

The Barbary Ground Squirrel *Atlantoxerus getulus* (Sciuridae), a Species with Dual Status Offender in the Arab Maghreb

Faiza Taibi, Mahieddine Boumendjel, Walid Boudjema, Mohamed Tahar Diabi,
Mohamed Amine Hennouni and Redouane Zenki

Research Laboratory on Biodiversity and Ecosystems Pollution,
Faculty of Nature and Life Sciences, Chadli Bendjedid El-Tarf University, Algeria

Abstract: During our work we were interested in the study of the ecology of a local species of squirrel, *Atlantoxerus getulus* living in Algeria. This species has been the subject of a morphological, anatomical and behavioral study to provide a knowledge base on this knownless species in Algeria. The aim of our work is to update some data on the Gaetulia Squirrel or Barbary Squirrel (*Atlantoxerus getulus* Linnaeus, 1758). Our work is based on a morphometric study of a marketed unlawfully in Annaba region (Algeria, North East) and may pose a threat as invasive species like that was the case at Fuerteventura in the Canary Islands. We also conducted a survey of the local population of massive Edough to Seraidi (Annaba). It turns out that the observations relate to a second rodent, (*Lemniscomys barbarus* Linnaeus, 1758). An investigation into the Edough's mountain and a study of its behavior on "Elevated Plus Maze" detected behavioral artifacts and conclude to terrestrial displacement. This demonstrates that individuals are from arid or semi-arid geographical area rather than a forest ecosystem such as that of Edough Mount.

Key words: Barbary Ground Squirrel • *Atlantoxerus getulus* • IUCN • Ethology • Conservation • Algeria

INTRODUCTION

One of the major environmental issues of our times is the preservation of biodiversity on Earth. Biodiversity is currently undergoing a wave of species extinction particularly worrying estimated at about 130 species per day. The hope to remedy that lies in changing of human beings behavior towards its environment [1]. The wave of extinction is mainly anthropogenic and a change in behavior of human beings is required. This may affect ecosystem function and lead to their imbalance. Several authors describe malfunctions which may occur with low ecosystems face the loss of biodiversity [2-10]. Non-native invasive species constitute the second greatest threat to biodiversity after destruction of habitat [11]. The effects of invasive species occur through the ecological processes of competition, disease, predation, hybridization at higher levels, in the reorganization of the ecosystem [12, 13]. Leung *et al.* [14] report that the prevention of upstream invasion is probably one of the

most highly recommended and cheapest ways to fight against it. This prevention indeed avoid the introduction of costly eradication plans that could affect both the target species that some local species with a serious attack on the specific biodiversity.

According to Aulagnier *et al.* [15] Aulagnier and Thevenot [16] and Kingdon [17] the Barbary Squirrel is an ideal example to explain the mechanisms for exploration in the success of invasive species on the Canary Islands [18]. Indeed, this rodent was introduced through illegal trade of animals and pets that has escaped to become an invasive species in this island, thus, destroying the vegetation and inducing significant changes in the functioning of the estuary ecosystem yet secular. This rodent originally from Morocco and Algeria saw its geographical area extended. The data on its distribution across the Maghreb should be reviewed and updated [5]. Several studies have concerned this species, but mainly people from Morocco [19-22] and Canary Islands [18, 23-25].

Corresponding Author: Mahieddine Boumendjel, Research Laboratory on Biodiversity and Ecosystems Pollution,
Faculty of Nature and Life Sciences. Chadli Bendjedid El-Tarf University. Algeria, BP73, El-Tarf 36000.

The present work is complementary to previous investigations, aims therefore, a better understanding of the ecology of the *Atlantoxerus getulus*, Barbary squirrel and possible threats that might arise in case of its introduction in the Annaba region.

MATERIALS AND METHODS

Localization of the Study Zone: The origin of this work is the observation of the Barbary squirrel in some pet stores in the city of Annaba (North East, Algeria) in October 2012 far of 900km from its natural geographical area. It was followed by the acquisition of four individuals to check through morphometry belonging to the species *Atlantoxerus getulus*.

Figure 1 shows the location of the city of Annaba, where were acquired individuals used for the study, compared to the geographical area of natural distribution of the species studied.

The Survey of the Origin of the Individuals Marketed: To verify the presence of the species in this region, we have first, conducted a survey of the local population in the municipality of Edough Seraidi (Annaba) and secondly, analyzed the shifting mode of captured individuals *via* a laboratory dispositive. We have drawn

up a semi-open questionnaire survey we have used with the population of the mountains of Edough (Annaba) in order to see whether the marketed individuals were originating from the region or not. The interview with the local population sample was carried out during the winter of 2012-2013. The audio recordings are used to complete the questionnaire at the end of the interview.

Morphometric Study: A morphometric study was conducted on sixteen (16) individuals consisting of seven (07) males and nine (09) females. The taking of measurements was carried according to Figure 2 and Table 1.

The width of the strips back squirrels is measured up to the chest of individuals from left to right, top to head. We noted that seven (07) distinct alternating bands are present on the dorsal boss.

Behavioral Study: The innate anxious behavior is a fundamental component of the general behavior of rodents. It is manifested by the attitude of the animal to fear when put, without prior experience, in an unprotected environment. This behavior can be evaluated using experimental devices such as the elevated cross maze (Figure 3) or *more Elevated Maze*, used to measure the degree of anxiety in rodents.

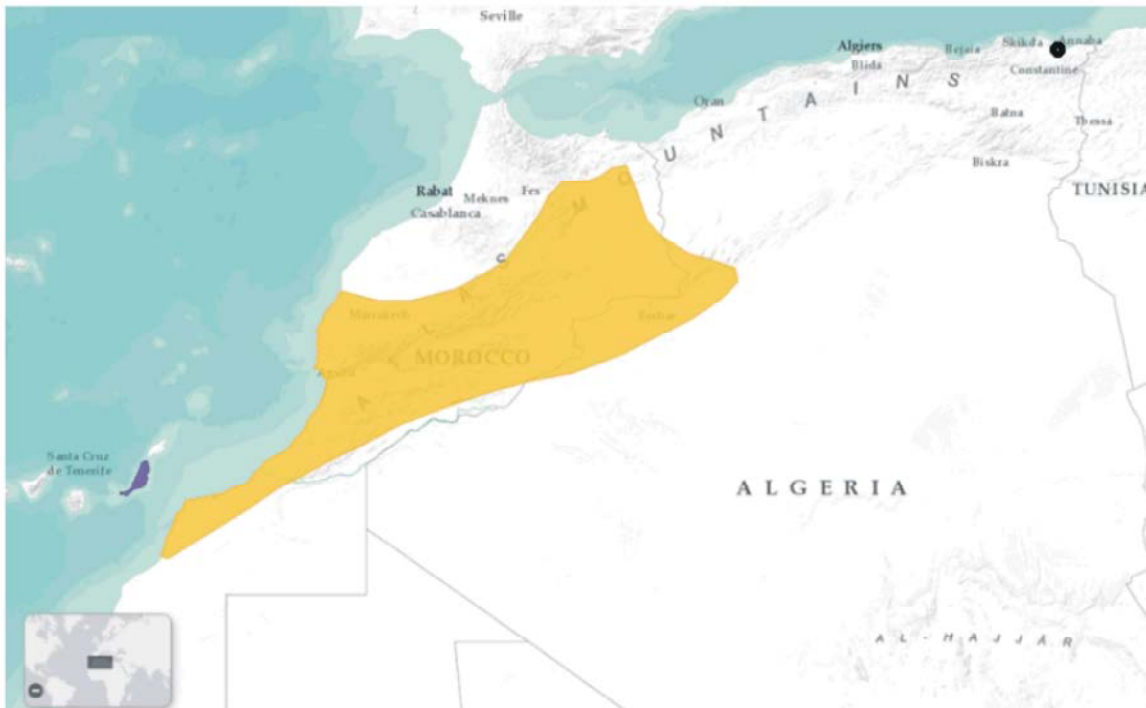


Fig. 1: Localization of Annaba compared to the geographical area of the Barbary squirrel (IUCN, 2014)

Table 1: Studied parameters and used equipment

	Parameters	Used equipment
T°	Body Temperature on the belly of the animal	Laser thermometer TESTO® 830-T4 class 2<den en 1mw /645660nm
Poids	Body mass	Balance field 1000g ± 1g
LT	Head length	Foot digital slides 150mm
HT	Head height	Foot digital slides 150mm
Øo	Eye diameter	Foot digital slides 150mm
LMs	Upper limb length	Foot digital slides 150mm
LMi	Lower limb length	Foot digital slides 150mm
LD	Back length	Foot digital slides 150mm
LQ	Tail length	Foot digital slides 150mm
Lv	Ventral length	Foot digital slides 150mm
B1	Band 1	Foot digital slides 150mm
B2	Band 2	Foot digital slides 150mm
B3	Band 3	Foot digital slides 150mm
B4	Band 4	Foot digital slides 150mm
B5	Band 5	Foot digital slides 150mm
B6	Band 6	Foot digital slides 150mm
B7	Band 7	Foot digital slides 150mm

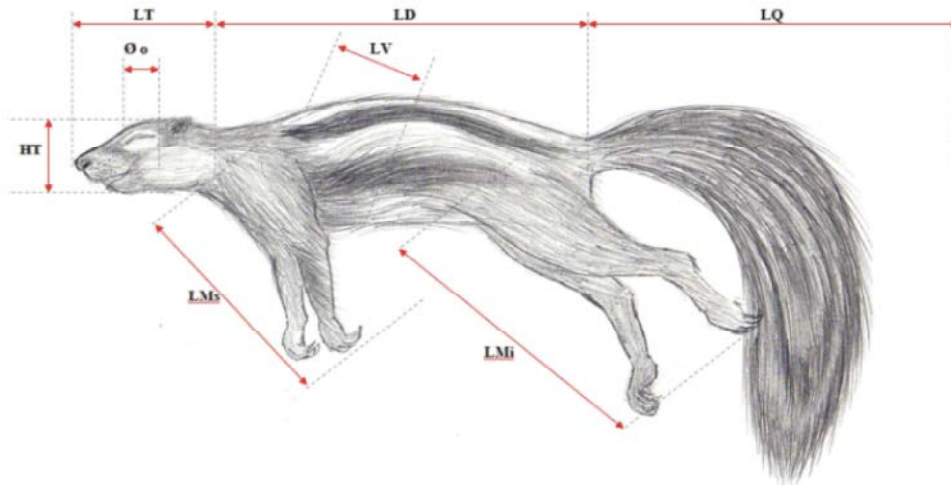


Fig. 2: Morphological descriptors of the Ground Squirrel

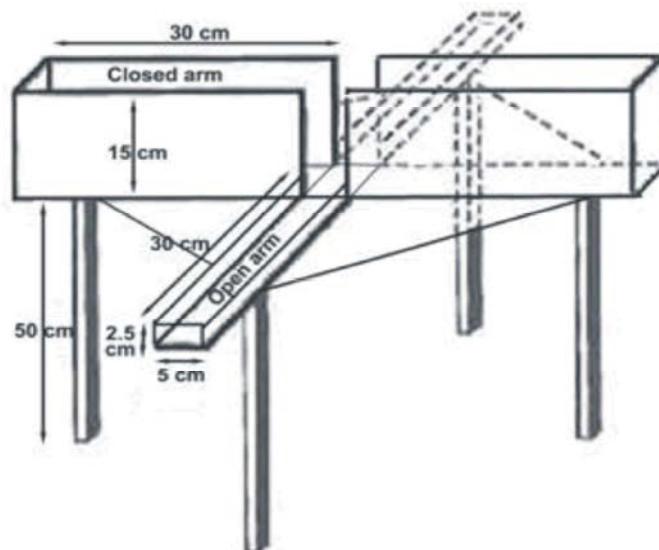


Fig. 3: Elevated Plus Maze

However we found it useful to apply this technique to study the behavior of the Barbary Squirrel to confirm its mode of terrestrial and arboreal movement as reported by Valverde [26]. The initial device as described by Montgomery [27] and Roy [28] was slightly modified and focused on the building material. We replaced the Plexiglas arms closed by plywood sheets. Indeed, we felt that a ground squirrel would have more trouble adjusting to the height of the modified device accentuating the initial height. A tree squirrel with wide experience of heights would take less time to adapt and to move within the experimental device. The measurement of time spent in open and closed arms and the number of inputs and outputs to the closed arms is recorded using a video camera (HD AVCHD Sony HDR-XR155). All our recordings lasted 300 seconds.

RESULTS AND DISCUSSION

Survey on the Presence of the Squirrel in the Edough Mountain: The average age of those who participated in the survey was 39 years. They were among 24 who responded to the questionnaire but only 16 have been selected in this study for reasons of data reliability. From these sixteen testimonies, we have compiled in Table 2. The inhabitants and residents of Seraidi were 88%. The remaining 12% were from residents in Annaba but working daily Seraidi as farmers or be keepers. The majority is represented by farmers (57%), followed by shepherds (19%), traders (12%) and pupils (12%). Among our villagers questioned, 12% spend most of their time in the forest with more than 7 hours a day on both sides West and East of the mountain. Most of them work in the morning (76%) until early afternoon while some of them (24%) work there until late afternoon. Concerning the object of survey, six (06) species of rodents emerge from our investigations. These are the Black Rat (*Rattus rattus* Linnaeus, 1758); the Least Weasel (*Mustela nivalis numidica* Pucheran, 1855); the Scrub Hare (*Lepus saxatilis* Cuvier, 1823); the field vole or short-tailed vole (*Microtus agrestis*, Linnaeus, 1761); the Garden Dormouse (*Eliomys quercinus* Linnaeus, 1758) and a sixth species resembling the Barbary Squirrel. The observations regarding the unknown animal have on average, been made at a distance of about 20 meters, all in the spring and during the day. The majority (57%) will be observed in early afternoon. The duration of the observation hardly exceeded 30 seconds. The size described of the unknown animal is 16 centimeters, with a coat color ranging from

brown, burgundy to black with red highlights. Multiple stripes along the back and alternate between light and dark. The size of the tail is highly variable ranging from 15 to 20 centimeters. The position is described in 88% close to the ground horizontally against 12% in the vertical standard. Some describe it of no great insurance as thin and hairless. The animal is described having a social behavior to 88%. It moves only on the ground and fed with corns; chestnuts and berries have fallen to the ground. It is clear from our investigation that the unknown species has probability similarities with Barbary ground squirrel but in the absence of capture after the laying of three traps in the areas of observation, we cannot affirm the precise presence of the Barbary ground squirrel in the region. In addition and in the presence an endemic species that has strong morphological similarities with the Barbary Squirrel, we believe that the people of Edough confused with the Barbary striped grass mouse (*Lemniscomys barbarus*), which has also dorsal scratches but larger than those of the Barbary Squirrel.

Morphometric Measurements: The results relating to anatomical and morphological parameters are presented in Table 3. It emerges from the results that the Barbary Squirrel generally has a total size of body 183.8 ± 37.23 mm without the tail, which measures 164.8 ± 14.74 mm. This mensuration approximates that emerged from the survey on the ground. The lower limbs are 1.43 times greater than the upper limbs. This ratio is slightly greater in females without presenting a significant difference between sexes. We note, however one significant difference ($p < 0.05$) for a single parameter which is the body mass of individuals. This difference is towards males which have a higher weight than females. We believe that this difference can be explained by the conservation and preservation of the species by allowing females to escape more quickly than males. The rest of morphometric measurements on the individuals showed no significant difference. Concerning seven (07) bands show no differences between males and females which constitute an absence of sexual dimorphism as shown in Figure 4. Overall, without digital measurement, we can also add a personal note to the coat color which is clearer in female.

Behavioral Study the Barbary Squirrels: We note on Figure 5 that squirrels avoid the central area of the cross and their cumulative average length of stay is 29 seconds over 300 seconds recording (Less than 10%). It is the same for the open arms. This is significantly different from its

Table 2: Results of the investigation

General information (n=16)	
Middle age	39 years
Origin	12% Annaba, 88% Séraïdi
Sex	100% men
Principal occupation	12% high school students; 57% farmers; 12% merchants; 19% bergers
Educational level	12% high school students, 88% secondary school students
Wearing glasses	57% No, 43% wear
Hours spent in the forest	12% spend 07 hours per day in the forest
Average hourly tranche	76% in the morning 24% in the end of the day
Information concerning the squirrel	
Number of species of rodents seen	06 different species
List of saw rodents	Rat, Weasel, Hare, Vole, Dormouse and unknown
Viewing distance	20 meters
Season	100% in spring
Occurrence observation	12% saw the squirrel and 88% saw a weasel
Approximate size	16cm
Coat colors	Brown, Bordeaux, Black, Red
Size of the tail	Between 15 and 20 cm
Position of the tail	88% horizontal, 12% vertical
Observation period	100% during the day
Hours of observation	12% in the morning; 57% in the afternoon; 31% in the late afternoon
Observation time (Duration)	30 seconds on average
Social behavior	12% saw it alone; 88% in group
Food	Gland, Chestnut, berries, fresh buds
Shifting mode	100% terrestrial

Table 3: Morphometric measures taken on the Barbary squirrel and presented by sex

	Moyenne totale (n=16)	Moyenne des males (n=7)	Moyenne des femelles (n=9)	P
P	230, 81 ± 24, 60	244, 71 ± 25, 47	220, 00 ± 18, 63	0, 022 *
LT	48, 47 ± 3, 00	47, 83 ± 2, 73	48, 96 ± 3, 27	0, 414
HT	26, 63 ± 1, 89	27, 16 ± 1, 50	26, 16 ± 2, 17	0, 295
Qo	11, 91 ± 1, 11	12, 14 ± 1, 34	11, 71 ± 0, 91	0, 446
LMs	82, 76 ± 9, 54	85, 45 ± 10, 14	80, 41 ± 8, 96	0, 292
LMi	118, 80 ± 10, 47	120, 58 ± 11, 00	117, 25 ± 10, 47	0, 531
LD	135, 49 ± 10, 41	137, 06 ± 8, 41	134, 13 ± 12, 31	0, 581
LQ	164, 83 ± 14, 74	164, 25 ± 14, 10	165, 35 ± 16, 23	0, 884
LT	183, 96 ± 37, 23	184, 88 ± 9, 78	168, 19 ± 48, 89	0, 859
Lv	43, 55 ± 4, 81	42, 39 ± 3, 16	44, 58 ± 5, 93	0, 372
B1	11, 52 ± 1, 60	11, 56 ± 1, 36	11, 48 ± 1, 88	0, 918
B2	6, 72 ± 0, 82	6, 60 ± 0, 74	6, 83 ± 0, 92	0, 577
B3	12, 22 ± 2, 20	12, 01 ± 2, 07	12, 40 ± 2, 45	0, 732
B4	8, 01 ± 0, 98	7, 59 ± 0, 94	8, 39 ± 0, 91	0, 094
B5	11, 41 ± 1, 92	11, 34 ± 1, 45	11, 47 ± 2, 36	0, 897
B6	6, 22 ± 1, 07	6, 60 ± 1, 17	5, 90 ± 0, 93	0, 185
B7	11, 18 ± 2, 10	10, 68 ± 2, 61	11, 61 ± 1, 59	0, 378

behavior with respect to the time spent on the closed arms that is 239over 300secondswhich corresponds to more than 90% of the duration of the recording. After treatment of data, it appears significant differences ($P < 0.01$) between the behavior of squirrels on open arms and closed arms of the device in an elevated cross, both in length of stay plan number of accesses (Figure 7).

Therefore, squirrels have an aversion to the height of the device. Indeed, Lopez-Darias *et al.* [24] argues that the observed structure of the habitat for this species strongly influence the installation of the latter and plays a significant role in the invasive behavior of the species. This pushes to think that these squirrels have a poured over the horizontal displacement behavior rather than

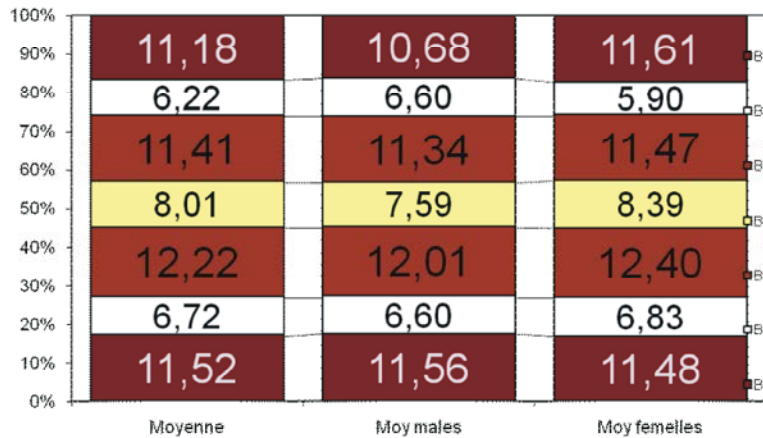


Fig. 4: Dorsal pattern of the Barbary Squirrel

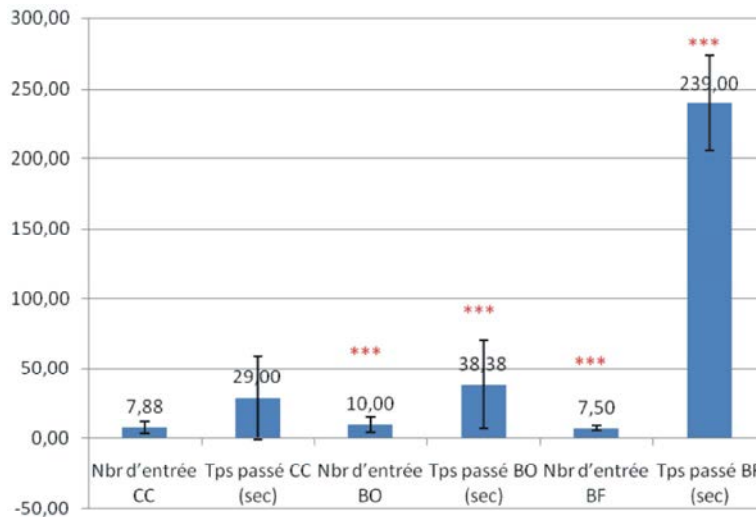


Fig. 5: Representation of the time and number of access of the squirrels on the three zones of the Elevated Plus Maze. CC: central square; BO: open arm; BF: closed arm

vertical. This gives an extra track on the preferred habitat of the species. Indeed, the population of Barbary squirrels as presented in the works of Lopez-Darias and Nogales [18] holds most terrestrial habitats such as wall sand rocks. They preferred habitat described as clear and rocky are as with little vegetation, consisting mainly of low scrub [29]. Our results suggest that this population has kept a terrestrial rodent behavior as it has a strong aversion to the height of the device. Nogales *et al.* [30] also describes the land Squirrel Gaetulia as a species preferring semi-desert habitats of the island of Fuerteventura. This leads us to say that this population, seizure of the animal, was probably taken from an environment with few trees which is not the case of the Edough Mountains. It therefore becomes a displaced species from its natural environment and presenting a risk of introducing in a new ecosystem [3, 31, 32].

Several studies have tried to model its ability to conquer new areas and new territories. The Barbary Squirrel has great potential as a species invasive as is the case on the island of Fuerteventura in the Canary Islands [23, 25].

The International Union for Conservation of Nature classifies the Barbary squirrels in the "Red List of Threatened Species" and in the category of species not undergoing a clear danger. The authorities should not only protect the Squirrel the Barbary squirrels but also monitor its exploitation and displacements nationwide. This, therefore, requires a change in status and its inclusion in Annex III of the Washington Convention on International Trade in plant species or non-domestic animal wild life endangered (CITES, 1973) pursuant to Article 2, paragraph 3. In Algeria, the Barbary a squirrel is protected under Decree No. 83-509 dated August 20, 1983

(Annexe2) species. It is integrated among the animals of particular scientific and cultural importance and plays a role in the natural balance. It is also part of the endangered species (Article 2).

CONCLUSION

We can conclude that the investigation reveals the presence of probably the Rat striped prickly and not the Barbary Squirrel. The priori similarity between the two species may well be misleading. The behavioral study with Elevated Plus Maze [33, 34, 35, 36, 37] confirms that the species has a strong aversion to the task and must originate in an arid or semi-arid environment, so probably its natural environment and its geographical area of origin. An annual monitoring program should be established in the area to recover individual pet and submit them to genetic analysis, more reliable and more accurate than a morphometric study.

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