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Monitoring of the Saharan cheetah and large fauna in the Ahaggar Cultural Park (southern Algeria)

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ABSTRACT The Ahaggar Cultural Park (Tamanrasset, Algeria) contains an extremely valuable faunal diversity of which the Cheetah is the flagship element of universal value. This biodiversity, threatened by the combination of climatic and anthropogenic constraints, led the park office to set up a monitoring system based on a holistic approach under the postulate of inseparability "Culture - Nature". The use of camera traps associated with the traditional ecological knowledge of the local population has confirmed the effective presence of 08 wild mammals, 06 of which are protected at the national level and 03 listed in the IUCN Red List of Threatened Species. This work has also provided more information on the behavior of the *Acinonyx jubatus hecki* (Schreber, 1775) (Mammalia Felidae), critically endangered species which has not been observed in the Atakor for more than 15 years.

KEY WORDS Ahaggar; Cheetah; Cultural Park; Fauna; Sahara.

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INTRODUCTION

In the context of a major biological crisis where one million animal and plant species are threatened with extinction (IPBES, 2019), the scientific community is increasingly insisting on the urgency of completing taxonomic inventories, which are often fragmented, and carry out diagnostics of ecosystems in order to decide on the implementation of conservation programs.

Moreover, it is accepted that faunal diversity is a key dimension in maintaining ecological balances, and represents an undeniable concept in a context of global changes. It contributes to the viability and functioning of ecosystems, and to increasing their resistance to external disturbances (Franklin et al., 2002).

Despite the extreme climatic conditions that prevail in Saharan landscapes, many taxa of different biogeographical origins have adapted and/or evolved there through long paleoenvironmental mutations, to constitute ecosystems of remarkable phenotypic and genetic diversity. They form a unique field of investigation for the sciences of biodiversity which nevertheless arouses on a global scale an interest qualified as insufficient with regard to the stakes and potentialities of the largest desert in the world (Durant et al., 2012).

In the current state, reinvesting and knowing the long-term capacity of these environments to maintain their multifunctionality, via their different roles, in particular as a refuge for biodiversity, will shed new light on the dynamics and conservation of biodiversity in extreme situations (Medal, 2013).

However, due to the extent of these ecosystems, the use of biological indicators, replacing biological entities that are much too large to be analyzed effectively, has become an essential approach in conservation biology (Oliver & Beattie, 1996; Chevassus-Au-Louis, 2009). In this sense, large mammals, in particular the Cheetah, by their position in the trophic chain, are a good model whose performance has been widely proven. Also, the population of this species is declining and is severely fragmented. It is limited to 9% of its historic range (Durant et al., 2017) requiring particular interest. In addition, work devoted to the monitoring and study of taxa associated with large ecosystems such as Saharan and desert ecosystems is very rare or even non-existent for certain species.

In Algeria, 43% of the country's surface are covered by a network of cultural parks with an area of 1,042,557 km² and devotes the conservation of biodiversity following a holistic approach based on the inseparability "Culture - Nature". Most of the Saharan cheetah's range is in these parks. As such, the contribution and the fundamental role of this category of territorial classification in the conservation of Saharan fauna will be highlighted in this work.

MATERIAL AND METHODS

Study area

The Ahaggar Cultural Park is located in the extreme south of Algeria covering the largest mountain range (Fig. 1). With an area of 633,887 km², it extends over the province of Tamanrasset and part of the province of Adrar (commune of Timiaouine). The site was classified in 1987 as a national park, then erected in 2011 as a cultural park. The park is an integral part of the Saharan domain and is part of the middle tropical erremic level. Very high daytime temperatures can exceed 50 °C with a thermal amplitude between day and night often greater than 35 °C. Precipitation is rare and irregular with an average annual rainfall of 46.4 mm recorded at the Tamanrasset meteorological station. It contains natural and cultural heritage with singular landscapes, wetlands classified as RAMSAR sites, remarkable biodiver-

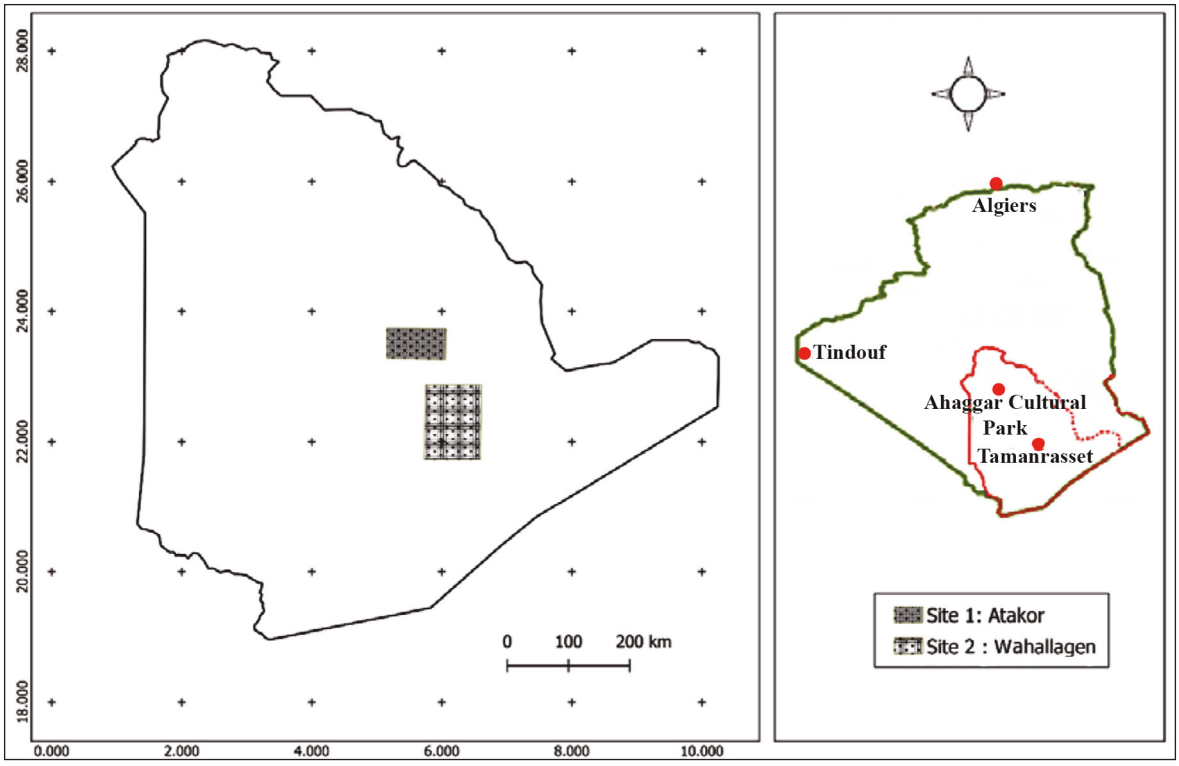


Figure 1. Location of the two study sites (Wa-Helleğen and Atakor) in the Ahaggar Cultural Park (Algeria).

sity of global importance and an archaeological heritage testifying to the first human manifestations dating from 600,000 to 1 million years ago. It also presents a diversified intangible cultural heritage produced by a living culture carried by a dynamic society which adapts to changes while maintaining the authenticity of its secular traditions, thus ensuring their transmission to future generations.

The sites concerned by this work are those of Wa-Helleğen and Atakor. The territories of these two sites are characterized by relative integrity and reflect a harmonious combination of nature and culture while presenting ecological and heritage connections. They are populated by a fauna particularly adapted to the xerility of the environment. These territories constitute one of the last refuges of a representative sample of Sahelo-Saharan biodiversity.

Materials

The monitoring, surveillance and control of natural and cultural heritage are complementary and systematized aspects in the management model of the Ahaggar Cultural Park. Prospecting missions are regularly scheduled in pilot sites to monitor and assess the state of conservation of biodiversity.

In this context, two sampling methods were tested during field surveys devoted to monitoring large fauna (Table 1). At the Wa-Helleğen site, we carried out systematic sampling based on a square mesh grid (10 km x 10 km). A total of 40 camera traps were installed. The minimum operating time is 23 days for each camera.

In the Atakor, we opted for reasoned choice sampling which combines the method of transects through the reconnaissance walk and the use of camera traps in stations where signs of the presence of large fauna have been spotted (droppings, hairs, remains of prey) (Fig. 2). The traditional ecological knowledge of the local population made it possible to make a pre-selection of potential habitats. This

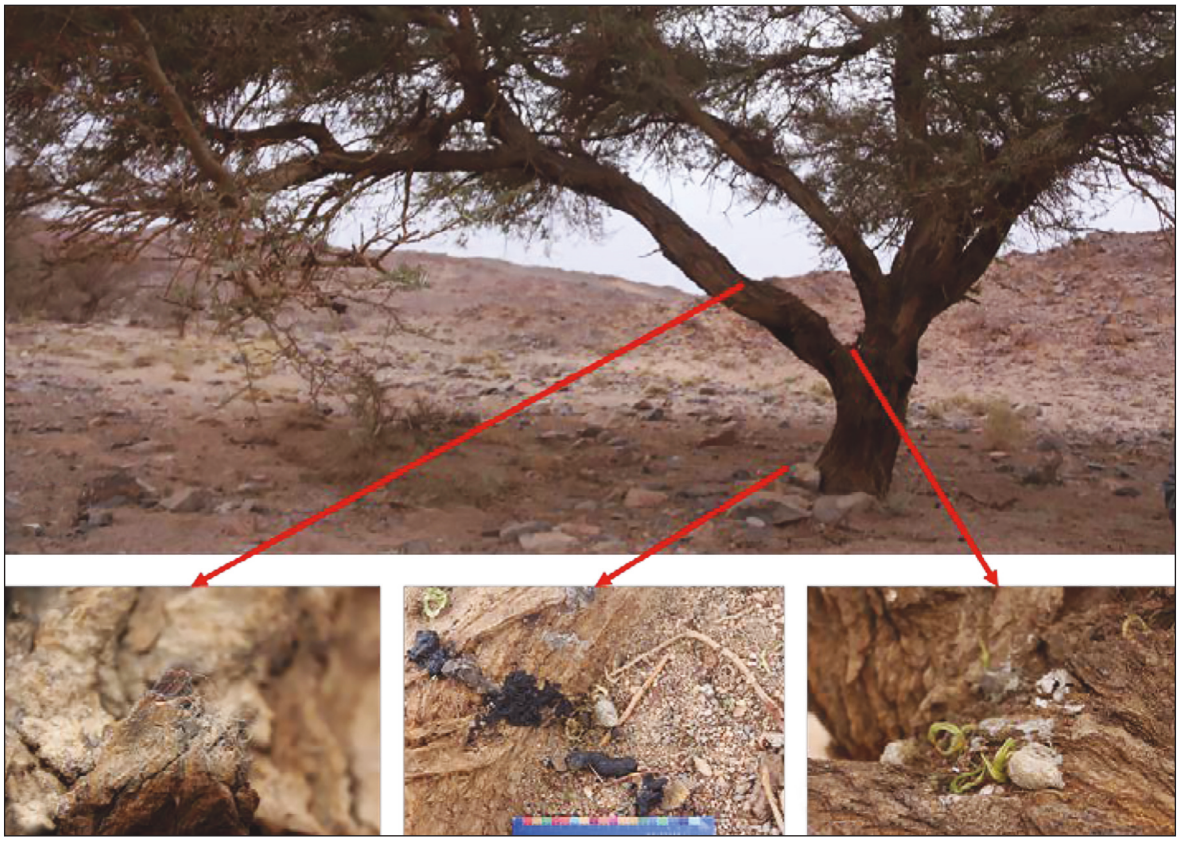


Figure 2. Signs of cheetah presence on an *Acacia raddiana*: hair (left), feces at ground level (center), feces on the trunk at a height of 130 cm (right).

process maximizes the chances of capturing species with a large home range, particularly the Saharan Cheetah, in order to confirm the presence of the species. The camera traps used for data collection are of the "Bushnell Trophy Cam HD Agressor" type.

RESULTS

Sampling effort: the potential capture effort was 1000 capture days for the Wa-Helleğen site and 240 capture days for the Atakor site. For various reasons the effective sampling effort is 895 nights of capture for the first site and 214 nights of capture for the second site.

Total richness: specific richness is an index that can be used to analyze the taxonomic structure of a stand. It makes it possible to distinguish spatio-temporal variations and translates the carrying capacity, which will be all the greater as the number of occupied ecological niches increases (Monteiro et al., 1990). In total, using camera traps, we accumulated 64 field days spread over the sites of Wa-Helleğen (40 days) and Atakor (24 days). This allowed us to capture photographic images of eight (8) wild mammals (Figs. 3–10) spread over five (5) families. Among them, six (6) are protected at the national level and three (3) are on the IUCN Red List of Threatened Species (Table 2).

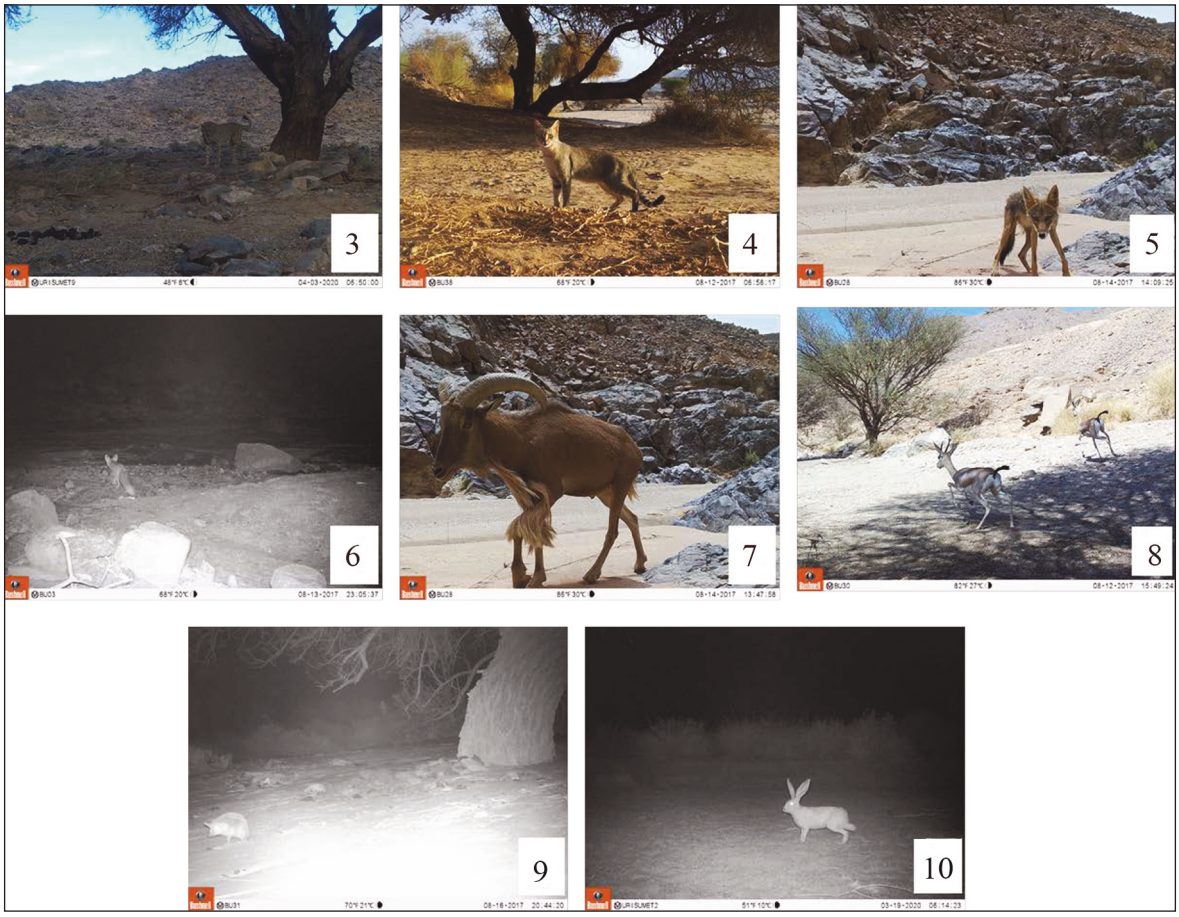
Point richness: this parameter consists in bringing the specific richness to the scale of the station. It reflects the total number of species contacted per survey. It is a reliable parameter for inter-station comparisons (Beisel et al., 1998), provided that the samples always have the same size (Ludwig & Reynolds, 1988). Of the stations recorded, 24% of

Sites	Period	Type of sampling	Materials used
Wa-Helleğen	From July 25 to August 30, 2017	Systematic	40 camera traps
Atakor	From March 15 to April 10, 2020	Reasoned choice	10 camera traps

Table 1. Sites, period, type of sampling and materials used.

Common name	Scientific name	Family	Protection status	
			National Protection	UICN
Dorcas Gazelle	*Gazella dorcas*	Bovidae	Arrangement n° 06-05	VU
Barbary Sheep	*Ammotragus lervia*		Arrangement n° 06-05	VU
African Golden Wolf	*Canis anthus*	Canidae	/	LC
Rüppell's Fox	*Vulpes rueppellii*		Executive Decree n° 12-235	LC
Desert Hedgehog	*Paraechinus aethiopicus*	Erinaceidae	Executive Decree n° 12-235	LC
Saharan Cheetah	*Acinonyx jubatus heckii*		Arrangement n° 06-05	CR
Wild Cat	*Felis silvestris libyca*	Felidae	Executive Decree n° 12-235	LC
Cape Hare	*Lepus capensis*	Leporidae	/	LC

Table 2. Protection and vulnerability status of mammals contacted by photo trapping.



Figures 3–10. Mammals captured by camera traps. Fig. 3: *Acinonyx jubatus heckii*; Fig. 4: *Felis silvestris libyca*; Fig. 5: *Canis anthus*; Fig. 6: *Vulpes rueppellii*; Fig. 7: *Ammotragus lervia*; Fig. 8: *Gazella dorcas*; Fig. 9: *Paraechinus aethiopicus*; Fig. 10: *Lepus capensis*

them have a specific richness greater than 4 species, while most stations (66%) only have two to three species (Fig. 11). No species of wild mammals were captured in stations 14 and 23.

Relative frequency: this is the number of occurrences of a species in each of the stations, divided by the total number of stations sampled, compared to 100. *Vulpes rueppellii* (Schinz, 1825), *Lepus capensis* (Linnaeus, 1758) and *Felis silvestris lybica* (Schreber, 1777) displays high relative frequencies with respectively 80%, 68% and 38% (Fig. 12).

The species contacted are:

Acinonyx jubatus hecki: of the 50 stations sampled, two recorded captures of the Saharan Cheetah. These are stations 48 and 49 located on the Atakor site. In station No. 48, the captures were recorded on March 23, 2020 during twilight between 8:11 p.m. and 8:13 p.m. with a total of 24 photographs taken. On the other hand, at station No. 49, the catches were recorded on April 3, 2020 at the start of the day (between 6:45 a.m. and 6:51 a.m.). The species is active both day and night (twilight). The analysis of the two series of individual photographic shots of the Cheetah on the basis of the identification of the characteristic traits of the coat shows that it is probably the same individual (Figs. 13–16). The cheetah was observed marking the trees at both stations. The trees used for this purpose are *Acacia raddiana* with an average stem diameter (60 to 80 cm) (Figs. 17–18). These are large trees with clear visibility, robustness and an architecture favorable to the installation of the cheetah.

Canis anthus (Cuvier, 1820): formerly called Golden jackal, the genetic study by Koepfli et al.

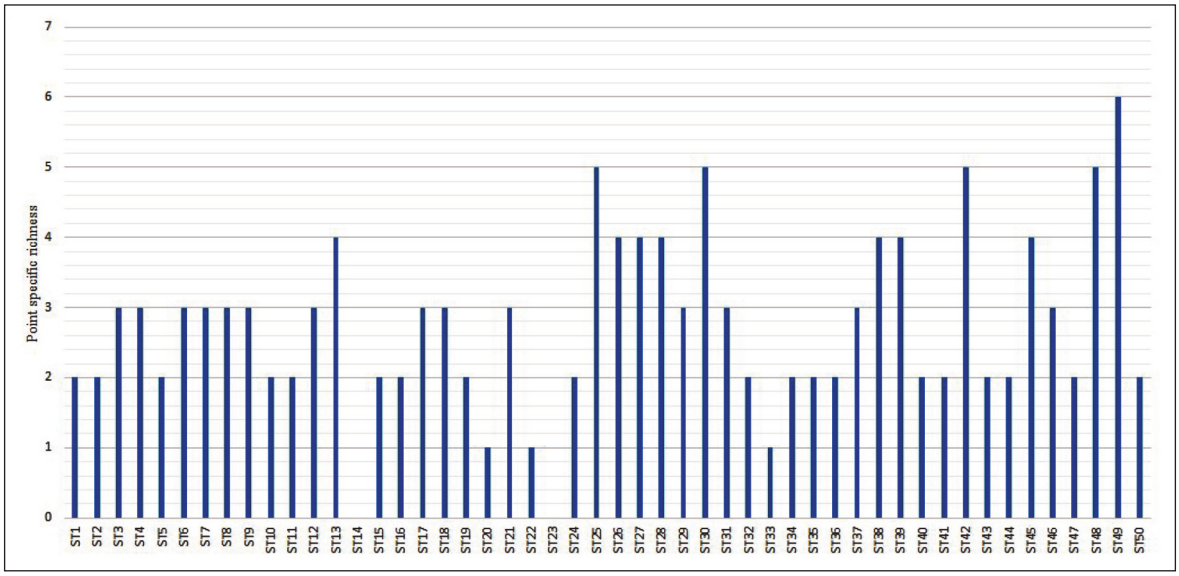


Figure 11. Point specific richness of the 50 monitoring stations.

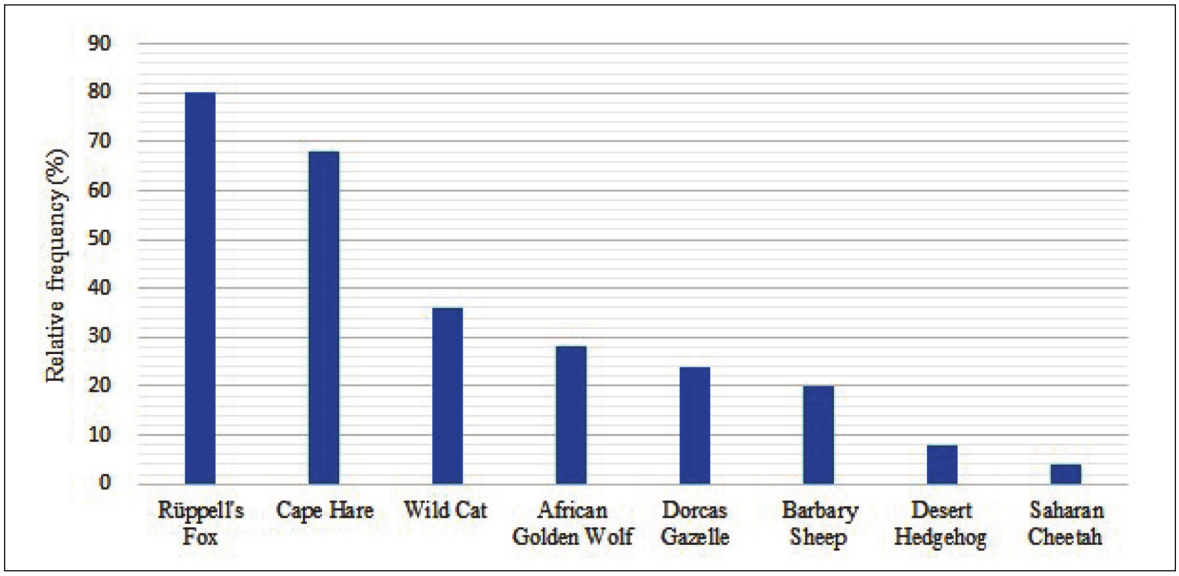


Figure 12. Relative frequency of the 8 species contacted by photo trapping.

(2015) reclassified the species. Based on genetic analyses, these authors showed that the African Golden Jackal and the Eurasian Golden Jackal were two genetically distinct lineages with an independent evolutionary history. They proposed that the African Golden Jackal be named the African Golden Wolf. This species has a wide distribution and a high adaptive capacity allowing it to occupy a variety of ecosystems (Yalden et al., 1996). In Ahaggar, it was reported by Geyr Von Schweppenburg in 1917 in Amguid Tefedest, Devilliers in 1939 in Mertoutek, Thomas in 1925 in Tazrouk and Berzenat in 2009 in Tanhart (Ahmim, 2019).

Vulpes rueppellii: this is one of the small predators widespread in the arid regions of North Africa up to the northern fringes of the Saharan desert. It exhibits wide dispersion. Recent data show the presence of the species in the Saharan Atlas (West-

ern Erg, Djelfa, Biskra, Labiod-Sidi-Cheikh). In Ahaggar, it was observed by Busby in 2005 (Ahmim, 2019) and photographed by us during a monitoring mission in Taessa (2015) and Imidir (2019).

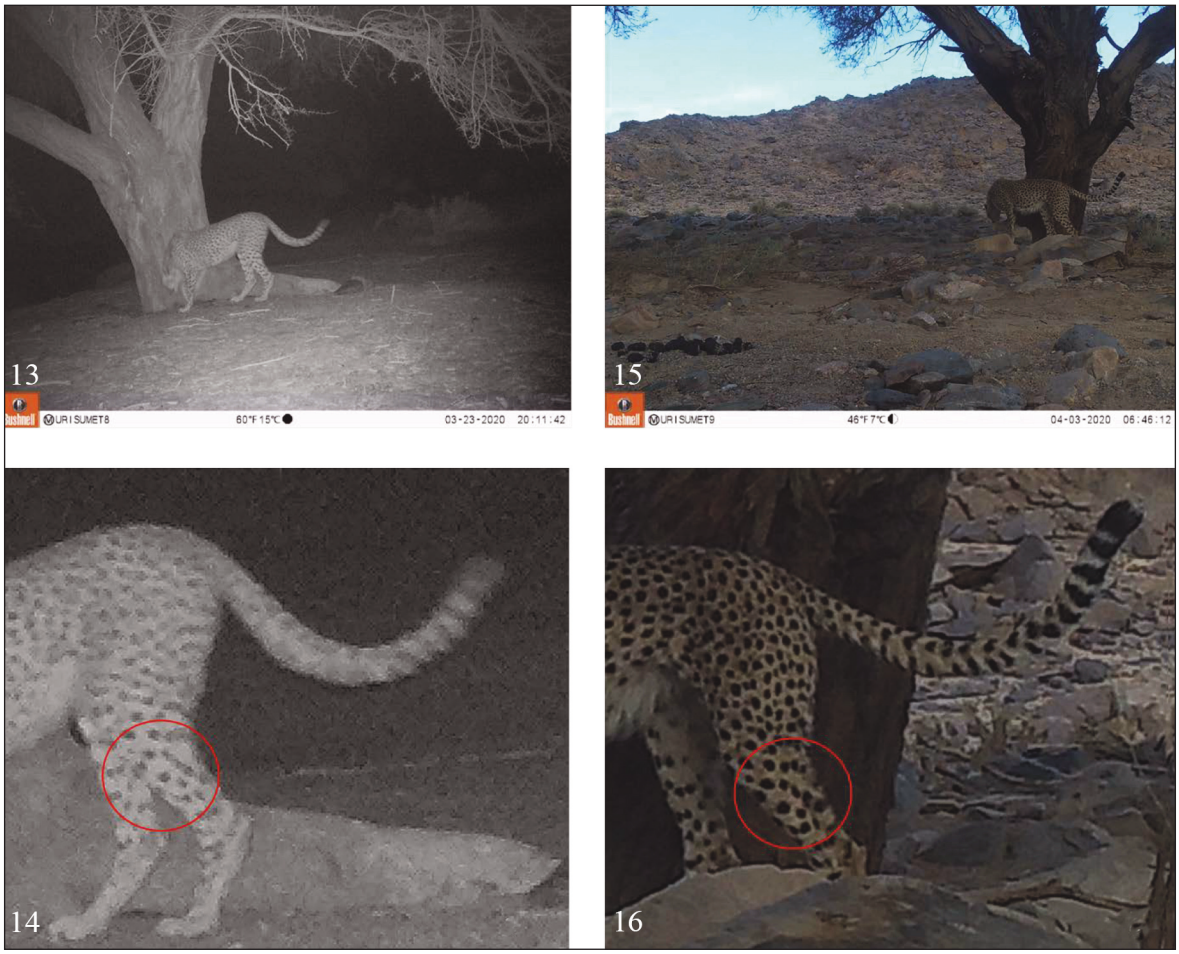
Felis silvestris lybica: this feline is found in different environments. In the Ahaggar-Tassili complex, mentions were reported by Geyr Von Schweppenberg in 1917 in Amguid, by De Smet and by Belbachir between 2006 and 2015 (Ahmim, 2019). On the basis of the synthesis made by the latter, one could suppose that the distribution area of the wildcat tends to diminish.

Gazella dorcas (Linnaeus, 1758): it is a species of large desert and sub-desert areas. It is the most ubiquitous of the Sahelo-Saharan antelopes. Frequenting several habitats, it is a favorite prey of the Saharan Cheetah. Its presence is confirmed in several Ahaggar sites (Amguid, Atakor, Idelès, Tefedest, Tahifet, Taessa, Immidir, Anhef).

Ammotragus lervia (Pallas, 1777)*:* endemic to North Africa, the species is adapted to arid and hot environments. It is one of the emblematic species of Algerian biodiversity. The subspecies *Ammotragus lervia saharienis* occupies almost all of the territories of Ahaggar and Tassili. Its habitat is practically unoccupied by human activity. However, poaching poses a major threat to the survival of the species.

Lepus capensis: present throughout the national territory, it is a prey species for humans and terrestrial carnivorous species. A high reproductive rate allows the species to compensate for losses in the wild. Many mentions relate to the species in the Ahaggar region.

Paraechinus aethiopicus (Ehrenberg, 1832): an omnivorous and solitary species, the desert hedge-



Figures 13–16. Comparison of photos of Cheetah recorded in the two stations. Fig. 13: Individual photographed in the station N°48. Fig. 15: Individual photographed in the station N°49. Figs. 14, 16: unique pattern of spots on the rear limb.

hog occupies the entire Sahara but with a tendency towards regression. It is reported in several localities of Ahaggar such as Tit, Ideles, Abalessa and Taessa.

Other species of birds and reptiles were captured by camera traps. These birds are the *Corvus rufi-collis* (Lesson, 1831), *Bubo ascalaphus* (Savigny, 1809), *Argya fulva* (Desfontaines, 1789), *Upupa epops* (Linnaeus, 1758), *Œnanthe leucopyga* (Brehm, 1855), *Lanius meridionalis* (Temminck, 1820), *Lanius senator* (Linnaeus, 1758), *Streprtopelia decaocto* (Frivaldszky, 1838) and *Ammomanes* sp. For reptiles it is the *Varanus griseus* (Daudin, 1803) and a lizard (*Agama* sp.).

DISCUSSION

Our work focused on a key area of biodiversity given its position straddling the Sahara and the Sahel. We are interested in the inventory of large and medium fauna in general, and the Saharan Cheetah in particular because of its status as a flagship species in critical danger of extinction and its key role in the functioning of the desert ecosystem.

The methodological protocol allowed us to contact mainly 08 species of wild mammals spread over 05 families. The use of camera traps, a method developed for the study of many species that are difficult to observe (Trolle, 2003; Trolle & Kery, 2005), has made it possible to provide objective field data, thus refining existing diagnoses and facilitating identification of issues related to the conservation of biodiversity.

The analysis of capture rates informs us about the relative abundance of species, the carrying capacity of the environment and activity rates (Richard-Hansen et al., 2006). The abundance of certain carnivores attests to the presence of food resources and prey species in sufficient quantities despite the xeric conditions of the environment.

The Saharan Cheetah was the main target species of our work for several reasons. Indeed, complex data tables have little direct impact on decision-makers, who need simpler and more explicit sustainability indicators to communicate key messages. Integrated assessments should target both detailed indicators of key issues and trends for specialists and one or more headline indices that will attract the attention of policy makers and the media (Dahl, 2007). This is the case of the Cheetah, which is classically one of the flagship species which is often chosen from among the threatened and charismatic mammals (Leader-Williams & Dublin, 2000) with particularly broad ecological requirements (Shrader-Frechette & McCoy, 1993). This makes it possible to realize conservation projects of global interest, by ensuring the support of the public and stakeholders (Julve, 2010; Leader-Williams & Dublin, 2000).

Also, the cheetah is one of the most recognized examples of the important links between evolutionary history, genetic variation and conservation. Its remarkable physical characteristics and unique evolutionary lineage as the only extant representative of its genus Acinonyx give it global biodiversity value (Schmidt-Küntzel et al., 2017).

In critical danger of extinction, the subspecies A. jubatus hecki whose last confirmed observation dates from 2010 in the T-in-Haǧǧen region (Belbachir et al., 2015) reappears within the framework of our study in the Atakor mountains. The last mention in the Atakor dates from 2005 when a corpse was found by the park office team. Since then, no sightings have been reported until the work of the present study.

This region forms a real refuge of biodiversity, because its contrasting reliefs offer heterogeneous environmental conditions and lead to more favorable climatic situations compared to the surrounding plains (Médail, 2013). Also, the wide beds of wadis with spatial configuration of an open vegetated system, with a sparse herbaceous-bushy stratum and weakly wooded by *Acacia* formations, are very frequented by small mammals and angulates which are prey species of the cheetah.

It is true that only two stations recorded photographic captures of Cheetah. However, assuming that the absence of detection results in the absence of the species would have the effect of biasing the estimate of the site occupancy rate (MacKenzie et al., 2003). After processing the historical data, it emerges that 77.94% of the mentions are located in the Ahaggar cultural park, making this vast park a highly valuable territory for the species.

Depending on the case studies, it is essential to know the identity of a cheetah (Broekhuis et al., 2017). This is based on the visual analysis of unique spotting patterns (Caro, 1994; Kelly, 2001; Chelysheva, 2004) on the front and hind limbs, as well as

Figures 17, 18. Trees marked by cheetah. Fig. 17 (left): *Acacia raddiana* in station N°48.
Fig. 18 (right): *Acacia raddiana* in station N°49.

spots and rings on the tail. The preliminary recognition of the captured individual on the basis of the spotting patterns that remain constant throughout their life (Caro & Durant, 1991) makes it possible to constitute a first reference library and to provide basic information to managers of the Ahaggar cultural park.

Differences in the functional use of scent marking sites can provide information about individuals (age class, rank, sex) and play a vital role in conspecific interactions (Walker et al., 2016; Allen et al., 2017). The description of marker trees, associated with the knowledge of local populations, particularly through the toponymic names of trees for which the name Cheetah is attributed, can help in the characterization of trees valued by the species for marking. In the Ahaggar Cultural Park, places called "Tabrakat Tan Imuyas" in Atakor and in the Tahifet region refer to *Tamarix* where the cheetah rests.

In these territories the old traditions are very deep. It is possible that a certain zoolatry or a very great veneration for certain animals, in particular the cheetah, has been known throughout the world (Marker et al., 2018) and among the Saharan nomads, ancestors of the Tuaregs (Camps, 1988). In the Ahaggar, the Saharan cheetah is of proven heritage interest because it strengthens the feeling of belonging and the identity of the territory. Several people bear the name "Amayas" (Cheetah in the Tergui language) in different localities.

Local populations have accumulated, through experience and tradition, knowledge related to the herding instincts and behavior of the cheetah in its natural habitat. A knowledge found, in particular, among the goatherds and the camel drivers because of their constant proximity to their cattle and the observation of the strategies of hunting and avoidance of the feline. However, it would seem that traditional knowledge related to this species is concentrated in the north of the Ahaggar massif (Badi, 2017).

The presence of the species in the territories of cultural parks dates back to prehistoric times, which is attested by the rock engravings of Oued Djerrat (Tassili Cultural Park) and Hadjar Berrick in the Ksour Mountains (Cultural Park of Saharan Atlas). It is clear that it is as rare as its current status in the representations of the great ensembles of the central Sahara.

Currently, a conflict situation exists between the local population and the cheetah. The latter's recourse to the predation of livestock is the origin of the main antagonistic relationship. In addition to this heritage fact, changes in traditional land and natural resource management practices are a factor threatening the survival of wildlife (Marker et al., 2018).

However, in the past, the process of heritage of the territories by the local populations led to the development of a resource management system called "Agadal", a term meaning "to prohibit". This ancestral system, based on traditional ecological knowledge, controlled and regulated access to natural resources, thus allowing their sustainable exploitation. This system still seems latent and is

linked to a set of values, representations and beliefs that permeate identity practices and relationships with the constituent elements of local ecosystems, including the cheetah (Badi, 2017).

Today, long-term conservation research programs are working collectively to put in place strategies to ensure the survival of cheetah (Marker et al., 2018) but it is essential to consider a paradigm shift in the conservation towards a holistic approach that incentivizes protection and promotes sustainable coexistence between people and wildlife in large multi-use landscapes (Biggs et al., 2007; Durant et al., 2017).

The approach developed in our study by combining the traditional knowledge of the local population with scientific monitoring protocols was of great interest. The use of adaptive cluster sampling will make it possible to continue sampling in sites adjacent to the one where the main flagship species “cheetah” was detected.

The category "Cultural Park" is recognized by the IUCN as “Other Effective Conservation Measures by area”. Combined with the extent of the network which covers 1,042,557 km² by ensuring territorial and ecological connectivity from the far south to the Saharan Atlas, this model constitutes an innovative conservation policy which acts at the scale of the landscape and supports the cultural dimension of Man-Nature interconnections. This approach can ensure the conservation of many species, especially those that are rare and have a very wide range.

“Culture - Nature”.

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