulagnier S. 1992. Status and distribution of Moroccan wild ungulates. Biology of Conservation 59: 9–18.
Sclater M. A. and Thomas O. 1894–1900. The book of antelopes. Vol. IV. R. H. Porter, ed. London: 109–115.
Sellami M., Bouredjli H. A. and Chapuis J. L. 1990. Répartition de la gazelle de cuvier (*Gazella cuvieri* Ogilby, 1841) en Algérie. Vie Milieu 40: 234–237.
Sellami M. 1998. La gazelle de Cuvier *Gazella cuvieri* (Ogilby, 1841) en Algérie. Statut et premiers éléments d'écologie, données sur le régime alimentaire dans la Réserve Naturelle de Mergueb (M'Sila). PhD thesis, Institut National Agronomique, Algier: 1–154.
Sakkouhi M. 1986. Creation et amenagement du Parc National du Boukornine. Memoire de fin d'etudes. Institute Sylvo-Pastorale de Tabarka, Tunisie: 1–47.
Stanley-Price M. 1988. Field operations and research in Oman. [In: Conservation and biology of desert antelopes. A. Dixon and D. Jones, eds]. Christopher Helm, London: 18–34.

Received 5 August 2003, accepted 7 December 2004.

Associate Editor was Joseph F. Merritt.