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Distribution and status of the striped hyena *Hyaena hyaena* (Linnaeus, 1758) (Mammalia, Hyaenidae) in Algeria

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Abstract: The striped hyena *Hyaena hyaena* is listed "Vulnerable" by the International Union for Conservation of Nature (IUCN) in the Mediterranean region as its population and range are decreasing in most countries. In Algeria, the distribution and status of this species have not been reviewed for nearly 30 years. A field survey was conducted during the last 10 years in many regions and suitable habitats in order to update this information. Our results show that the striped hyena was eradicated from some northern areas of its former range, but still occurs in most regions of Algeria. Causes of mortality are reported and conservation measures are suggested in order to keep sustainable populations.

Keywords: Carnivora; habitat; North Africa; range; survey.

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Introduction

Global analyses show that carnivores are among the most threatened mammals (Ceballos et al. 2005, Schipper et al. 2008). Over the 295 existing species, 114 are currently on the International Union for Conservation of Nature's (IUCN) Red List of Threatened Species and six are "Data Deficient" (IUCN 2018). It is challenging for scientists to identify the causes of decline of carnivores, and for conservationists to keep sustainable populations over their whole range (Karanth and Chellam 2009). Due to their position high up in the trophic network, carnivores usually have low population densities (Riple et al. 2014). Most species are threatened by habitat loss and fragmentation, hunting for curative purposes or trophies, depletion of their prey due to excessive shooting, snaring, netting or other forms of exploitation (Robinson and Bennett 2000).

In the 20th century, North African carnivores lost the type subspecies of lion *Panthera leo leo* (Linnaeus, 1758) (Black et al. 2013), and possibly the African wild dog, *Lycaon pictus* (Temminck, 1820), and leopard, *Panthera pardus* (Linnaeus, 1758); in addition, cheetah, *Acinonyx jubatus* (Schreber, 1778) and serval, *Leptailurus serval* (Schreber, 1776) are on the verge of extinction (Kowalski and Rzebik-Kowalska 1991, Aulagnier et al. 2015). After these "Critically Endangered" or "Endangered" species of the Mediterranean region (Temple and Cuttelod 2009) comes the "Vulnerable" striped hyena, *Hyaena hyaena* (Linnaeus, 1758).

The striped hyena is widely distributed in the northern half of Africa (Wagner 2013), in Asia, the Middle East and the Arabian Peninsula, albeit now patchily (Kolowski and Holekamp 2009). Over a total population of 5000–14,000 individuals, the African population, 2450–7850 individuals, represents roughly half of the worldwide striped hyenas (Hofer and Mills 1998). The species is listed "Near Threatened" under the criterion C1 (AbiSaid and Dloniak 2015), given that the numbers are likely to be below 10,000 mature individuals and the deliberate and incidental persecution it suffers. Other ecological factors

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such as scarcity of food and shelter and competition with other carnivores may also be factors contributing to the decline of this species (Wagner 2006, Alam 2011).

After the extinction of the spotted hyena *Crocuta crocuta* (Erxleben, 1777) during the Neolithic period (Geraads 2017), the striped hyena became the only representative of the four extant hyaenid species in North Africa where it is sometimes considered to be a subspecies, *Hyaena hyaena barbara* Blainville, 1844. For northwestern Africa, the distribution and status have not been evaluated in Tunisia where the species is considered "historically present" by Hofer and Mills (1998). In Morocco, Cuzin et al. (2017) recently reported a dramatic decline due to illegal hunting and trapping for sorcery purposes (Bellakhdar 1978), poisoning campaigns (Ogada 2014) and road fatalities. In Algeria, the most recent information about the distribution of the striped hyena was documented by De Smet (1989) and compiled by Kowalski and Rzebik-Kowalska (1991).

After the recent increase in human activities including habitat destruction and persecution and in the absence of recent reported sightings updating the distribution and status of the striped hyena, it became a priority to initiate ecological studies and prepare a conservational action plan.

Wild carnivores are charismatic but competing animals for humans, and the assessment of population trends and status is often tricky due to ecological traits such as solitary, nocturnal and elusive behavior, low population densities and concealment of information by local people when they are protected. Nevertheless we conducted field surveys over Algeria in most habitats suitable for the striped hyena. We also questioned many potential sources of information in order to map its current distribution and assess the recorded causes of mortality. Due to the lack of past and present knowledge, we were unable to identify population trends; therefore, we will update the status of the species by comparing this distribution to the maps prepared similarly by De Smet (1989) (Figures 1A, 2A).

Materials and methods

The hyena survey was conducted between 2008 and 2018 in all regions and natural habitats of Algeria. Two teams were involved in collecting data. First, LD collected data through a collaboration with forest conservationists of the General Forest Office (DGF), and with national parks from different Algerian sites including: Chréa (CNP, Blida), Belzma (BNP, Batna), Tlemcen (TNP, Tlemcen), Theniet El Had (THENP, Tissemsilt), El Kalaà (EKNP, El Taref), Djurdjura (DNP, Bouira – Tizi-Ouzou), Gouraya (GNP, Bejaïa). The help of veterinaries and naturalists from different parts of the country was also relevant. Second, FB and his team visited four to five times each locality where the presence of the striped hyena was reliably reported by forest officers. In the field, information was collected either by direct sighting or by interviewing local shepherds, hunters, forest rangers and wildlife naturalists.

Each specimen or track sighting was visited by one author, and some sites were visited more than once. Unfortunately, some sites were unreachable, and associated data were discarded. Information recorded at each site included: location, date, GPS coordinates, type of record (live sighting, dead animal, feces, etc.), main habitat type and human activities.

Each data sheet was completed by one of the authors with the help of local game hunters or shepherds. Confirmation of sightings or tracks was based on our field investigations.

Collected data were used to map the presence of the striped hyena using MapInfo v 8.0 (North Greenbush, NY, USA). The distribution reported by De Smet (1989) was also mapped accordingly for comparison (Figure 1A, B).

Results

We recorded 314 striped hyena locations (Figures 1B, 2B) supporting a wide distribution of the species in the country, including southern Sahara. Most new records were obtained from northern Algeria (Supplementary Table 1), with the presence of the species in 28 locations near Tlemcen in north-west, ranging from the Mediterranean strand to the semi-arid part of this governorate. Heading east, the striped hyena was reported mainly in the mountainous regions north to the Atlas chain, with numerous locations in some governorates: 34 in Bouira, 29 in El Taref, 27 in Batna, 22 in Biskra, 14 in Souk Ahras, 13 in Médéa, 10 in Ain Defla, Constantine, Relizane, Tissemessilt and Setif. In the most northern part of the country, it was reported only from Bejaia (cultivated area), Chlef (Bissa cork-oak forest), Tipaza (cultivated area) and the Medejerda mountains in El Taref governorate at the extreme north-east.

The striped hyena was recorded mainly in mountain open and dense forests (43.9% of records) of pine (*Pinus halepensis*) and green oak (*Quercus ilex*), but also in cultivated lands (41.4%), often bordered by clear forests, and peri-urban areas (Figure 3). Steppe (6.7%), matorral and maquis (1.0%) provided fewer records.

A total of 121 specimens were found dead (Figure 4). Road fatality was the main cause of mortality (57.0%), before human shooting (19.8%), trapping (5.8%) or

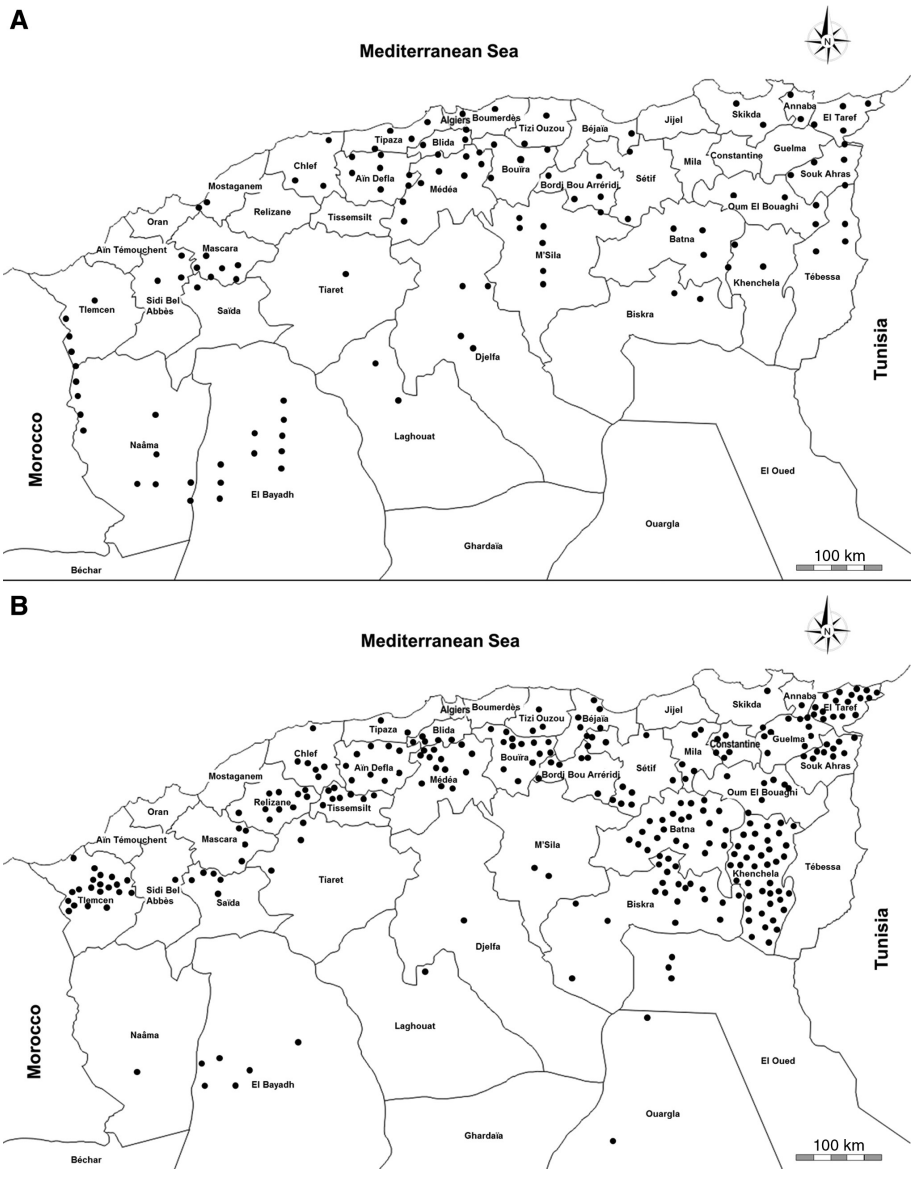

Figure 1: Distribution of the striped hyena (*Hyaena hyaena*) in northern Algeria. (A) According to De Smet (1989) and (B) data collected between 2008 and 2018.

poisoning (0.8%). One animal was killed by feral dogs. At last the cause of mortality was undetermined for 19 dead specimens.

Discussion

Distribution and habitat

By comparison with the distribution mapped by De Smet (1989), we collected a data set including several new records of occurrence. This set also shows that the striped hyena is still widely distributed in Algeria from the Mediterranean Sea to central Sahara, through semi-arid and arid regions. Yet some differences can be emphasized. The retreat from the northernmost parts of the country, reported during the 20th century (Kowalski and Rzebik-Kowalska 1991), is ongoing.

The striped hyena has disappeared from the vicinity of important economic localities such as Algiers, Boumerdes and Mostaganem where it was reported until the 1990s (De Smet 1989). In the north of the Saharan Atlas, we did not record any sign of presence where it occurred previously in Bayadh Naâma and Ghardaia governorates (De Smet 1989, Kowalski and Rzebik-Kowalska 1991).

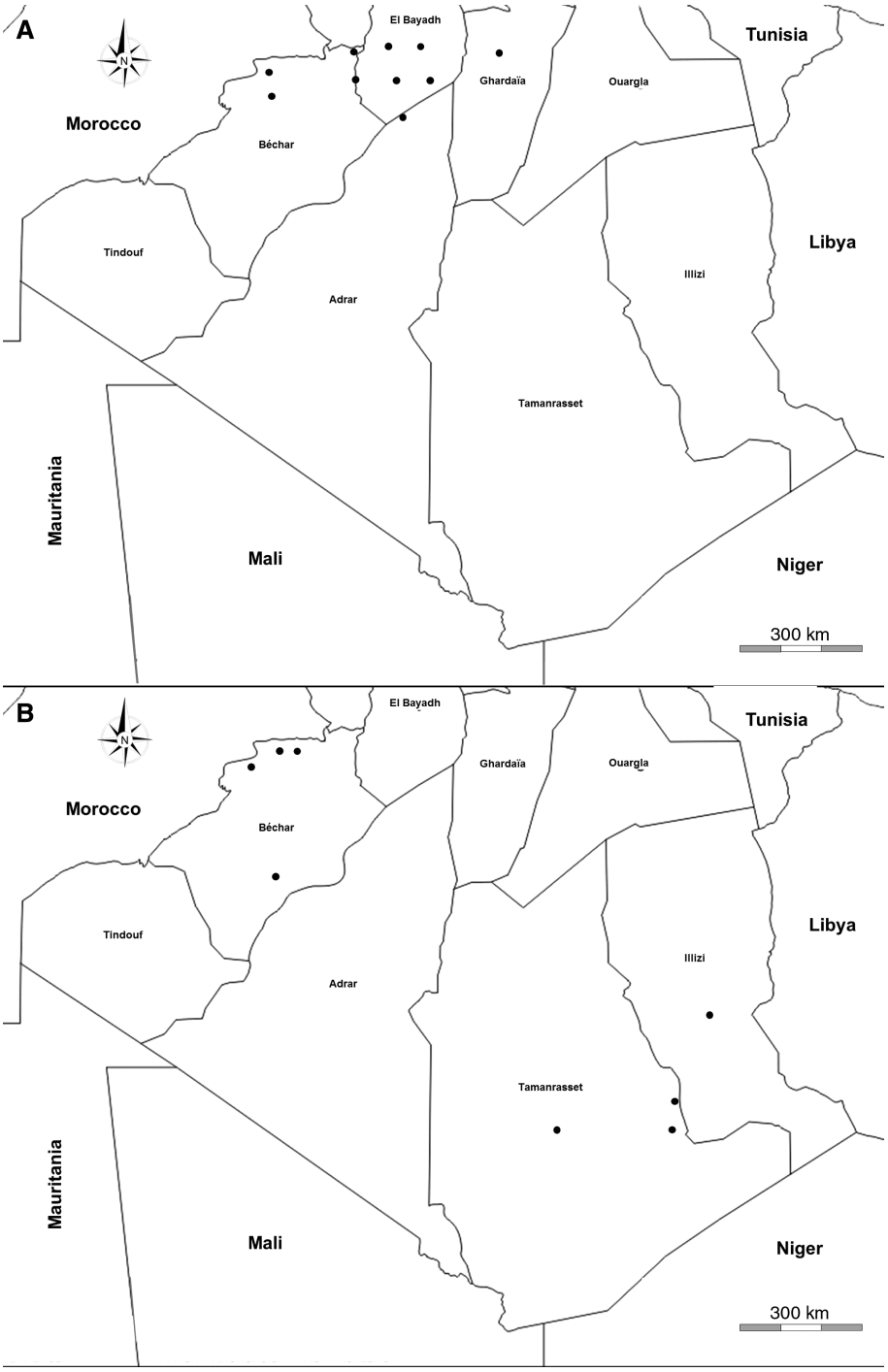

Figure 2: Distribution of the striped hyena (*Hyaena hyaena*) in southern Algeria.
(A) According to De Smet (1989) and (B) data collected between 2008 and 2018.

Our investigations in these areas were possibly not very efficient due to the lack of surveyors and the wide area to survey. Similarly, the lack of striped hyena data from the north-eastern region in Tebessa governorate, which is a difficult region to survey due to insecurity, should be further investigated.

On the other hand, the striped hyena was recorded in southern Sahara (Hoggar and Tassili n'Ajjer) where the previous record dated back to the middle 20th century (Régnier 1960). We believe however that there are still more undiscovered populations in this area. Many occurrences were also collected in Tlemcen, Batna and

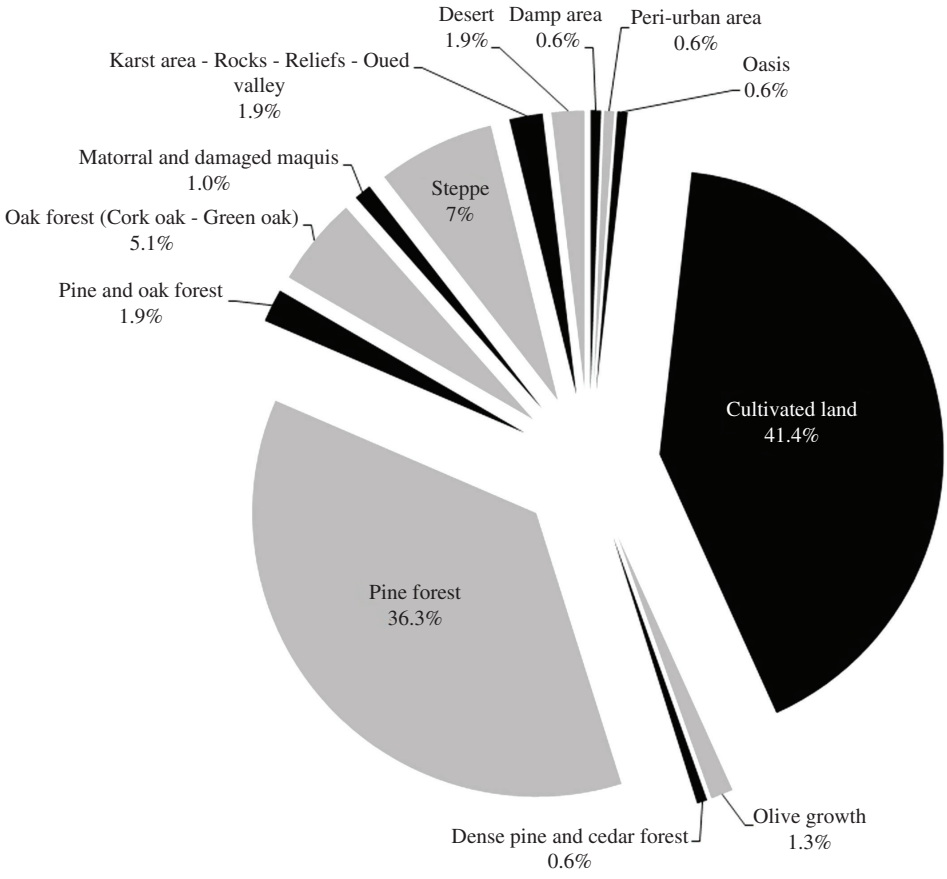

Figure 3: Main habitats of the striped hyena (*Hyaena hyaena*) in Algeria according to data collected between 2008 and 2018.

Khenchela governorates where De Smet (1989) reported only few sightings. The number of data from Tlemcen is surprising as there is no evidence of remaining hyenas across the Moroccan border (Cuzin et al. 2017). Many data also originated from Médéa, Bouira, Biskra, Souk Ahras and El Taref governorates, whereas the species is suggested to remain as several small isolated populations in the nearby northern Tunisia (Dalhoumi et al. 2018). These various "spots" are located in different bioclimates, geographical areas and elevations with a maximum vertical distribution of ca. 2000 m in Djurdjura mountains whereas it is 2700 m in Morocco (Cuzin 2003) and 3300 m in Pakistan (Roberts 1997).

According to the literature, the striped hyena generally favors open or thorn bushes in arid to semi-arid environments, where water is available, and avoids open desert and dense thickets and forests (Wagner 2013). In Algeria, most data were collected from mountains or rough terrains, including deep valleys in karst areas, which could offer resting sites for the species as it was reported by Rieger (1979). They were also mainly recorded in, or near, open forests which are not part of the habitat described in central Asia by Heptner and Sludskij (1980) or more recently in India by Alam et al. (2015). It is noteworthy but not surprising to notice the presence of striped hyenas in cultivated zones and near rural settlements, as this species is among the main carnivores using human-provided food resources as components of their diet (Mills and Hofer 1998). Such opportunistic behavior may prevail in crowded Algerian regions like Constantine governorate. In India, population densities of the striped hyena are linked to the availability of safe refuges and livestock abundance (Alam et al. 2015). Similarly, the largest number of records from eastern Algeria could be related to the presence of shelters, human settlements and free-ranging livestock.

Causes of mortality

Over 122 dead striped hyenas, 68 resulted from road fatality, which was also reported from Israel (Mendelsohn 1993), Turkey (Akay et al. 2011) and Iran (Tourani et al. 2012). In Morocco, this cause of mortality has increased

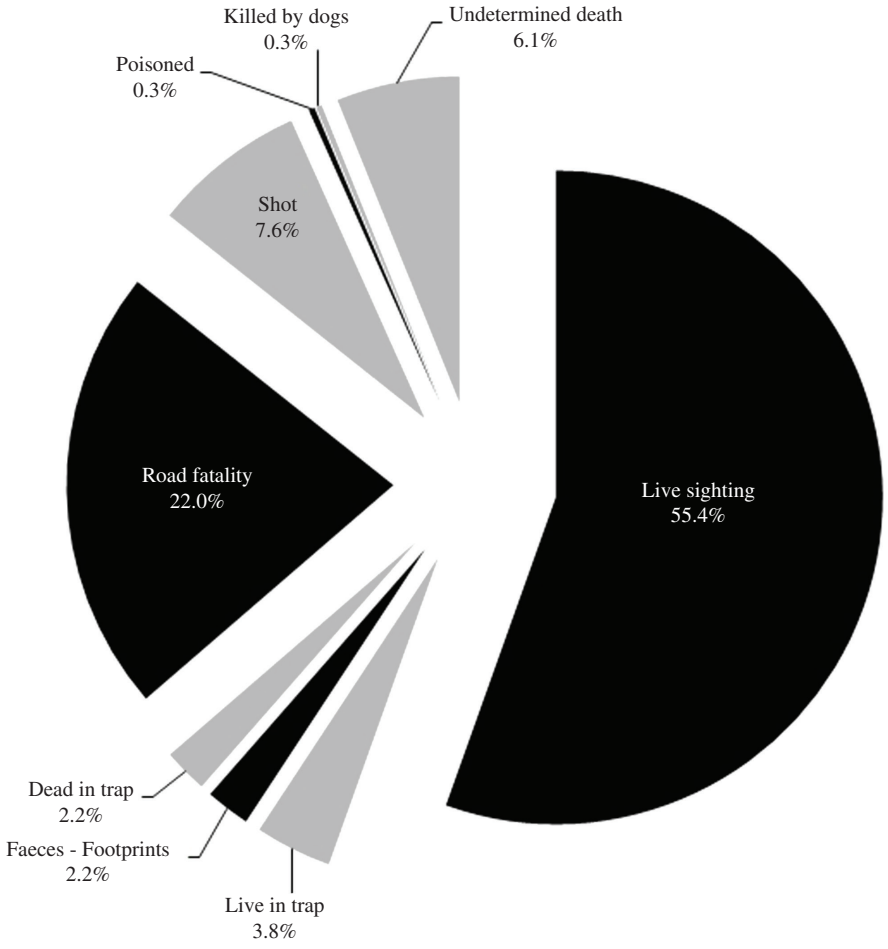

Figure 4: Categories of observations (including causes of mortality) of the striped hyena (*Hyaena hyaena*) in Algeria from data collected between 2008 and 2018.

with road traffic as hyenas are attracted by roadkills (Aulagnier et al. 2015). Beyond socio-economic and traffic safety impact (e.g. Bissonette et al. 2008), animal populations may suffer from isolation and increased inbreeding leading to population declines and local extinctions (Forman and Alexander 1998, Coffin 2007, Jackson and Fahrig 2011).

The second reported cause of mortality was hunting and poisoning as, like in its whole range (Hofer 1998), the striped hyena is blamed for damages on livestock (goats, sheep) and poultry. Human-hyena conflict is one of the major challenges to save the remaining populations. Studies analyzing the conflict between human and wildlife in many parts of the world showed that the rate of tolerance toward predators mostly depends on the degree of predation on their domestic animals (Kolowski and Holekamp 2006, Holmern et al. 2007, Bhandari and Chalise 2016, Dejene et al. 2016, Bhandari and Bouchal 2018). In Algeria, the increasing level of conflict is probably due to the lack of conservation awareness and mitigation programs for this species.

The third cause of mortality was trapping targeted to control wild boar, *Sus scrofa*, whose numbers are rising everywhere in Algeria and Tunisia (Cuzin and Randi 2013). Finally, the cause of mortality of 20 specimens was not identified due to the lack of local veterinary laboratories where autopsies can be performed. We suspect that some of these specimens were poisoned either intentionally or indirectly after eating a poisoned prey mainly used for jackal control.

Status and conservation issues

Striped hyena populations are declining throughout the geographical range due to prosecution, poisoning and hunting for medicinal purposes, depletion of prey populations, habitat destruction, wildlife diseases and

competition with other carnivores (Singh et al. 2010, Akay et al. 2011, Alam 2011, Dejene et al. 2016). In Algeria, there are no data on population trends. Our current records suggest the scarcity of most populations. Regarded as endangered in North Africa for a long time (Simon 1969) and in Egypt more recently (Hoath 2003), the striped hyena is dramatically declining in Morocco (Cuzin et al. 2017). Yet records are still numerous in Algeria, where the species is however highly vulnerable.

Numerous data were collected from cultivated zones and peri-urban areas as natural prey depletion forces hyenas to venture into human settlements in search of food, such as livestock and other domestic animals (Wagner 2013). In this case, the human-hyena conflict cannot be solved by only legal protection of the species (order 06-05 of July 15, 2006 for Algeria) and authority supervision. So, trade of skins, teeth and legs still occurs on the market in Taghit and Béni Abbès (south-western Algeria) for traditional medicine purposes (pers. obs.).

The concept of conservation and sustainable use of natural resources is deeply rooted in Islamic culture (Bakader et al. 1983), and should convince a larger number of people to accept the presence of striped hyenas. Additionally, conservation strategies should involve the preservation of numerous wild prey, as well as adopting methods to reduce livestock killings (e.g. effective nocturnal livestock management in predator-proof pens, herding during daytime, use of guard dogs). In most conflicting sites, compensation programs should be launched.

In order to reduce road fatalities, a number of mitigation measures have been designed (Glista et al. 2009, van der Grift et al. 2013, Rytwinski et al. 2015). However, these measures may not apply in the North African landscapes and for the striped hyena which is attracted by roadkills.

In conclusion, our data indicate that the occurrence of the striped hyena is larger in Algeria than it is widely believed, even if only a limited number of sites have been surveyed. Moreover, it was impossible for us to estimate populations for various reasons, including the extent of suitable habitats for the species and the insecurity in some regions. Additional studies on populations living in different habitat types are needed for improving our knowledge of the striped hyena conservation status in Algeria.

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References

AbiSaid, M. and S.M.D. Dloniak. 2015. *Hyaena hyaena*. The IUCN Red List of Threatened Species 2015: e.T10274A45195080.

Akay, A.E., S. Inac and I.C. Yildirim. 2011. Monitoring the local distribution of striped hyenas (*Hyaena hyaena* L.) in the Eastern Mediterranean region of Turkey (Hatay) by using GIS and remote sensing technologies. Environ. Monit. Assess. 181: 145–455.

Alam, M.S. 2011. Status ecology and conservation of striped hyena (*Hyaena hyaena*) in Gir National Park and Sanctuary, Gujarat. PhD Thesis, Aligarh Muslim University, Aligarh, India.

Alam, M.S., J.A. Khan and B.J. Pathak. 2015. Striped hyena (*Hyaena hyaena*) status and factors affecting its distribution in the Gir National Park and Sanctuary, India. Folia Zool. 64: 32–39.

Aulagnier, S., A. Bayed, F. Cuzin and M. Thévenot. 2015. Mammifères du Maroc: extinctions et régressions au cours du XXème siècle. In: Approche intégrative de la 6ème extinction: influence de l'installation des hommes modernes au Maroc sur l'évolution de la biodiversité des petits vertébrés terrestres. Trav. Inst. Sci., Sér. gén. 8: 53–67.

Bakader, A., A. Al-Sabbagh, M. Al-Genid and M. Izzidien. 1983. Islamic principles for the conservation of the natural environment. IUCN, Gland. pp. 25.

Bellakhdar, J. 1978. Médecine traditionnelle et toxicologie ouest-sahariennes. Contribution à l'étude de la pharmacopée marocaine. Ed. tech. nord-africaines, Rabat. pp. 357.

Bhandari, S. and D.R. Bouchal. 2018. Notes on human–hyena (*Hyaena hyaena*, Linnaeus 1751) conflict in Jajarkot, Kalikot and Mahottari district of Nepal. J. Inst. Sci. Tech. 22: 127–131.

Bhandari, S. and M.K. Chalise. 2016. People's attitudes toward striped hyena (*Hyaena hyaena* Linnaeus, 1758) (Mammalia: Carnivora: Hyaenidae) conservation in lowland Nepal. J. Threat. Taxa 8: 9125–9130.

Bissonette, J.A., C.A. Kassar and L.J. Cook. 2008. Assessment of costs associated with deer–vehicle collisions: human death and injury, vehicle damage, and deer loss. Hum. Wildl. Interact. 2: 17–27.

Black S.A., A. Fellous, N. Yamaguchi and D.L. Roberts. 2013. Examining the extinction of the Barbary lion and its implication for felid conservation. PLoS One 8: e60174.

Ceballos, G., P.R. Erlich, J. Soberon, I. Salazar and J.P. Fay. 2005. Global mammal conservation: what must we manage? Science 309: 603–607.

Coffin, A.W. 2007. From roadkill to road ecology: a review of the ecological effects of roads. J. Transp. Geogr. 15: 396–406.

Cuzin, F. 2003. Les grands Mammifères du Maroc méridional (Haut Atlas, Anti Atlas et Sahara): distribution, écologie et conservation. Thèse Doctorat E.P.H.E., Montpellier. pp. 340.

Cuzin, F. and E. Randi. 2013. *Sus scrofa* Wild boar (Eurasian wild pig). In: (J. Kingdon and M. Hoffmann, eds.) Mammals of Africa. Volume VI. Pigs, hippopotamuses, chevrotain, giraffes, deer and bovids. Bloomsbury Publishing, London. pp. 28–31.

Cuzin, F., S. Aulagnier and M. Thévenot. 2017. Carnivora (pp. 155–196). In: (S. Aulagnier, F. Cuzin and M. Thévenot, eds.) Mammifères sauvages du Maroc. Peuplement, répartition, écologie. Société Française pour l'Etude et la Protection des Mammifères, Paris. pp. 340.

Dalhoumi, R., N. Nefla, W. Bedoui, R. Ouni and S. Aulagnier. 2018. Liste préliminaire des mammifères terrestres de la région

Mastouta-Bishshouk (Beja, nord-ouest de la Tunisie). Rev. Fac. Sci. Bizerte 16: 1–10.
De Smet, K.J.M. 1989. Studie van de verspreiding en biotoopkeuze van de grote Mammalia in Algerie in het kader van het natuurbehoud. Doctorat Landbouwkundige Wetenschappen, Rijksuniv. Gent. pp. 355.
Dejene, S.W., N. Dechassa and R.U. Reddy. 2016. Coexistence of human and hyena and associated impacts in Haramaya district of Eastern Ethiopia. Int. J. Biodivers. Conserv. 8: 1–7.
Forman, R.T.T. and L.E. Alexander. 1998. Roads and their major ecological effects. Ann. Rev. Ecol. Syst. 29: 207–231.
Geraads, D. 2017. Grands Mammifères fossiles du Maroc. In: (S. Aulagnier, F. Cuzin and M. Thévenot, eds.) Mammifères sauvages du Maroc. Peuplement, répartition, écologie. Société Française pour l'Etude et la Protection des Mammifères, Paris. pp. 63–72.
Glista, D.J., T.L. DeVault and J.A. DeWoody. 2009. A review of mitigation measures for reducing wildlife mortality on roadways. Landscape Urban Plan. 91: 1–7.
Heptner, V.G. and A.A. Sludskij. 1980. Die Säugetiere Der Sowjetunion. Raubtiere (Feloidea) (Vol. III). Veb Gustav Fischer, Jena. pp. 607.
Hoath, R. 2003. A field guide to the mammals of Egypt. The American University in Cairo Press, Cairo – New York. pp. 236.
Hofer, H. 1998. 3.2 Striped hyaena *Hyaena (Hyaena) hyaena* (Linnaeus, 1758). In: (G. Mills and H. Hofer, eds.) Hyaenas. Status survey and conservation action plan. I.U.C.N./S.S.C. Hyaena Specialist Group, Cambridge. pp. 21–26.
Hofer, H. and G. Mills. 1998. Population size, threats and conservation status of hyaenas. In: (G. Mills and H. Hofer, eds.) Hyaenas. Status survey and conservation action plan. I.U.C.N./S.S.C. Hyaena Specialist Group, Cambridge. pp. 64–79.
Holmern, T., J.W. Nyahongo and E. Roskaft. 2007. Livestock loss caused by predators outside the Serengeti National Park, Tanzania. Biol. Conserv. 135: 518–542.
IUCN. 2018. The IUCN Red List of Threatened Species. Version 2018-2. <http://www.iucnredlist.org>.
Jackson, N.D. and L. Fahrig. 2011. Relative effects of road mortality and decreased connectivity on population genetic diversity. Biol. Conserv. 144: 3143–3148.
Karanth, K.U. and R. Chellam. 2009. Carnivore conservation at the crossroads. Oryx 43: 1–2.
Kolowski J.M. and K.E. Holekamp. 2006. Spatial, temporal, and physical characteristics of livestock depredations by large carnivores along a Kenyan reserve border. Biol. Conserv. 128: 529–541.
Kolowski J.M. and K.E. Holekamp. 2009. Ecological and anthropogenic influences on space use by spotted hyaenas. J. Zool. 277: 23–36.
Kowalski, K. and B. Rzebik-Kowalska. 1991. Mammals of Algeria. Ossolineum, Krakow. pp. 370.
Mendelsohn, H. 1993. The present situation of the hyaena (*Hyaena hyaena suriaca*) in Israel. IUCN/SSC Hyaena Specialist Group Newsletter 6: 24–25.
Mills, G. and H. Hofer. 1998. Action plan for hyaenid conservation into the 21st century. In: (G. Mills and H. Hofer, eds.) Hyaenas. Status survey and conservation action plan. I.U.C.N./S.S.C. Hyaena Specialist Group, Cambridge. pp. 103–108.
Ogada, D.L. 2014. Power of poison: pesticide poisoning of Africa's wildlife. Ann. N.Y. Acad. Sci. 1322: 1–20.
Régnier J. 1960. Les Mammifères au Hoggar. Bull. Liais. sahar. 11: 300–320.
Rieger I. 1979. A review of the biology of striped hyaenas, *Hyaena hyaena* (Linné, 1758). Säugetierk. Mitteil. 27: 81–95.
Ripple W.J., J.A. Estes, R.L. Beschta, C.C. Wilmers, E.G. Ritchie, M. Hebblewhite, J. Berger, B. Elmhagen, M. Letnic, M.P. Nelson, O.J. Schmitz, D.W. Smith, A.D. Wallach and A.J. Wirsing. 2014. Status and ecological effects of the World's largest Carnivores. Science 343: 1241484.
Roberts T.J. 1997. The mammals of Pakistan. Revised edition. Oxford University Press, Karachi. pp. 525.
Robinson, J.G. and E.L. Bennett. 2000. Hunting for sustainability in tropical forests. Columbia University Press, Irvinton. pp. 1000.
Rytwinski, T., R. van der Ree, G.M. Cunnington, L. Fahrig, C.S. Findlay, J. Houlahan, J., J.A.G. Jaeger, K. Soanes and E.A. van der Grift. 2015. Experimental study designs to improve the evaluation of road mitigation measures for wildlife. J. Environ. Manage. 154: 48–64.
Schipper, J. and co-authors. 2008. The status of the world's land and marine mammals: diversity, threat and knowledge. Science 322: 225–230.
Simon, N.M. 1969. Proposals for field investigations of rare and endangered mammals. Biol. Conserv. 1: 280–290.
Singh, P., A.M. Gopalaswamy and K.U. Karanth. 2010. Factors influencing densities of striped hyenas (*Hyaena hyaena*) in arid regions of India. J. Mammal. 91: 1152–1159.
Temple H.J. and A. Cuttelod. 2009. The status and distribution of Mediterranean mammals. IUCN, Gland – Cambridge. pp. vii + 32.
Tourani, M., E.M. Moqanaki and B.H. Kiabi. 2012. Vulnerability of striped hyaenas, *Hyaena hyaena*, in a human-dominated landscape of Central Iran. Zool. Middle East 56: 133–136.
Van der Grift, E.A., R. van der Ree, L. Fahrig, S. Findlay, J. Houlahan, J.A.G. Jaeger, N. Klar, L.F. Madriñan and L. Olson. 2013. Evaluating the effectiveness of road mitigation measures. Biodivers. Conserv. 22: 425–448.
Wagner, A.P. 2006: Behavioral ecology of striped hyena (*Hyaena hyaena*). PhD Dissertation, Montana State University, Bozeman, Montana.
Wagner, A.P. 2013. *Hyaena hyaena* striped hyaena. In: (J. Kingdon and M. Hoffmann, eds.) Mammals of Africa. Volume V. Carnivores, pangolins, equids ans rhinoceroses. Bloomsbury Publishing, London, pp. 267–272.

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