

Distribution, Population Status and Ecology of the Endangered Barbary Macaque *Macaca sylvanus* in North Africa

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Abstract—The Barbary macaque *Macaca sylvanus* currently survives in small fragmented isolates in Morocco and Algeria. Between 65 and 75 % of the world's population occurred in the central zone of the Moroccan Middle Atlas. In Morocco, the species survives today in the Rif, the Middle Atlas and the High Atlas mountains. In Algeria it occurs in three areas: Chiffa, Grande Kabylie and Petite Kabylie. Free-ranging Barbary macaques are currently found in Gibraltar. In Europe, there are three major free ranging captive colonies of Barbary macaques in France and Germany. In the early 1980s, the total population size was estimated to be 14 000–23 000. Several recent studies indicated a dramatic decline of the Barbary macaque populations and concluded this decline on habitat destruction, impact of livestock grazing, the population fragmentation, the illegal capture of infant macaques, and the effects of human activities on the Barbary macaques' behaviour. The species is listed in CITES Appendix I and is classified as an endangered species on the IUCN's Red List. Barbary macaques are an essential component of North Africa biodiversity, contributing to forest regeneration and ecosystem health. This paper aims to determine the current distribution, status and ecology of the Barbary macaque in Morocco and Algeria, to identify the potential threats to the species, and to make recommendations for the protection of the species in North Africa.

Keywords—Barbary macaque, North Africa, distribution, population status, decline, conservation.

I. INTRODUCTION

The Barbary macaque *Macaca sylvanus* (Linnaeus 1758) is today the only macaque species that occurs beyond Asia [1]. In ancient times, *M. sylvanus* inhabited parts of Europe and all of North Africa, from Libya and Egypt to Morocco [2],[3],[4],[5],[6]. Fossils of this species have been discovered throughout southern regions of Europe [7]. Barbary macaques currently survive in small fragmented isolates in Morocco and Algeria (Figure 1). Around 200 free-ranging Barbary macaques are currently found in Gibraltar [2],[6],[7],[8]. The population was subsequently subjected to human intervention to regulate group size over a long period. The Gibraltar population includes Algerian and Moroccan haplotypes [7]. In Europe, Barbary macaques live in captivity in France (Kintzheim and Rocamadour) and Germany (Salem).

The current distribution of this species ranges from a latitude of around 31°15'N to 36°45'N and from a

longitude of around 7°45'W to 5°35'E [6],[9]. The species lives in altitudes between 400 and 2 400 m [9],[10]. In Morocco, the species currently survives in the Rif, the Middle and High Atlas mountains [5],[11],[12],[13]. Between 65 and 75 % of the Barbary macaque population occurred in the central zone of the Moroccan Middle Atlas [11]. In the High Atlas and the Rif Mountains, a few scattered groups occur in disturbed habitats [10],[11],[12],[14],[15],[16],[17]. In Algeria the Barbary macaque occurs in three areas: Chiffa, Grande Kabylie and Petite Kabylie [4],[12],[18]. The Algerian population showed considerably greater genetic diversity than the Moroccan population [7].

In the early 1980s, the total population size was estimated to be 14 000-23 000 [11],[12],[19]. In the 1990s the population was 10 000-16 000 [20],[21]. Several recent studies indicated a decline of the Barbary macaque populations and concluded this decline on habitat destruction, impact of livestock grazing, the population

fragmentation, the illegal capture of macaques and the effects of human activities on Barbary macaques' behaviour [16],[17],[22],[23],[24],[25]. Since 2008, the Barbary macaque has been classified as an endangered species (Endangered A2bcd) on the IUCN's Red List [26]. The species is listed in CITES Appendix I [27].

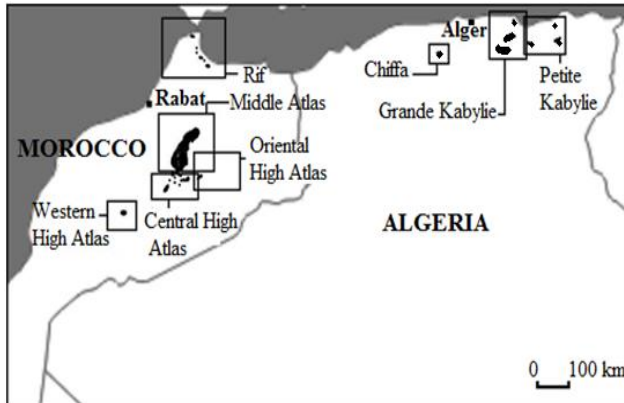


Figure 1: Distribution of *M. Sylvanus* in North Africa [11],[12].

The Barbary macaque occupies a wide range of habitats. This endangered macaque occurs mainly in cedar and oak forests, but it can also be found in habitats with junipers, Aleppo pine, Barbary thuya, in tourist sites and Mountain ridge [10],[11],[28]. This monkey consumes a wide variety of foods: seeds, leaves, animal prey, fruits, flowers, roots, barks, mushrooms and lichens [4],[29],[30],[31],[32],[33]. This species can survive in a wide variety of habitats due to its great adaptability. The Barbary macaque has a highly flexible diet [34]. It is generally considered to be an eclectic feeder and colonizes various habitat types [28],[30],[31],[35],[36],[37]. These macaques live in tourist sites, where they interact with visitors providing food to them [24],[33],[38],[39],[40],[41]. The human effects may influence the behaviour of macaques living in tourist sites [24],[41]. This paper aims to review the distribution, current status and ecology of the Barbary macaque in North Africa.

Rest of the paper is organized as follows, Section I contains the introduction of the Barbary macaque in North Africa, Section II contain the related work of the distribution and ecology of the species, Section III contain the data collection method, Section IV describes results and discussion of the distribution, status and the major threats to the Barbary macaque conservation in Morocco and Algeria, Section VI contains the conclusion and the recommendation for the protection of this Endangered species.

II. RELATED WORK

The distribution and the Barbary macaque population status throughout its range were determined during 1970s and 1980s by [11],[12],[19],[39]. During the last two decades, the authors of this article have carried out studies on the species in different regions of North Africa [10],[17],[23],[52]. These studies indicated a decline of the

Barbary macaque populations in several regions. The objective of this paper was to compare the results of these recent studies with those of studies carried out during the last half of the 20th century, and to analyze them in order to determine the current distribution and status of the species throughout its range in North Africa. Determining the current distribution and the population status of this endangered primate is essential to develop effective Barbary macaque conservation strategies and action plans in Morocco and Algeria.

III. METHODOLOGY

The Data on the distribution, population status and ecology of the Barbary macaque are gathered from published works of the authors and of other researchers. The majority of these publications are research articles published in journals indexed by Scopus database. Results of recent publications about the distribution and status of the Barbary macaque in Morocco and Algeria were compared with the results of publications from the 1970s and 1980s. The data were analyzed to determine the regions where the species had disappeared or where it is in decline. In addition, the densities and the mean total number of macaques during the 1970s and 1980s in different regions were compared with data from recent studies.

IV. RESULTS AND DISCUSSION

The Barbary macaque in Morocco

Currently the Barbary macaque in Morocco can be found in the mountain ranges of the Rif and the Middle and High Atlas. The total Moroccan population is now estimated to be 5 000-6 000 [16],[23], a large decline since 2003, when the Moroccan population was estimated to be c. 10 000 [42].

Middle Atlas

Forests of the Middle Atlas (Figure 2) contain the majority of Moroccan forest tree species including cedar, oaks, Junipers and Aleppo pine. The majority of the high cedar forests (*Cedrus atlantica*) of North Africa occur in the central zone of the Middle Atlas. About 65–75% of the world's population of *M. sylvanus* (Figure 3) lived in the cedar forests of the Middle Atlas [11],[43]. The central zone of the Middle Atlas plays a crucial role on the *M. sylvanus* species survival [11],[12],[44].

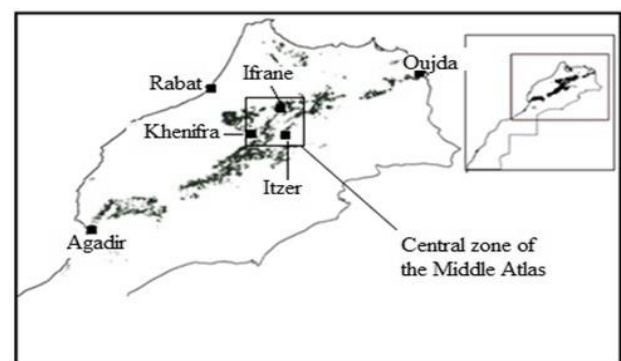


Figure 2: Localisation of the Middle Atlas in the Moroccan Map.



Figure 3: Barbary macaques in the Middle Atlas, Morocco (Photographed by El Alami A.).

Distribution, population estimates and habitat types of *M. sylvanus* in the Middle Atlas during 1980s are given in the Table 1. In the eastern zone of the Middle Atlas (the triangle formed by the towns of Fes, Taza and Enjil), Barbary macaques were rare and it was likely that fewer than 100 individuals lived in habitats that consist of cedar and oak. In the central zone of the Middle Atlas (the triangle formed by the towns of Khenifra, Itzere and Ifrane), the forests are mainly cedar and/or oak forests. In this zone, the majority of all North African populations of this macaque can be found [12]. *M. sylvanus* occurred mainly in the regions of Azrou, Ifrane, Michlifene, Ain Leuh, El Hamman, Seheb, Ajdir, and Midelt. Population estimates and description of habitats were detailed by Taub [11] and Fa et al. [12] (Table 1). In the central zone of the Middle Atlas, absolute abundance and relative density vary widely within and between regions. The regions of Sidi M’Guild, Ifrane, Mishiliffin, Ain Kahla, Ain Leuh, Ajdir, Kerrouchene and Khenifra contain highest concentrations of Barbary macaques [12]. In the southern zone of the Middle Atlas, the habitats are principally Holm oak, oak-juniper mixtures, Aleppo pine, Barbary thuya, and sparse mixed cedar. In this zone, Barbary macaques occur principally in the oak forests of El Ksiba [12]. Macaques were distributed thinly throughout the region of Tagueleft, but they have disappeared from several sites [12]. Small groups of Barbary macaques are found also in oak habitat in the Gorges of Oued El Abid and in Aleppo pine and Holm oak forests in Ait M’Hammed.

Table 1: population estimates and habitat types of *M. sylvanus* in the Middle Atlas [11],[12].

Area	Size (km ²)	Habitat type	Population estimates
Fes-Taza	5	Cedar forest	100 - 200
Azrou-Ifrane-Mishiliffin	296	Cedar forest	2 000 - 3 000
Ain Leuh-El Hamman	134	Cedar forest	500 - 1 500
Seheb	137	Cedar forest	2 000 - 5 000
Ajdir	396	Cedar forest	2 000 - 3 000
	148	Cedar forest	500 - 1 500
Midelt	75	Cedar forest	1 000 - 1 500
Six areas	1 191 km ²	Cedar forest	8 100 - 15 700 ind.

In the central zone of the Middle Atlas, the density of macaques was estimated to be 70 individuals per km² [45]. Taub [11] estimated a density of 44 individuals per km². But recent studies indicate a decline of the density of macaques in the Middle Atlas [22],[23]. The study conducted by Camperio Ciani et al. [22] in the central zone of the Middle Atlas between June 1994 and October 2002 indicated a progressive population decline, from 25 to 30 individuals per km² in 1994, down to an average density of 7–10 individuals per km² in 2002.

Another study was conducted in 2005 by Van Lavieren and Wich [23] to determine the status of the macaque in regions of Azrou, Sidi M’Guild and Michlifène, in the central zone of the Middle Atlas. Results of this study (Table 2) indicated densities of 12.1-28.2 individuals per km²: 12.1 individuals per km² in Azrou, 28.8 in Sidi M’Guild, and 23.5 in Michlifène. These authors reported also a mean total number of individuals of 4 146 in the three regions: 965 individuals in Azrou, 3 107 individuals in Sidi M’Guild, and 74 individuals in Michlifène.

Table 2: Mean group density and mean individual density of Barbary macaques, and an estimation of the total number of macaques in three regions in the central zone of the Middle Atlas [23].

Region (area, km ²)	Mean group density (/km ²)	Mean individual density (/km ²)	Total number of individuals
Azrou (160)	2.08	12.1	965 (835-1 123)
Sidi M’Guild (220)	3.07	28.2	3 107 (2 692-3613)
Michlifène (6.25)	3.27	23.5	74 (64-86)
Total (386.25)	2.8	21.3	4 146 (3 591-4821)

The main threats to the Barbary macaque survival in the Middle Atlas are the habitat loss, degradation and fragmentation [46]. According to several studies about the species in the central Middle Atlas, the last populations of Barbary macaques have a very low reproduction rate and that the abnormally low proportion of young individuals. This was mainly due to the human impact and systematic poaching of the young individuals. An estimated 300 infant macaques were smuggled into Europe annually in the first years of the new millennium [47].

High Atlas

Central High Atlas

The distribution of the Barbary macaque (Figure 4) in the central High Atlas (Figure 5) was restricted to 10 sites located in the valleys of Oued El Abid, Oued Ahansal, Oued Lakhdar and Assif Melloul [10],[14],[15].



Figure 4: Barbary macaques in the tourist valley of Ouzoud, central High Atlas, Morocco (Photographed by El Alami A.).

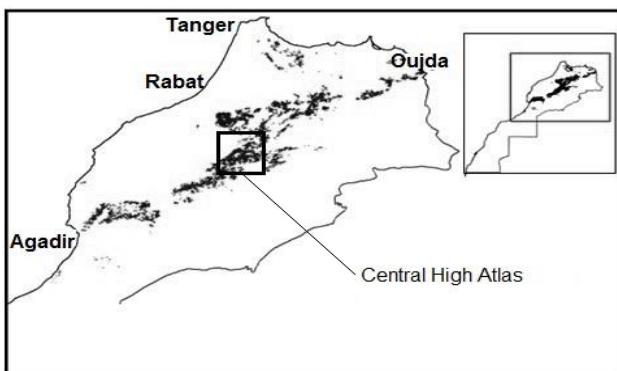


Figure 5: Localisation of the central High Atlas in the Map of Morocco.

El Alami et al. [10] sighted a total of 35 groups and counted a total of 644 individual in four regions in the central High Atlas (Table 3). This study also reported that the species was extinct today in four localities: Tazerkount, Taguleft, in the forest downstream of the lake of Bin El Ouidane, and in some localities to the south of the town of Beni Mellal. In the central High Atlas, Barbary macaques were observed in a wide range of habitats but 49% of the groups were seen in oak forests. The species was also found in habitats with junipers, Aleppo pine and Barbary thuya, and in the tourist region of Ouzoud [10].

Table 3: Distribution, habitat type and population estimate of *M. sylvanus* in the Moroccan central High Atlas during the period of 2004-2008 [10].

Region	Habitat type	Population estimate (individuals)
Oued Lakhdar	Open forest, non-wooded land.	94
Oued Ahansal	Open forest, pine oak forest, mixed forest.	185
Assif Melloul	Thermophilous scrub, pine forest.	63
Oued El Abid	Thermophilous scrub, oak and juniper forests.	302
Four areas	Wide variety of habitats	644

El Alami et al. [10] indicated a decline of the Barbary macaque populations in the central High Atlas. The habitat degradation, hunting activities, the impact of livestock grazing and disturbance by people are responsible for this decline. The Barbary macaque is today restricted to relict habitats [10],[15]. In the central High Atlas the local people mentioned that macaques come close to agricultural land and occasionally cause damage to crops. The conservation of Barbary macaque requires protecting their habitats and minimizing the impacts of human activities.

Western High Atlas

Drucker [28] estimated the total population of the western High Atlas to be around 200 macaques [12]. According to Cuzin [14],[15], the Barbary macaque (Figure 6) in the western High Atlas used to occur in the regions of Ourika and the High Zat (Figure 7). This population is separated from the populations of the central High Atlas by a great distance. This author reported that several groups have disappeared from certain valleys where they were present about fifty years ago, but the species still occurs in certain valleys in the region of Ourika. In the western High Atlas, *M. sylvanus* occurs in Holm oak forests, maple oak groves, and sometimes in cedar groves close to oak groves [15]. This author reported that the group located less than a 1 km away above the Ourika waterfalls showed very fluctuating numbers: 52 animals (January 24, 1998), 46 animals (September 27, 1998), 19 animals on (January 15, 1999), and 23 animals on (May 17, 1999).



Figure 6: Barbary macaques in the region of Ourika, western High Atlas, Morocco (Photographed by Namous S.).

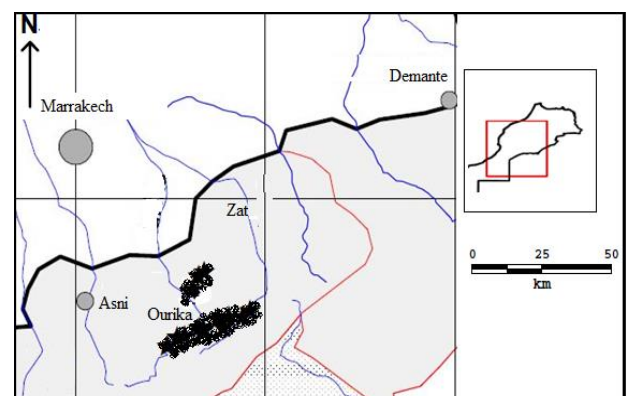


Figure 7: Map of the western High Atlas showing the Oued Ourika and Zat where *M. sylvanus* is found.

Results of a recent study [17] showed that the *M. sylvanus* population size in the Upper Ourika Valley was 122 and 84 individuals in the summers of 2009 and 2013 respectively. In 2009 four groups were identified in this area: in Tourcht, Setti Fatma, Tamatert and Kissaria, with a mean global density of 42.95 individuals per km². The population contains 49.65% of adults (24.82% males and 24.82% females), 11.03% of subadults, 12.87% of juveniles and 26.43% of infants [17]. In summer 2013, only groups of Setti Fatma and Tamatert were detected by these authors. The difference in population size between 2009 and 2013 can be explained by the fact that macaques have moved to more favorable areas outside the surveyed area, perhaps in the adjacent valleys, following the chronic drought that occurred in 2009 [17]. The mean density of the Upper Ourika Valley population was 27 individuals per km². The population age structure comprised 50 to 56% of immature individuals. The average apparent fecundity was one infant per one adult female. The Barbary macaques carried out a daily movement of more than 1 400 m, much shorter than those of other macaque species in relation to the high dependence on the crops. Setting up a local reforestation plan to plant preferred trees for macaques and possibly multiple kind of fruit trees, could possibly shift the macaques ranging patterns. In this area, Barbary macaques are not usually seen as pests. The conservation of the species in the Upper Ourika Valley requires restoration of natural habitat and evaluation of the effects of human influences.

Oriental High Atlas

Although the regions of Tounfite and Tagoulalelt belong to the oriental High Atlas, Data concerning this area were included, being the southern zone of the Middle Atlas in many publications. But these regions belong to the oriental High Atlas. In the region of Tounfite, macaques occur in small numbers in habitats with cedar, Holm oak and juniper; monkeys can be found throughout the mixed cedar forests in Sidi Yahia ou Youssef [12]. According to Cuzin [15], the distribution of the Barbary macaque in the oriental High Atlas is restricted to regions of Aqqa n'Ouanine, the national park of the oriental High Atlas, the west of Tounfite and the reserve of Tagoulalelt. In the oriental High Atlas, macaques were found in areas containing cedar, Aleppo pine and oak. No recent published Data is available on the Barbary macaque in the oriental High Atlas. Therefore, we highly recommend studying the distribution, current status and ecology of the population living in this area.

Rif

The species has been observed in certain localities in the Rif Mountains where it occupies various habitats [11],[12],[48],[49]. The presence of this species has been demonstrated in seven regions: 1. Djebel Moussa, 2. Fath Lemhar, 3. Djebel Buzeitune, Kelti Kaiat, Sidi-Salah, 4. Djebel Bouhassim, 5. Djebel Tazonte, 6. Djebel Tissouka, Lakraa, Talassemrane, 7. Djebel Tizirane (Figure 8). The population estimates and habitat types of the species in the Rif are detailed by Fa et al. [12] (Table 4). In the Moroccan

Rif, the Barbary macaque is found in wide range of habitats and the highest concentrations of macaques are in the fir forests of Djebel Tissouka, Lakraa, Talassemrane, and Tazoute. The habitats of Barbary macaques in the Rif are very disturbed by man and deforestation has significant effects on the wild habitats. Consequently, the species disappeared from several localities in the Rif [11],[12].

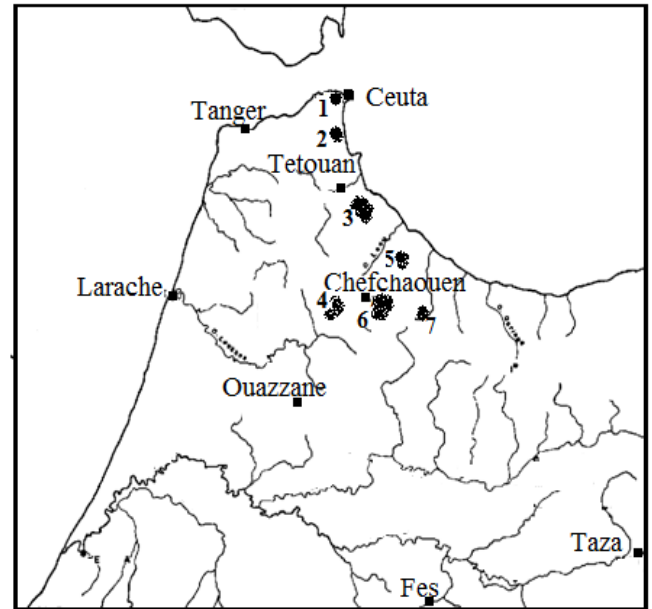


Figure 8: Map of Moroccan Rif showing regions where *M. sylvanus* is found. 1. Djebel Moussa, 2. Fath Lemhar, 3. Djebel Buzeitune, Kelti Kaiat, Sidi-Salah, 4. Djebel Bouhassim, 5. Djebel Tazonte, 6. Djebel Tissouka, Lakraa, Talassemrane, Beni M'Hamed, Oued Tilljida 7. Djebel Tizirane [11],[12].

Table 4: The population estimates and habitat types of *M. sylvanus* in the Moroccan Rif [12].

Locality	Size (Km ²)	Habitat type	Population estimate
Djebel Moussa	11	Thermophilous scrub	12
Fath Lemhar	28	Thermophilous scrub	20
Djebel Buzeitune, Kelti Kaiat, Sidi-Salah	200	Thermophilous scrub	100
Djebel Bouhassim	142	Mixed oak forest	70
Djebel Tazonte	6	Fir forest	
Djebel Tissouka, Lakraa, Talassemrane	45	Fir forest	254-400
Beni M'Hamed	5	Pine/fir forest-matorral	
Oued Tilljida	21	Matorral	
Djebel Tizirane	5	Cedar forest	200
Nine localities	463 Km ²	Wide variety of habitats	656-802 ind.

In the Rif, Alvarez and Hiraldo [49] indicated 14 localities occupied by the species and Whiten and Rumsey [48], Taub [11] and Fa et al. [12] indicated seven localities. One study reported that in the Djebala, the species was found

mainly in forest areas, especially the oak, pine/fire and fire forests; it also occurs in secondary vegetation [39]. This study suggests a maximum population of nearly 400 monkeys in an area of 332 km² in the Djebela region. In three locations in the Djebela region (Djebel Moussa, Djebel Bou Hassim and Djebel Talassemthane) the number of individuals had decreased from 200 monkeys found in 13 groups to 89 monkeys organized in nine groups between 1980 [39] and 2004 [16]. The lower numbers of macaques recorded in Djebel Bou Hassim and Djebel Talassemthane compared to those recorded in 1980 may indicate a significant decline of the species in the Djebela region [16]. At 10 km south of the city of Tetouan, this study reported the presence of seven macaques in the El Haouz region. In this location, the study of [16] reported the observation of a group of 18 macaques in January 2005. In Djebel Bouhassim, Fa [39] reported the presence of five groups ranging in 8-27 individuals and two groups with a mean group size of 7 and 16 individuals [16]. A recent study showed that group size of Barbary macaques in Bouhachem is larger than those reported in previous surveys. Waters et al. [50] reported the presence of 249 Barbary macaques organized in four groups in Djebel Bouhassim with a group size of 52, 72, 66, and 59 individuals. This study provides evidence that Bouhachem may be an important area for the species' long-term conservation.

The Barbary macaque in Algeria

In Algeria, Barbary macaques (Figure 9) occur in three areas: Chiffa, Grande Kabylie and Petite Kabylie [4],[12],[18] (Figure 10). The species disappeared from six localities in Algeria [2],[11].



Figure 9: Barbary macaques in Algeria (Photographed by Ahmim M.).

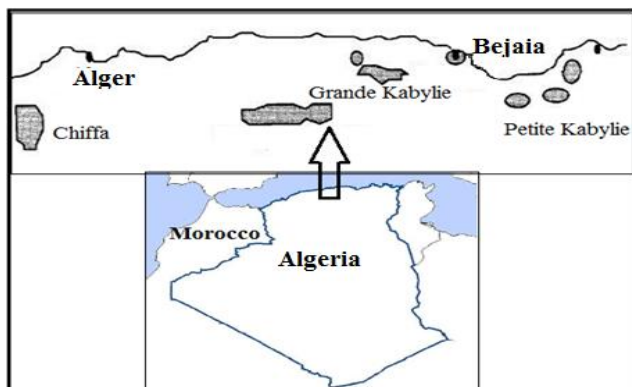


Figure 10: Distribution of *M. sylvanus* in Algeria [4],[12],[18].

The population estimates and habitat types of *M. sylvanus* in Algeria are given in the Table 5. In Chiffa, the habitats are mainly Holm oak with patches of cork oak, Portuguese oak and Aleppo pine. The Barbary macaque population was estimated at 300 individuals [12],[19] and monkeys are well habituated to humans and readily accept food offered to them, especially in the Ruisseau des singes site [12]. In the Grande Kabylie, macaques occur in three regions: in Bejaia, Djurdjura and Aqfadou. The habitats are mainly kermes oak and Aleppo pine in Bejaia (Pic des singes). In this region, Fa et al. [12] reported the presence of about 15-50 individuals. In the Massif of Djurdjura, habitats types range from cedar to Holm oak mixed forests to grass land and rocky slopes [12]. In this region, macaques were found in high density, especially in Tigounatine, Tala Guilef, Tikjada, Ait Ouabane and Irlit [12]. This study showed also that macaques occur in the rocky summits of Djebel Icetcifere, Ras Timedouire and Tizi M'Cenoad. In cedar forests, the density of macaques was about 13.8 individuals per km² and in rocky summits, it was about 9.8 individuals per km². In the Djurdjura National Park, there was a population of 400-600 individuals in cedar and 950-1 150 in rocky summits [12]. In Aqfadou, the predominant tree species are the Portuguese oak and the cork oak. In this region, a maximum population used to be around 1 310 -2 100 individuals. In the La Petite Kabylie, macaques are found in Kerrata and Ghabet El Akra, in Babors and in Guerrouch. In Kerrata and Ghabet El Akra, about 200 monkeys lived in the gorge area. The habitat in this region is similar to that of Chiffa. The habitat of Barbors is very like that of Djurdjura with presence of Numidian fir. Taub [11] estimated around 300 macaques restricted to fir forest within the park. The habitat in the Guerrouch is mainly cork, Portuguese and Afares oaks. Taub [11] estimated a maximum population of 1 500 individuals.

Table 5: The population estimates and habitat types of *M. sylvanus* in Algeria [12].

Area	Region	Size (Km ²)	Habitat type	Population estimate
Chiffa	Chiffa	20	Thermophilous scrub	300
	Bejaia	7	Thermophilous scrub	15-50
Grande Kabylie	Djurdjura	156	Cedar forest	1 350 – 1 750
	Aqfadou	175	Mixed oak forest	1 310 – 2 100
	Kerrata	20	Thermophilous scrub	200
Petita Kabylie	Babors	17	Fir forest	300
	Guerrouch	100	Mixed oak forest	1 500
Three areas	Seven localities	495 km ²	Wide variety of habitats	5 075 – 6 200 ind.

Two population surveys conducted in 2013 and 2015 at 23 locations in Algeria estimated the Algerian population to be 1 336-3 506 animals, representing an average population decrease of 50% in comparison to the last published survey [51]. One study reported that between

2004 and 2016, there were 155 groups of Barbary macaques in 15 sites belonging to four national parks of Algeria (the Djurdjura National Park, the Chrea National Park, the Gouraya National Park, and the Taza National Park), resulting in a total number between 3 229 and 3 888 individuals [52]. This study reported also that outside the national parks there are approximately 186 individuals, living in seven locations (Matera, Oued Zhour, Zitouna, Tamanart, Sidi Maarouf, Ain Lehmane, and Bourbatache–El Kseur). This study [52] showed that groups of Barbary macaques are now found up to 212 km east of their formerly known range and that the monkey tends to move from West to East from Chiffa, in Chrea National Park, to Salah Bouchaour locality in the Wilaya of Skikda. The management plan of the National Parc of Djurdjura of 2013 reported that there were 1 441 Barbary macaques organized in 102 groups in the National Parc of Djurdjura [52]. This result is similar to the population size reported by Taub [11] and Fa et al. [12] and confirms that there is no decline of the species in the Djurdjura region. The management plan of the Chrea National Park of 2012 reported between 476 and 630 macaques organized in 14 groups [52]. The management plan of the Gouraya National Park of 2004 mentioned the presence of 10 groups with a total of 367 individuals [52]. This study reported also that in Taza National Park, 29 groups were mentioned as living in forest and the Jijilian Cornish near the sea. As in many regions of Morocco, several Barbary macaque groups live in tourist sites in Algeria. Generally, macaques attract a large number of visitors every year in tourist sites in Asia and North Africa and they are favorable for their potential benefits to tourism [10],[26],[27],[53],[54]. Therefore conservation efforts on behalf of Barbary macaques in Algeria should consider the advantages and disadvantages of tourist activities.

V. CONCLUSION

Barbary macaques are an essential component of North Africa biodiversity, contributing to forest regeneration and ecosystem health. Macaques attract a large number of tourists every year and they are favorable for their potential benefits to tourism. This review showed that the species is actually restricted to small and fragmented habitats in the Moroccan Rif, Middle and High Atlas, and in the Algerian areas of Chiffa, Grande Kabylie and the Petite Kabylie. The Barbary macaque population is now estimated to be 10 000-12 200, a large decline since the early 1980s, when the population was estimated to be c. 14 000-23 000. The destruction and degradation of the Barbary Macaque's forest habitat is the most serious threat to the species. Barbary macaque populations are threatened not only by the habitat loss and degradation but also by increasing the population fragmentation, capture and trade of macaques, effects of human activities on Barbary macaques' behaviour and conflict with inhabitants due to crop raiding. In recent years, the roles of these monkeys in their ecosystems have been more widely appreciated. We recommend to establish other protected areas in the Morocco and Algeria, to increase fencing and guarding of

forests, to educate local people about more sustainable use of the forest and about ecological and economical roles of macaques, protecting and restoring forests, and developing the local economy through an ecotourism project to compensate farmers for their crop losses.

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