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Monitoring threatened ungulates (*Gazella cuvieri* and *Ammotragus lervia*) in the semi-arid North African Nador Mountains

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Abstract

Cuvier's gazelle (*Gazella cuvieri*) and aoudad (*Ammotragus lervia*) are listed as *Vulnerable* in the IUCN red list, and any population should be the subject of scientific attention. Both ungulates were monitored for a year in the Nador Mountains (western Algeria). This is the first record of aoudad in this part of Tiaret province. Both species are partly sympatric. However, the aoudad was sighted only in small numbers in the roughest valleys in the north. The gazelle population is larger, but with few juveniles. The future of these wild ungulates is therefore worrying, and new conservation measures are required, including protecting this area.

Introduction

At the beginning of the 20th century, mountains of northwest Africa were still inhabited by large carnivores such as lion (*Panthera leo*) and leopard (*Panthera pardus*) and their main preys, aoudad or Barbary sheep (*Ammotragus lervia*) and Cuvier's gazelle (*Gazella cuvieri*) (Trouessart 1905). The last lions were sighted in 1912 in Kabylia for Algeria (De Smet 1989), and 1942 in the High Atlas for Morocco (Cuzin et al. 2017a), where the species was suspected to be extinct in the 1950s (Lee et al. 2015). The last leopards were reported at the turn of the 21st century in the High Atlas and Saharan Atlas (Cuzin 2003; Purroy 2010). The main causes of extinction were hunting in order to protect livestock, and the decline of the two wild mountain ungulates (Cuzin 2003).

This decline was assessed by the IUCN, whose red list until 2016 categorized Cuvier's gazelle as *Endangered*, with sub-populations of fewer than 250 mature individuals (C2a(i)). The species was then re-categorized as *Vulnerable*, as two sub-populations were found with well above 250 mature individuals (IUCN SSC Antelope Specialist Group 2016). The aoudad is also listed as *Vulnerable* (C1) at international level (Cassinello et al. 2021). Formerly distributed in all craggy terrains of northwest Africa, both species retreated to the mountains under the increasing pressure of human activities at lower altitudes (e.g. Aulagnier 1992; Gil-Sánchez et al. 2017). Nowadays, poaching and habitat loss due to overgrazing by livestock are the main causes of decline (DGF 2017; Cassinello et al. 2021). Habitat fragmentation is another risk, as some sub-populations may fall below the viable population size (Wacher et al. 2002; Aulagnier et al. 2015; Ramzi et al. 2018; El Alami 2019).

In Algeria, the status of these species has recently been updated (Bounaceur et al. 2016a, b); the picture is now quite different, at least in the northern part of the country, where there is a relatively large and stable population of Cuvier's gazelle (Bounaceur et

al. 2016b) and only five remaining small populations of aoudad (Bounaceur et al. 2016a). These sub-populations should therefore be monitored in order to evaluate their dynamics and so that management steps can be taken to improve the species' probability of survival.

We surveyed one of the last areas inhabited by both ungulate species in northwestern Algeria in order to (1) assess their local distribution and (2) estimate their abundance and population composition.

Methods

Study area

The Nador Mountains cover an area of 14,181 ha in Tiaret province (western Algeria) between 34° 04' and 35° 11' N, 1° 33' and 1° 53' E (Figure 1). This massif of limestone and dolomites includes, from west to east, a low-altitude plateau (126 m), high summits reaching 1,493 m at Djebel Chemakh, and an inclined plane sloping down to 883 m. The topography is very complex, with steep cliffs and deep valleys; there are no permanent watercourses and only a few springs.

The climate is Mediterranean continental according to the Debrach Continental Index (1953). Rainfall (which occurs from late autumn to spring) is around 300 mm/year. The dry period, estimated by the ombrothermal diagram of Bagnouls & Gaussen (1953), extends from March to November. The average daily temperature varies from 4.8°C in winter to 38.2°C in summer. According to Emberger's quotient (1930) of $Q2 = 26.35$, the area belongs to the upper arid stage, with cool winters.

Most of the plateau is covered by a steppe of *Stipa tenacissima*. The vegetation on the slopes is dominated either by *Juniperus oxycedrus* or by a mix of *Juniperus oxycedrus* and *Stipa tenacissima*; the most north-easterly parts are covered mainly by *Pistacia lentiscus* and *Tetradlinis articulata*. *Pinus halepensis* or *Quercus ilex* occupy the northern summits. A total of 79 plant species are found, which include *Cupressus sempervirens*, *Juniperus*

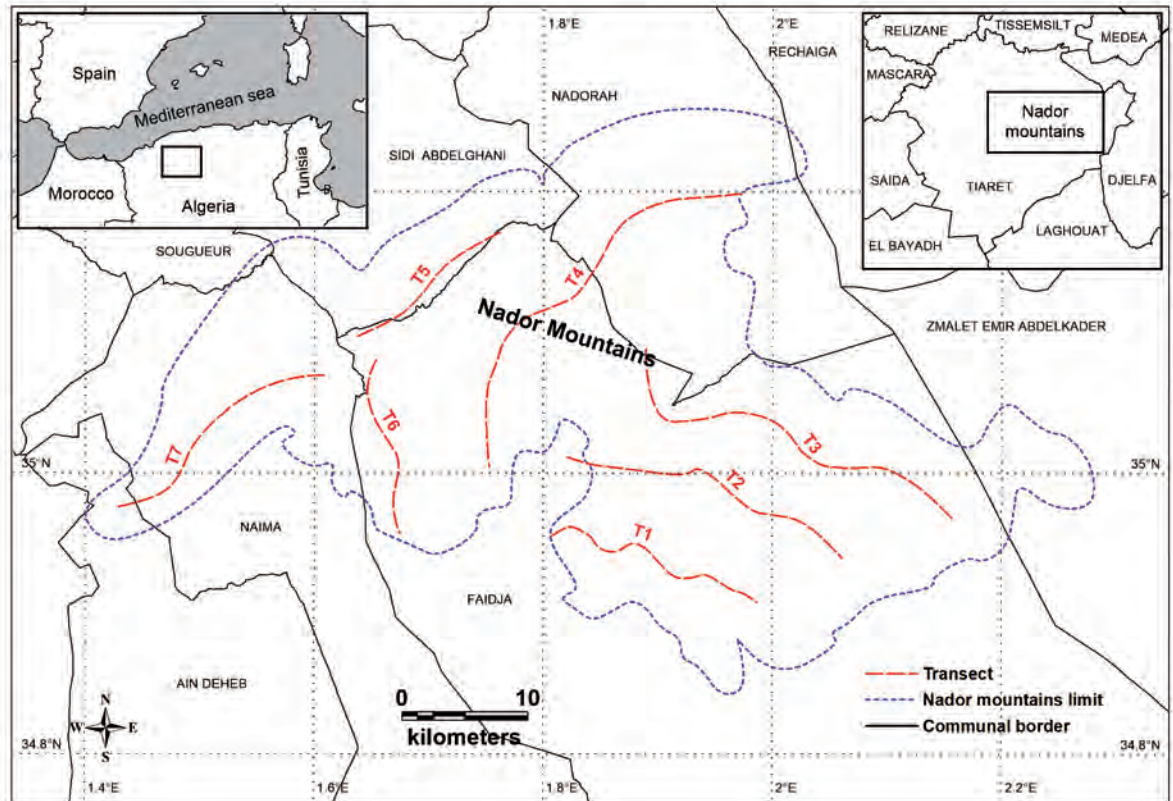


Figure 1 – Transects (T1 to T7) surveyed on foot and by car to monitor the threatened populations of Cuvier's gazelle (*Gazella cuvieri*) and aoudad (*Ammotragus lervia*) in the Nador Mountains (Tiaret province, northwestern Algeria).

phoenicea, *Pistacia terebinthus*, *P. atlantica*, *Olea europea*, *Phillyrea latifolia*, *Artemisia herba-alba*, *Ampelodesma mauritanica* and *Asparagus acutifolius* (Benkhattou et al. 2015).

Human activities are limited in the area because the nearest villages are located 15 to 20 km away. Hunting is prohibited, but poaching occurs.

Survey methods

The same team of three people, aided by local guides, conducted opportunistic surveys from January to December 2014 by car or on foot. From January to May and October to December, we also sampled seven transects on foot, over a total distance of 180 km (Figure 1), in the main habitats of the region, avoiding the vicinity of villages and areas of intense cultivation (Attum et al. 2014). These surveys were conducted each month on consecutive days. Following Abáigar et al. (2005), we recorded two types of field data: (1) direct observations or sightings, using binoculars Barska 10x50 and a telescope x20–60, in early morning and late afternoon; (2) photographs using a Canon camera (EOS 1200D 18–55 mm lens). For each ungulate group, we recorded the GPS coordinates and the number of animals; as far as possible, sex and age were estimated from body size, and from horn shape and length. GPS coordinates of all sightings were processed using MapInfo v 8.0 in order to map the distribution of the two species.

Results

We recorded 13 sightings (raw total of 58 individuals) of Cuvier's gazelle over the study period (Figure 2). Two main areas of occurrence were identified: (1) the northern mountains, near the Oued el Mouilah and Oued Mkaber valleys (transect 4), and between Oued er Reem and Oued Besbassa (transect 5); (2) the southern inclined plane, mainly near Oued er Remel (transect 1), Oued el Euch el Guelbi and Oued Souffiguig (transect 2). No gazelle was sighted along transects 3, 6 or 7. Encounter rates (maximum number of individuals during one survey / transect) were 0.33, 0.20, 0.14 and 0.33 for transects 1, 2, 4 and 5 respectively.

Group sizes were between 2 and 7 individuals (4.5 ± 1.5), mainly females with one male or with sub-adults (or juveniles, in October only). The two largest groups, one comprising 6 females and one male, and the other 7 females, were observed along transect 1 in February and transect 2 in May, respectively. Most groups, including sub-adults and juveniles, were observed in transect 4. One or two groups of gazelles were sighted every month during which surveying took place at altitudes varying between 960 and 1,290 m ($1,147.84 \pm 94.99$ m), with no seasonal pattern.

Aoudad was recorded in just 8 localities (raw total of 20 individuals), mainly in Djebel Chemakh (transect 5), in the rocky valleys of Oued El Mouilah and Oued Souffiguig, and near the southernmost valley

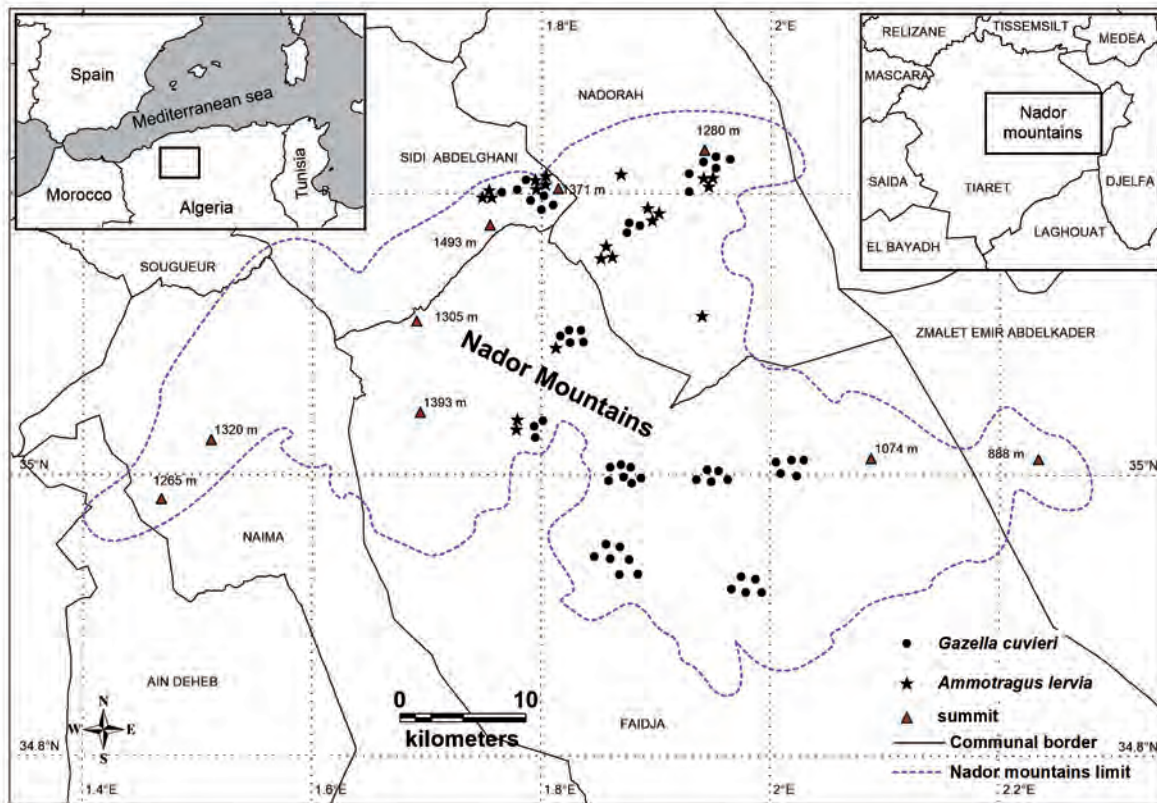


Figure 2 – Spatial distribution of *Gazella cuvieri* and *Ammotragus lervia* in the Nador Mountains (Tiaret governorate, north-western Algeria) in 2014.

of Oued Mkaber (transect 4) (Figure 2). One isolated male was sighted near Oued Mkaber (transect 3) in May. No aoudad was sighted along transects 1, 2, 6 or 7. Group sizes were between 1 and 4 individuals (2.5 ± 1.1), mainly females with one male, with no seasonal pattern; no juvenile or kid was recorded. The altitudes at which animals were sighted ranged from 1,010 to 1,290 m (1097.75 ± 105.69 m).

Discussion

Our results rely mainly on direct sightings as the most practical and efficient survey method in the study area. In quite similar conditions, Gil-Sánchez et al. (2017) reported that distance sampling, which requires considerable effort, does not provide additional information or improvement in the results in terms of distribution data and relative abundance for Cuvier's gazelle. Additionally, Manor & Saltz (2003) consider that distance results are affected by the shy and vigilant behaviour of gazelles. In the absence of additional techniques, such as ones using genetics on droppings, direct sightings remain a major source of information for surveying wild ungulate populations and identifying both the sex and the age of animals.

The occurrence of Cuvier's gazelle in the Nador Mountains confirms previous records (De Smet 1989; 1991; Boualem et al. 2016). This gazelle, which is not a *mountain* species (Abaigar et al. 2005), is, however, widely distributed in Tiaret province (De Smet 1989;

Sellami et al. 1990; Bouaceur et al. 2015; Boualem et al. 2016). Aoudad, in contrast, was sighted for the first time in these mountains only recently (Bouaceur et al. 2016a), and we report the first year-long monitoring allowing the status of this small isolated population to be evaluated.

Spatial distribution

The spatial patterns of the Cuvier's gazelle and aoudad sighted in the Nador Mountains show similarities and differences. Both were recorded in the same altitudinal range, both species forsaking the low western plateau and inhabiting the northern mountains and rocky valleys, but only Cuvier's gazelle ranged in the southern inclined plane. This distribution cannot be related to altitude, as both species are known in Morocco at lower and at higher altitudes, from close to sea level up to 3,100 m for Cuvier's gazelle, and up to 4,100 m for aoudad (Cuzin et al. 2017b). In Algeria north to the Sahara, where the mountains are lower (Debel Chelia, 2,328 m, is the highest peak), both species ranged from 200 up to 2,000 m (De Smet 1989). The largest population was recorded in Djebel Boukahil (south of M'Sila, adjacent to Djelfa and Laghouat provinces), a mountain ranging between 1,415 and 1,675 m (Bouaceur et al. 2016a). Vegetation cannot explain this distribution either, as both species usually live in open forests, maquis and steppes (Beudels et al. 2013; Cassinello 2013), including the steppe of *Stipa tenacissima* (De Smet 1991; Sellami 1999) that cov-

ers most of the low western plateau. The main difference is more subtle: Cuvier's gazelles live on stony and sandy terrain on hills and plateaus (Beudels et al. 2013), such as the slopes of the southern inclined plane; aoudads require more rocky and precipitous terrain (Cassinello 2013), found only in the northern mountains and rocky valleys. The absence of Cuvier's gazelle in the low western plateau is quite surprising, as this species, which avoids areas of dense vegetation where visibility is limited (De Smet 1991; Boualem 2017), frequently forages in crop fields in the vicinity of Tiaret, 70 km from the Nador Mountains (Boualem 2017). This difference of habitat may also explain the respective distributions of each species in Algeria (Bounaceur et al. 2016a, b), and support the present difference in abundance.

Abundance and group size

The raw number of Cuvier's gazelle was higher than the raw number of aoudad, partly due to a larger range and probably a larger population size. The more open habitat of Cuvier's gazelle also facilitates sightings in comparison with aoudad, which lives in more inaccessible areas. However, the encounter rate of Cuvier's gazelle is low, even in the southern inclined plane, when compared to data from the Tiaret region (0.67–2.00, Bounaceur et al. 2016b). It is closer to the encounter rate in the M'sila region (0.21 for 136 km) or near Bezaz (0.20 for 77 km) (Bounaceur et al. 2016b). Habitat and food availability could explain these differences of encounter rate. First, sighting gazelles is easier in flat open areas than in the open pine forests or the rough maquis of the Nador Mountains, or in the M'sila and Bezaz regions. Second, foraging in crop fields near Tiaret (Boualem et al. 2016; Boualem 2017), Cuvier's gazelle benefit from a more abundant and nutritive food source, supporting a larger population. For aoudad, a recent survey showed that only five very small natural populations remain in northern Algeria, the Djebel Chemakh population probably being the smallest (Bounaceur et al. 2016a). On the other hand, Cuvier's gazelle has many remaining larger populations in southwestern Algeria, where they retreated to the optimum habitats (Bounaceur et al. 2016b).

Such differences in abundance may also be related to local group size, which is larger in the case of Cuvier's gazelle than for aoudad. The aoudad, however, is known to form larger groups (2–63, mean 14.7, for introduced aoudad populations in the USA (Valdez, 2011), vs 1–8, mean 3.71 for native populations of Cuvier's gazelle (Huffman 2011)). In fact, most sightings of Cuvier's gazelle were of harems, including sometimes sub-adults and occasionally juveniles, as in Mergueb reserve (Sellami & Bouerdjil 1992). Aoudad were recorded alone or in small groups of adults. Groups of 1 to 10 animals were observed in Chaambi National Park (Tunisia), but sub-adults accounted for 25.0% and 38.4% of sighted animals depending on the season (Ben Mimoun & Noura 2013). The absence of

juveniles may be associated with a low reproduction rate and / or with the protective behaviour of females with kids, which favour the most inaccessible habitats (Cuzin 2003). In a growing introduced population in Texas, juveniles accounted for 30–42% of individuals depending on the year of (aerial) survey (Gray & Simpson 1983).

Conclusion

Whereas both Cuvier's gazelle and aoudad still occur in the Nador Mountains, their statuses are quite different. Occupying a wider ecological niche, the gazelle is more extensively distributed and its population appears locally larger. Moreover, this population is more or less connected with other populations ranging in the Tiaret region. Cuvier's gazelle currently benefits from particular protection; hunting and poaching are prohibited, because this species is associated with local myths (Bounaceur et al. 2016b; Boualem 2017). The aoudad population, on the other hand, is isolated and restricted to the rougher parts of the mountain; its low numbers render it critically endangered, like most of the remaining populations in northern Algeria (Bounaceur et al. 2016a). Like all small, isolated populations, they are threatened by the loss of genetic diversity and possible inbreeding depression (Berger 1990; Nunney & Elam 1994; Schwartz et al. 1989), negative stochastic events, and habitat loss due to global change (Frankel & Soulé 1981). In order to avoid extinction in the near future, aoudad require the effective enforcement of legal protection and a funded national action plan, including establishing new protected areas and a captive breeding programme to enhance the size and genetic diversity of some populations. Cuvier's gazelle, on which the IUCN focused (2018), could also benefit from such an action plan where it lives sympatrically with aoudad, and more widely from raising conservation awareness of wild ungulates, which have declined heavily during recent decades. The Nador Mountains, which are relatively accessible, could be the first site for implementing this action plan, the first step being the regular monitoring of both species' populations.

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