Original language: English CoP19 Inf. 23

(English only / únicamente en inglés / seulement en anglais)

CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES
OF WILD FAUNA AND FLORA

Nineteenth meeting of the Conference of the Parties
Panama City (Panama), 14 – 25 November 2022

# THE SITUATION OF THE CHEETAH IN ASIA

1. This document has been submitted by the Secretariat on behalf of the Secretariat of the Convention on Migratory Species (CMS) in relation with agenda item 59*.

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# THE SITUATION OF CHEETAH IN ASIA

CMS

The Situation of Cheetah in Asia

Cover Image: Female cheetah 'Delbar' and male cheetah 'Kooshki' in Tehran in 2014. Photo: Alireza Shahrdari.

Prepared for the Secretariat of the Convention on Migratory Species (CMS), October 2022.

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The Support for this report:
Development and production of this report has been achieved with the financial support of the IUCN CAT SG through a grant provided by the CMS Secretariat to the Foundation KORA – the host organisation of the IUCN Cat Specialist Group – and the Wildlife Conservation Society through a grant generously provided by the Flora Family Foundation.

Recommended citation:

Khalatbari L., Durant S., Kitchener A.C., Breitenmoser-Würsten C., Ostrowski S., Brouwer E. & Breitenmoser U. 2022. The situation of the Cheetah in Asia. CMS, Bonn, Germany.

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# Tables and Figures

## Acronym List

| Abbreviation | Explanation |
|---|---|
| **ACI** | Joint CITES-CMS African Carnivores Initiative |
| **BR** | Biosphere Reserve |
| **CACP** | Conservation of Asiatic Cheetah and its Natural Habitats Project |
| **CAMI** | Central-Asian Mammals Initiative |
| **CBO** | Community based organisation |
| **CITES** | Convention on International Trade in Endangered Species of Wild Flora and Fauna |
| **CMS** | Convention on the Conservation of Migratory Species of Wild Animals |
| **CR** | Critically Endangered |
| **DoE** | Department of Environment |
| **EN** | Endangered |
| **EW** | Extinct in the Wild |
| **FRWMO** | Forests, Range and Watershed Management Organization |
| **GEF** | Global Environment Facility |
| **HPA** | Hunting Prohibited Area |
| **ICS** | Iranian Cheetah Society |
| **IUCN** | International Union for Conservation of Nature |
| **LC** | Least Concern |
| **LCC** | Livestock Control Committee |
| **NP** | National Park |
| **NRWMO** | Natural Resources and Watershed Management Organization (now: FRWMO) |
| **NT** | Near Threatened |
| **PA** | Protected Area |
| **PCA** | Principal Component Analysis |
| **POW** | Programme of Work |
| **PR** | Private Reserve |
| **PVA** | Population Viability Analysis |
| **PWHF** | Persian Wildlife Heritage Foundation |
| **SGP** | The GEF Small Grants Programme |
| **SNP** | Single Nucleotide Polymorphism |
| **SSG** | Species Survival Commission |
| **UNDP** | United Nations Development Programme |
| **VU** | Vulnerable |
| **WCS** | Wildlife Conservation Society |
| **WR** | Wildlife Refuge |

## Abstract

The Asiatic Cheetah *Acinonyx jubatus venaticus* is listed as Critically Endangered on the IUCN Red List for Endangered Species. The effective population size is estimated to be only twelve individuals. Once widespread in Southwest Asia, the Asiatic Cheetah has been extirpated from nearly its entire range except for Iran, where it is persisting in two small subpopulations, with only the Northern one having recent evidence of breeding. The connectivity between the two subpopulations decreased over the last decades; individuals within the subpopulations are highly related and assumedly highly inbred. Despite conservation efforts undertaken for the past 20 years, the Asiatic Cheetah is now very close to extinction.

Proximate causes for decline are habitat loss and fragmentation, anthropogenic mortalities, (e.g., road kills), wild prey loss, grazing pressure through livestock, and expansion of mining excavation and other activities. Ultimate drivers for decline include lack of land-use planning, capacity, resources, and incentives for local people; site insecurity and drought; and lacking awareness/commitment for the conservation of the Asiatic Cheetah and its prey. The long-term survival of the Asiatic Cheetah depends on their rigorous protection, but also on the recovery of habitats and prey populations, as well as on mitigating the impacts of climate change which has been exacerbating some of these threats.

In the absence of any substantial increase in its size, the Asiatic Cheetah population is very likely to be non-viable and faces a high risk of extinction within a few generations. To prevent extinction, a rapid increase of the population size and genetic diversity is crucial, whilst habitat conditions and wild prey base need to be improved. A recovery plan for the Asiatic Cheetah must consider strategies including options from the *in situ* and *ex situ* spectrum. However, given the difficulties and risks of *ex situ* management, interventions should be taken with extreme care and should be well planned to avoid loss of individuals and hence diversity. In addition, any plan for the genetic (*ex situ*) rescue of the Asiatic Cheetah should be implemented in parallel to *in situ* measures to mitigate the primary, mostly human-caused, threats.

The rescue of the Asiatic Cheetah may still be possible, but only if adequate conservation measures are implemented rigorously and without any further delay. *Ex situ* considerations depend on the questions (1) whether the population in Iran can be maintained with *in situ* measures alone, (2) whether the Asiatic Cheetah can still be rescued as a standalone subspecies through breeding in captivity, and (3) whether most of the *A. j. venaticus* genome can be conserved through reinforcement of the Asiatic Cheetah population with another Cheetah subspecies. Depending on the answers to these questions, four scenarios are identified, with associated risks, costs and benefits. Scenario A consists of *in situ* measures, scenario B of *ex situ* measures in which there would either be a pure-bred *A. j. venaticus ex situ* population (B1) or an admixed population including individuals from other Cheetah subspecies (B2), and scenario C would consist of a combination of *in situ* and *ex situ* approaches by maintaining a group of reproducing Cheetahs in the only subpopulation with breeding evidences, and accelerating (admixed) breeding to provide animals for reinforcement. None of these scenarios can guarantee saving Asiatic Cheetahs from extinction and all have their own associated risks. Saving the Asiatic Cheetah will be a complex, expensive and difficult undertaking, but timely agreement on a strategy and rigorous implementation of actions is the only possible solutions to prevent extinction of the Asiatic Cheetah. Therefore, Iranian and international efforts need to be joined immediately to make this undertaking happen in the shortest possible time.

## Executive summary

1. *Introduction.* The Cheetah *Acinonyx jubatus* is an increasingly endangered large cat occurring at very low densities in Africa and South-West Asia. It has been listed on CMS Appendix I since 2009. Under CITES, the Cheetah was listed on Appendix I in 1975. All African Cheetahs are considered under the Joint CITES-CMS African Carnivores Initiative (ACI); the Critically Endangered (CR) Asiatic Cheetah *A. j. venaticus* is a subspecies considered under the CMS Central Asian Mammals Initiative (CAMI). Given its very critical status, an Intersessional Working Group on the Asiatic Cheetah was established by the Fifth Meeting of the Sessional Committee of the CMS Scientific Council (ScC-SC5) in July 2021, which adopted UNEP/CMS/ScC-SC5/Outcome 1.3 *Programme of Work Terrestrial Species Conservation Issues.* This Working Group has the mandate to consider options for the recovery of the Asiatic and North-East African Cheetah and to report to the Sessional Committee at its 6th meeting on its findings, and to inform a Decision at COP14, as per its Terms of Reference (UNEP/CMS/ScC-SC5/Outcome 7), and further based on Resolution 11.24 (Rev.COP13) *Central Asian Mammals Initiative*, adopted by the meeting of the Thirteenth Conference of the Parties to CMS (CMS COP13, Gandhinagar, India, 2020). To provide a basis for the deliberations of the Working Group, the IUCN SSC Cat Specialist Group was tasked to compile a report on the situation of the Cheetah in Asia. The Asiatic Cheetah was assessed as CR by the IUCN already in 1996 and remained the same ever since. With presently only three reproducing female Cheetahs observed in the wild in the central desert of Iran, the Asiatic Cheetah is very close to being Extinct in the Wild (EW). The Cheetahs in Iran face threats that are "classical" to large felids, including illegal and accidental killing, conflicts with livestock keepers, low wild prey availability, habitat fragmentation and degradation and, most recently, inbreeding. Asiatic Cheetahs live in very arid areas increasingly affected by climate change. Halting further population decline will not be enough to conserve the Asiatic Cheetah; immediate population growth to enlarge the gene pool and expansion into suitable habitats are urgently needed. There can be no doubt that the population of the Asiatic Cheetah is now on its final path to extinction unless rigorous protection and conservation measures are implemented without delay.

2. *Review of the history and present status of the Cheetah*. The Cheetah is the only extant member of its genus *Acinonyx*. Based on morphological characteristics, several subspecies have been described (section 2.2, Tables 2.2 and 2.3.). Recent genetic studies proposed four to five subspecies, although separation at subspecies level in some cases are not well supported (Figs. 2.7 and 2.8, section 2.2). The Cheetah once occupied a broad range of habitats across most of Africa and South-West Asia (Figs. 2.9–2.13, section 2.3.1). Currently, Cheetahs only occur in 9% of their historic distributional range (Fig. 1.1). In Asia, the Cheetah has been extirpated from its entire range except in Iran, where it persists in two small subpopulations in north-Eastern and central Iran; a third subpopulation in Kavir National Park went extinct in 2013 (section 2.3.2). The main reasons for Cheetah population decline are habitat loss and fragmentation, anthropogenic mortalities (road accidents, human-wildlife conflicts, illegal trade), high livestock numbers and grazing pressure (competition with wild prey and transmission of pathogens) and wild prey loss (section 2.3.3). Beyond these proximate causes of Cheetah decline, many ultimate drivers foster the decline, such as lack of land-use planning, site insecurity, lack of awareness and/or commitment for conservation of Cheetah and wild prey, exacerbated through lack of capacity, financial resources, and incentives for local people

for nature conservation. Increasing human populations and social transitions are putting increasingly pressure on natural landscapes. Unlike other large cats, Cheetahs occur mainly on unprotected lands (77% of distribution range, 67% of populations). Population modelling suggests that the pressure outside protected areas may cause a global Cheetah population decline by >50% over the next 15 years (section 2.3.3). In Iran, climate change models predict gazelles to lose over 50% of their current suitable habitat, which in turn will affect Cheetahs and other carnivores preying on them. For Cheetahs, a habitat decline of 22% over the next 100 years has been predicted mainly as a result of prey population declines and climate change (Fig. 2.14, section 2.3.4). The long-term survival of the Asiatic Cheetah thus depends not only on direct protection, but also on the recovery of remnant habitat and prey, as well as on effective action to mitigate the impacts of climate change.

3. *Morphology and ecology of the Asiatic Cheetah compared to the African subspecies*. Cheetahs are slender cats, with a small head, long legs, a narrow waist and a wide chest. There are reported inter-subspecies differences in terms of body size and colouration (Table 3.1, and Appendix II), with the Asiatic Cheetah being the smallest subspecies with a longer, denser, and paler coat than the African subspecies. Across their distribution, Cheetahs occupy a wide range of habitat types, outside of forests, where they can utilise their specific morphological and behavioural adaptations. Cheetahs are only absent from mountainous areas, tropical rainforests, and sand dunes. Competitors include Lions *Panthera leo*, Leopards *Panthera pardus*, Striped, Brown and Spotted Hyaenas *Hyaena hyaena, Parahyaena brunnea*, *Crocuta crocuta*, African Wild Dogs *Lycaon pictus*, and Gray Wolves *Canis lupus*. Cheetahs are poorly adapted to defend themselves or their kills (section 3.2, and Table 3.2). Most information on the Cheetah's diet comes from Africa, where their preferred prey consists of small to medium-sized ungulates with body masses of 15–65 kg. Cheetahs also take smaller prey such as Hares. They can also prey on livestock, particularly when wild prey is scarce. In Iran, Cheetahs' main prey was reported to consist of Chinkara *Gazella bennettii*, followed by Goitered Gazelle *G. subgutturosa*, wild sheep *Ovis vignei* and wild goat *Capra aegagrus*, occasionally wild pig *Sus scrofa* and Cape Hare *Lepus capensis*. Predation on livestock (sheep, goat, and dromedary) was reported, although marginal. Recently, relatively high predation on wild sheep in the hills and highlands were detected; possibly a consequence of human pressure on the gazelle populations and the lowland habitats, forcing Cheetahs into suboptimal habitats where gazelles are less abundant and where they are sympatric with competing Leopards.

4. *Conservation of the Cheetah in Iran.* After the Cheetah had gone extinct in many parts of Asia (section 2.2, and Fig. 4.1), some 200–400 Asiatic Cheetahs persisted in Iran in the 1970s, but decreased significantly by 2001 (Fig. 4.2). In 2008, however, Cheetah presence was still confirmed in several areas (Fig. 4.3), but despite considerable conservation efforts, the distribution range further contracted and Cheetahs disappeared from several PAs (Fig. 4.4). Causes remained unclear, but the expansion of the Yazd-Kerman highway, the expansion of mining and other activities near Kavir National Park may have played a role in these local extinctions (section 4.1). The population size was estimated to be "fewer than 50 individuals" in 2017, but camera trapping in 2021–2022 identified only 12 adult individuals, among which only three reproducing females (Table 4.1). Main threats to the Cheetah in Iran are summarised in Table 4.2 and include direct killing of Cheetahs and prey, road and railroad mortalities, nomadic grazing (conflicts with livestock, pressure on wild prey), and the lack of protection/law enforcement in several PAs. Habitat loss is exacerbated as climate change progresses (section 4.2). In Iran, the Cheetah was designated as an endangered and protected species in

1959 and the fines for capturing or killing of Cheetahs and their prey was augmented repeatedly over the past years (section 4.3.1). Cheetah habitats in Iran are protected as national parks, wildlife refuges, protected areas and hunting prohibited areas (section 4.3.2, Fig. 4.5 and Table 4.3). In order to protect the Asiatic Cheetah, several conservation programmes and projects were initiated, e.g., the Conservation of the Asiatic Cheetah Project (CACP; section 4.4.1) and projects funded by the Small Grant Programme of the Global Environment Facility (GEF SGP; section 4.4.2 and Appendix V) in a collaboration between GEF, the United Nations Development Program (UNDP), and the Department of Environment of Iran (DoE). NGOs such as the Iranian Cheetah Society (ICS) and the Persian Wildlife Heritage Foundation (PWHF) carried out Cheetah conservation projects (section 4.4.3 and Appendix VI and VII). Besides protecting and monitoring of Cheetahs and their prey, three conservation activities received special attention: (1) livestock husbandry and sustainable rangeland management within the PAs, (2) mitigation of losses of Cheetahs due to road mortality, and (3) captive breeding of Cheetahs (section 4.5). Threats resulting from livestock grazing include competition over forage and water with wild herbivores, transmission of pathogens from livestock and herding dogs to wildlife, poaching of wildlife by shepherds, the direct killing of wildlife by herding dogs, and retaliatory or precautionary killing of Cheetahs (section 4.5.1). Fifty per cent of reported Cheetah mortalities in Iran between 2001 and 2012 were caused by the direct killing of Cheetahs by poachers or herders and their dogs. Over the years, several efforts have been undertaken to reduce livestock pressure which included limiting the annual number of (vaccinated) livestock and dogs entering Touran by the Livestock Control Committee (LCC), attempts to establish livestock-free zones within Touran BR through negotiations over the buy-out of grazing rights (Fig. 4.10), and restricting dromedary access to water sources (Fig. 4.11). However, the issue has not (yet) been resolved due to a lack of financial resources and complicated legal and administrative processes; the removal of livestock from core Cheetah habitat remains a priority conservation measure (section 4.5.1). Between 2004 and 2016, 30% of reported Cheetah mortality were road kills. These losses are affecting Cheetah movements between different subpopulations. Cheetahs often move across vast distances within and between PAs and cross many dangerous roads (Fig. 4.12; section 4.5.2). At collision hotspots in known corridors (e.g., Yazd-Kerman and Semnan-Mashhad Road), wildlife warning signs have been installed (Figs. 4.13B, 4.14, and 4.15), and in some cases speed limits were implemented. Parts of one of the roads with highest reports of Cheetah mortality was fenced, funneling Cheetahs to large culverts passing under the road, but this was not sufficient to stop road mortality. Captive breeding as an additional rescue strategy was discussed for a long time. A specific conservation breeding plan was not included in the action plans of CACP I and II, due to concerns about the potential impacts of the removal of Cheetahs for breeding purposes on the remaining wild population. It was recommended to restrict captive breeding to animals that are “rescued, injured, or orphaned” in the action plan of CACP III, but respective trials were not successful. Currently, there are three confiscated Cheetahs (2 females and one male), one deliberately captured male and one orphan male cub in a facility in Touran PA (section 4.5.3). The newly captured male and one confiscated female mated in January 2022 and on 1 May 2022, and three male cubs were born by caesarean section (Fig. 4.18). As the mother did not accept her cubs, they were hand-reared. Two of the cubs died soon after birth; the third one survived, although with some health problems (section 4.5.3). Further conservation challenges are the management of water resources, conservation of prey, conservation of habitat corridors, and expansion of mine excavation (section 4.6). Long-term survival of wild cheetahs is possible through providing secure landscape inside and outside of protected areas. Therefore, conservation of habitat corridors and stepping-stones is of utmost importance.

Several important stepping-stones were predicted between the current network of protected areas (Fig.4.20; section 4.6.3).

5. *Genetic status of the (Asiatic) Cheetah*. Studies on the genetic diversity of Asiatic Cheetahs were based on nuclear and mitochondrial DNA (mtDNA). The Kerman subpopulation was found to have the highest mtDNA haplotype diversity, followed by the Yazd and Touran population, and the (now extinct) population from Kavir to have the lowest genetic diversity. Several studies have analysed various Cheetah populations across Africa and South-West Asia based on nuclear markers (Table 5.1). These studies confirm the relatively low genetic diversity of Asiatic Cheetahs compared to African populations in Botswana and Tanzania (chapter 5). Genetic diversity of Asiatic cheetahs was similar to the genetic diversity observed in the Iberian Lynx *Lynx pardinus* when they were fragmented into two small subpopulations, but higher than that of the highly inbred Asiatic Lion *P. leo* from Gir forest (chapter 5). A genome-wide study on the genetic status of Cheetahs found that Asiatic Cheetahs display lower heterozygosity and higher levels of inbreeding than other Cheetah subspecies (Fig. 5.1 and 5.2) and found reduced variation on the Major Histocompatibility Complex (MHC) in *A. j. venaticus* compared to the other subspecies *A. j. jubatus* and *A. j. soemmeringii*, indicating that there might be a reduced immune-response. Average pairwise relatedness between Asiatic Cheetahs in Iran was similar for the Northern and Southern subpopulations with values of >0.25, representing relatedness between half-siblings or grandparents and their grandchildren. Individual relatedness analysis confirms a genetic division into two subpopulations: a Northern and a Southern subpopulation. Traces of past migration and gene flow were observed in four individuals (out of 26), indicating that there were functional corridors between the subpopulations until recently (Fig. 5.3); migration was estimated to have occurred only two generations ago. Loss of migration might be a result of population decline and/or expansion of human-made barriers. The Northern subpopulation showed higher values of heterozygosity and allelic richness than the Southern subpopulation. A study that included samples from the now extinct Kavir subpopulation revealed former connectivity between Kavir and Yazd, indicating the importance of these subpopulations as steppingstones for gene flow between the north and the south. The high levels of inbreeding, fragmentation of populations, the decrease in connectivity over the last two generations and the extinction of the Kavir subpopulations are reasons for great concern. The effective population size was low and estimated to consist of 11–17 individuals in 2021, which is much lower than what is considered to be needed for the long-term persistence of a (sub)species.

6. *Plans for the reintroduction of Cheetahs in Asia.* Cheetah reintroduction has been considered in India and Uzbekistan (chapter 6). In both countries, the initial idea was for Asiatic Cheetah *A. j. venaticus* to be reintroduced, which is however impeded by the dire situation of the last remaining population in Iran. In India, three landscapes within the historical range of the Cheetah were found to have potential for Cheetah reintroduction: Kuno-Palpur Wildlife Sanctuary in Madhya Pradesh, Shahgarh Landscape in Jaisalmar, and Nauradehi Wildlife Sanctuary in Madhya Pradesh. Within these landscapes, six sites were assessed with regard to prey availability, habitat suitability, anthropogenic challenges and preparatory management actions required. Kuno NP-Sheopur Forest Landscape, Gandhi Sagar-Chittorgargh-Bhainsrodgarh WLS with parts of Mukundara TR landscape, and for an initial, fenced population Nauradehi WLS, were prioritised. Enclosures like Mukaundara TR would be able to host a small breeding group. Currently (status: October 2022), Cheetahs from Southern Africa are planned to be brought into India. In Uzbekistan, the Ustyurt plateau was home to the Asiatic

Cheetah up to the 1980s, and the goal is to re-establish a free-ranging viable Cheetah population within its former natural range and habitats. The plan is to breed and rewild Cheetahs, but first, wild prey populations have to be re-established and enabling conditions secured (chapter 6). An adequate protected area has been gazetted, and the programme on Cheetah reintroduction in Uzbekistan is being revised.

7. *Assessment of the demographic and genetic viability of the Asiatic Cheetah*. In Iran, while a small breeding population of three females and four males was observed in Touran in 2021-2022 (Table 4.3), there are no records of breeding in Yazd Province and Naybandan since 2013, but no systematic population monitoring has been conducted over the last 7 years. The current population is fewer than 50 individuals and could probably be as small as 12 individuals (section 4.1). In its present state and without fast and substantial increase of the population, the Asiatic Cheetah population is not viable and faces a high risk of extinction within a few generations. Estimates of effective population size show that Asiatic Cheetahs have been in a continuous decline. After a historic decline between 800 and 250 generations ago (circa 4,000–2,500 years ago; Fig. 7.1, chapter 7), the Asiatic Cheetah experienced two severe recent declines, in the 1960s (to assumed 400 individuals) and in the 1980s (to estimated 50–100 individuals). Data on population size has been limited, but several estimations from 1980–2017 (Table 4.1, section 4.1) suggested about 50–100 adult individuals during the past 25 years, with a severe decrease in the past 10 years. Consequently, the level of inbreeding in *A. j. venaticus* was higher than in other subspecies of Cheetah. As low numbers in the Cheetah population have sustained over multiple generations, inbreeding has built up and the most recent decline might also have intrinsic reasons. It therefore needs to be considered that an increase in population size might not be sufficient to save the subspecies, if a possible inbreeding depression becomes irreversible. Assumedly, the subspecies needs a genetic rescue strategy. Therefore, a conservation plan to recover the Asiatic Cheetah should include strategies for population management, which might include options from across the *in situ* and *ex situ* spectrum.

8. *Final considerations and outlook.* The Asiatic Cheetah is Critically Endangered and very close to extinction, despite conservation efforts having been undertaken for more than 20 years. Recovery of the Asiatic Cheetah may still be possible if timely and effective *in situ* conservation measures are implemented, potentially with the support of *ex situ* breeding (section 8.1 and 8.2). *In situ* conservation considerations include actions to effectively manage the protected area network, the ranger system and the conditions for rangers, to improve monitoring and patrolling by rangers; to limit the conflict between livestock husbandry and wildlife conservation; to prevent Cheetah mortalities on roads; to manage and safeguard water sources; to conserve and monitor wild prey; to conserve habitat corridors, suitable marginal habitats, and habitat stepping stones; and to control negative effects of mine excavations (section 8.1.1). *Ex situ* conservation breeding seems highly recommendable, but the practical approach depends on the questions (1) whether the population in Iran can be maintained with *in situ* measures alone, (2) whether the Asiatic Cheetah *A. j. venaticus* can be rescued as a standalone subspecies, and (3) whether at least most of the *A. j. venaticus* genome can be conserved through the reinforcement of the Asiatic Cheetah population with another Cheetah subspecies. Based on the answers to these questions, four scenarios and sub-scenarios are identified, all with associated risks, costs and benefits explained in section 8.2.1. The scenarios consist of (A) *in situ* measures alone, (B) *ex situ* measures in which there would either be

a pure-bred *A. j. venaticus ex situ* population (B1) or an admixed population including individuals from other Cheetah subspecies (B2), and (C) a combination of *in situ* and *ex situ* approaches by maintaining a group of reproducing Cheetahs in Touran, and accelerating (admixed) breeding to provide animals for reinforcement. Variations and spatially explicit adaptations (e.g., different approaches for the Northern and Southern Cheetah range in central Iran) are also possible. If genetic rescue through a conservation breeding programme is to be considered, this should be implemented as soon as possible to preserve as much local genetic diversity and local adaptations as possible. The reproductive behaviours of Cheetahs also need to be considered, i.e., many wild-breeding females do not reproduce in captivity, and female Cheetahs mate promiscuously in the wild. Several scenarios for genetic rescue modelling are needed to minimise the risk of losing male and female lineages. While a successful *ex-situ* reproduction was achieved in Touran (section 4.5.3), subsequent mortalities in the litter have demonstrated the difficulties of such a programme. If conservation breeding continues, any Iranian Cheetah is of high value for their survival and must be handled with utmost expert care. Available information suggests that there are no reproducing females left in the Southern subpopulation and that the functional connectivity between Southern and Northern subpopulations may have been lost. The lone males of this region therefore could be integrated into a conservation breeding programme, or females from another subspecies could be released in the south. The general IUCN Reintroduction Guidelines on mixing subspecies advocate for such approaches to be handled with care and to be case-specific (section 8.2.1). Mixing populations or subspecies is a balance between inbreeding and outbreeding, and if *A. j. venaticus* is to be admixed with animals from another subspecies, biological considerations (phylogenetic, ecological and morphological similarities) need to be kept in mind. Both *A. j. jubatus* and *A. j. soemmeringii* would be the most easily available (Appendix X). Phylogenetically and geographically the closest subspecies is *A. j. soemmeringii*, which would likely be available from the EAZA Northern Cheetah EEP, and possibly from confiscated animals held in the United Arab Emirates. All actions for increasing the population size should be implemented simultaneously with actions to mitigate the primary, mostly human-caused, threats, and these actions need to be tightly coordinated with any *ex-situ* actions (chapter 8).

So far, Asiatic Cheetah conservation has received about USD 2,400,000 from national and international budget over the past 20 years. Although the allocated budget and conservation actions were essential for the prevention of the extinction of the Asiatic Cheetah, they were insufficient to halt the decline of both the population as well as the distribution range. The lack of funding for Asiatic Cheetah was also related to the United Nations UN Security Council sanctions against Iran. The capacity and available funding within Iran seems not to be sufficient to launch a rapid and effective emergency programme for saving the Asiatic Cheetah from extinction. International cooperation in such a priority conservation task is indispensable. Considering exemptions for urgent conservation tasks for such sanctions by the international community along with measures to protect conservation personnel in range countries could overcome these obstacles (section 8.3). Implementing the CMS CAMI POW Activities related to fundraising for the Asiatic Cheetah specifically (10.10) and fundraising in general (31.6) are crucial to implement much-needed conservation action.

To prevent the impendent extinction, it is vital to learn from the experiences of the last two decades, summarised in this report, to decide on future actions. Funding and other means needed to save the Asiatic Cheetah from extinction are presently not sufficiently available to the Iranian conservation agencies, and international collaboration and support are essential to achieve this goal in due time.

# 1. Introduction

The Cheetah *Acinonyx jubatus* is an increasingly endangered large cat occurring in Africa and Southwest Asia (Fig. 1.1). It was listed on Appendix I of the Convention on the Conservation of Migratory Species of Wild Animals (CMS) in 2009. CMS Appendix I comprises migratory species that have been assessed as being in danger of extinction throughout all or a significant portion of their range. The Conference of the Parties has further interpreted the term "endangered" as meaning "facing a very high risk of extinction in the wild in the near future" (Res. 11.33 paragraph 1). Res. 11.33 also defines a general correspondence between the term 'endangered' as defined within CMS and the IUCN Red List Criteria (Version 3.1). Parties that are a Range State to a migratory species listed in Appendix I shall prohibit their taking, with very restricted scope for exceptions; and shall endeavour to conserve and, where appropriate, restore their habitats; prevent, remove or mitigate obstacles to their migration; and control other factors that might endanger them (Article III of the Convention). The Critically Endangered Asiatic Cheetah *A. j. venaticus* is a subspecies considered under the CMS Central Asian Mammals Initiative (CAMI) and subject of "Species-specific Measures" in the Programme of Work (2021–2026) for CAMI (annexed to Resolution 11.24 (Rev.COP13); Appendix I). Under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Cheetahs have been listed on Appendix I since 1975. CITES Appendix I includes species threatened with extinction, and trade in specimens of these species is permitted only in exceptional circumstances. Illegal trade in Cheetahs, especially in North-Eastern Africa, has been considered since the meeting of the Conference of the Parties to CITES in 2013 in Bangkok, Thailand (CoP16 Doc. 51) and was taken up again in 2022 at the seventy-fourth meeting of the Standing Committee of CITES in Lyon, France, based on SC74 Doc. 62. African Cheetahs are considered under the Joint CITES-CMS African Carnivores Initiative (ACI).

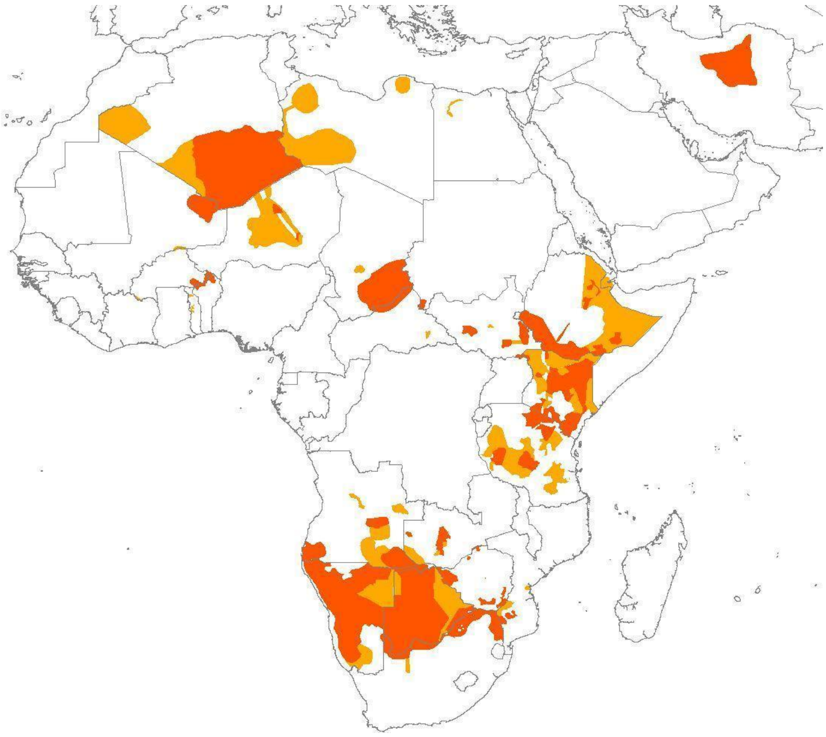

**Fig. 1.1.** Distribution of the Cheetah in the early 20th century. Orange indicates the possible range and red indicates the resident range. Source: Durant et al. (2022).

The Fifth Meeting of the Sessional Committee of the Scientific Council of CMS (ScC-SC5) decided in July 2021 to establish an Intersessional Working Group (IWG) on the Asiatic Cheetah. This Working Group has the mandate, according to its Terms of Reference, to consider options for the recovery of the Asiatic and North-East African Cheetah, and to report to the Sessional Committee at its 6th meeting on its findings and to inform a decision at COP14, envisaged to take place in October 2023. The Working Group should consist of the Range States concerned, as well as African regional representatives of the Sessional Committee, experts from the IUCN, other interested members, and other experts as appropriate.

In February 2022, the IUCN SSC Cat Specialist Group was commissioned by the CMS Secretariat, with funding received from the Government of the United Kingdom of Great Britain and Northern Ireland, to compile a report summarising the situation of the Cheetah in Asia and in North-Eastern Africa, based on the scientific literature and on other published materials and information collected from Cheetah and conservation experts and Range State representatives. The Report presented here aims to inform the members of the IWG on the history and the present situation of the Cheetah in Asia.

In 1965, the Asiatic Cheetah already was considered by the IUCN to be "very rare and believed to be decreasing in numbers", first assessed in the IUCN Red List of Threatened Species as Endangered (EN) in 1986 and then, in 1996, as Critically Endangered (CR). The latest assessment was published in 2008 (Jowkar et al. 2008a) and needs updating, but certainly, the Asiatic Cheetah is still critically endangered. Indeed, according to the latest assessment of the Department of the Environment of the Islamic Republic of Iran, the Asiatic Cheetah is now very close to being "Extinct in the Wild" (EW): only three reproducing females were observed recently in the Cheetah areas around the Dasht-e Kavir in the central desert of Iran (France 24 09.01.2022, Tasnim News 09.01.2022). Although the protected areas located around the Dasht-e Kavir are remote and difficult to survey, there can be no doubt that the population of the Asiatic Cheetah is now on its final path to extinction unless rigorous protection and conservation measures are implemented without delay.

The remaining Cheetahs in Iran face "classical" threats common for most large cats, namely: illegal and accidental killing, conflicts with local herders, low wild prey availability, habitat loss and fragmentation, and increasing inbreeding as the population continues to decline. However, beyond these "classical" threats, the last Iranian Cheetahs live in arid landscapes that face additional threats due to climate change. Simply halting the further decline of the population will not be enough to save the Asiatic Cheetah. Population growth and expansion into suitable habitats are also needed. Saving the Asiatic Cheetah is not an easy endeavour; if it were, the efforts over the past decades would have been more fruitful. Nevertheless, securing a future for the Cheetah on the Asiatic continent is a regional and global responsibility.

# 2. Review of the history and present status of the Cheetah


**Chapter summary**

The Cheetah is the only extant member of the genus *Acinonyx*. Based on morphological characteristics of a (limited) number of specimens collected in the 19th and early 20th century, several subspecies have been described (section 2.2). An overview of the five recognised Cheetah subspecies is given in Tables 2.2 and 2.3. Recent studies have used genetics rather than morphological characteristics to clarify subspecies delineation and have identified four to five subspecies, although separation at subspecies level in some cases is not well supported. Not well separated subspecies, in combination with the low number of samples for some subspecies, the species' wide historical distribution, and their ability to move across vast distances, suggests that some subspecies are not valid, owing to isolation by distance and range fragmentation. Therefore, further work is needed to assess whether all subspecies are valid or not (Fig. 2.7, section 2.2). The Cheetah was once one of the most wide-ranging large felids with a distribution encompassing a broad range of habitats across most of Africa and Southwest Asia (Figs. 2.8–2.11, section 2.3.1). Currently, Cheetahs are known to only occur in 9 % of their historic distributional range (Fig. 2.12). In Africa their distribution has retracted across most of Western, Central and Northern Africa, but significant populations remain in Southern and Eastern Africa. In Asia, the Cheetah has been extirpated from nearly its entire range except in Iran, where it is believed to persist in two small subpopulations in North-Eastern Iran and Central Iran; a third subpopulation in Kavir National Park has been locally extinct since 2013 (section 2.3.2). The main reasons for Cheetah population decline are: habitat loss and fragmentation, anthropogenic mortalities (road accidents, human-wildlife conflicts, illegal trade), high livestock numbers and grazing pressure, and wild prey loss due to unsustainable exploitation of wild meat (section 2.3.3). While these threats constitute the proximate causes of Cheetah decline, they are a consequence of many ultimate drivers that also need to be addressed, such as lack of land-use planning, site insecurity, and a lack of awareness and/or commitment to foster conservation of the Cheetah and its prey. Additionally, many Range States lack capacity, financial resources, and incentives for local people to support nature populations. A lack of environmental awareness, increasing human populations, and social transitions are putting increasingly pressure on natural landscapes. Unlike other large cats, the majority of known global Cheetah range (77%) and of the remaining known Cheetah populations (67 per cent) occurs on unprotected lands, where the animals face elevated threats. Population modelling suggests that if Cheetahs outside protected areas (PAs) are subject to increasing levels of threat, the global Cheetah population may decline by more than 50 per cent over the next 15 years or three generations (section 2.3.3). Climate change can also negatively influence Cheetahs across their range. Reductions in land, due to rising sea levels, large-scale movements of human populations, and increased rainfall variability, will exacerbate negative impacts of rising human populations. In Iran, climate-change models predict gazelles to lose over 50 per cent of their current suitable habitat, which in turn will affect Cheetahs and other carnivores via a reduced prey base. For Cheetahs, a habitat decline of 22 per cent in the next century has been predicted mainly as a result of prey population declines and climate change (Fig. 2.13, section 2.3.4). Therefore, the long-term survival of the Asiatic Cheetah depends both not only on direct protection, but also on the recovery of remnant habitats and prey, as well as on effective action to mitigate the impacts of climate change.

## 2.1. Cheetah taxonomic history, evolution and biogeography

### *2.1.1. Taxonomic history*

The Cheetah was first described as *Felis jubata* by Schreber in 1775 based on a skin from the Cape of Good Hope, South Africa (Schreber 1777: 392–393, see Fig. 2.1). *F. venatica* was described by Griffith in 1821 based on a sketch of a live animal made by Devis from India (Griffith, 1821; see Fig. 2.2).


**Fig. 2.1**. The figure of the holotype of *F. jubata* on plate 105 (Schreber 1775). Public domain: https://www.biodiversitylibrary.org/item/97341#page/1/mode/1up

**Fig. 2.2.** The illustration of the holotype of *F. venatica* by Devis (Griffith 1821). Public domain: https://www.biodiversitylibrary.org/item/221477#page/9/mode/1up

Although Schreber (1775) included the Cheetah in the genus *Felis*, Brookes (1828) created a new genus, *Acinonyx*, for *F. venatica*, the Asiatic Cheetah (see above). The name probably describes a large dew claw that the Cheetah uses to pull down its prey when in pursuit (Rosevear 1974).

Fitzinger (1855) described *Cyanilurus soemmeringii* in 1855 based on a male from the steppes of the Kababish in the south of the Bayuda Desert, Sudan that was living in the Menagerie at Schönbrunn, Vienna, Austria. Fitzinger (1855) distinguished it from *C. guttatus* [= *Acinonyx* *jubatus*] by its "Taller legs, darker coloration, a tail somewhat bushy at the tip, and a weaker dorsal mane are the differences that clearly separate this species from the previous one"[1].

Hilzheimer (1913) described *Acinonyx hecki* based on a living specimen in the Berliner Zoological Garden as follows: "The most strikingly different [Cheetah] is the small, dainty specimen from Senegal [Figure 1] (Fig. 2.3). The ground colour of the back and sides is a bright pale reddish ochre yellow, becoming lighter towards the belly. The underside is white, unspotted, only a few shadowy, brownish spots can be found on the lower neck. The spots on the upper side of the body are mostly black, only the spots on the cheeks under the eyes, which are small and indistinct, are brownish, the spots on the hind feet are also brownish, which are also very indistinct, and a few spots on the front of the front limb. The tail has a white tip and four separate bands, the penultimate being the widest. The Senegal Cheetah is fairly well described by Frédérik (sic.) Cuvier and was also illustrated by Geoffroy-St, Hilaire and Frédéric Cuvier in *Histoire Naturelle des Mammifères, vol II*, 1824. Unfortunately, the illustration has the error that the tail tip is coloured black, although it is correctly stated as white in the description. I dedicate this Cheetah, which has not yet been named, to the meritorious director of the Berlin Zoological Garden, Professor Heck, on the occasion of his 25th anniversary as Director, and call it *Acinonyx hecki* n. sp." [2]

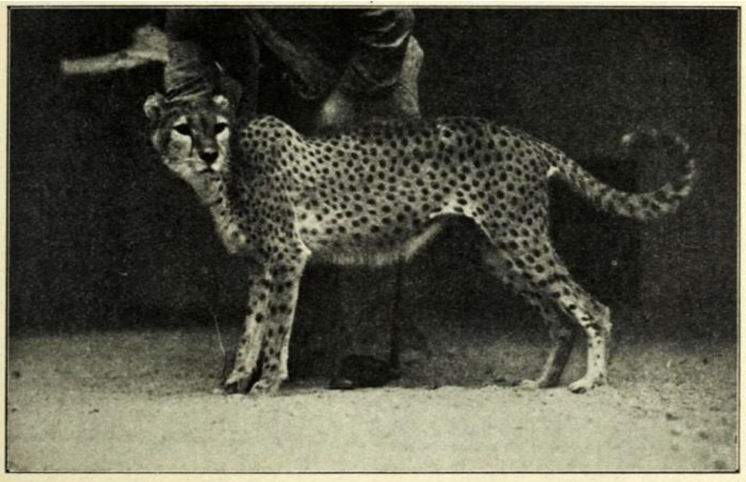

Fig. 1. *Acinonyx hecki* Hilzh.

**Fig. 2.3.** The holotype of *A. hecki* (Hilzheimer 1913). Public domain: https://www.biodiversitylibrary.org/item/148160#page/7/mode/1up

[1] "Höhere Beine, dunklere Färbung, ein an der Spitze etwas buschiger Schwanz und die schwächere Rückenmähne sind die Unterschiede, welche diese Art deutlich von der vorigen abtrennen."

[2] "Am auffalendsten verschieden ist das kleine, zierliche Exemplar von Senegal (Fig. 2.3). Die Grundfarbe des Rückens und der Seiten ist leuchtend blassrötlichockergelb, nach dem Bauche zu heller werdend. Die Unterseite ist weiss, ungefleckt, nur einige schattenhaft bräunliche Flecken finden sich auf dem Unterhals. Die Flecken der Oberseite des Körpers sind meist schwarz, nur die Flecken an den Wangen unter den Augen, die klein und undeutlich sind, sind bräunlich, bräunlich sind auch die Flecken der Hinterfüsse, die ebenfalls sehr undeutlich sind, und einzelne Flecken auf der Vorderseite der Vorderextremität. Der Schwanz hat eine weisse Spitze und vier getrennte Vollringe, von denen der vorletzte der breiteste ist. Der Senegalgeppard ist ziemlich gut von Frédérik Cuvier beschrieben und auch abgebildet in Geoffroy-St. Hilaire et Frédéric Cuvier Histoire Naturelle des Mammiferes, II, Bd., 1824. Leider hat aber die Abbildung den Fehler, dass die Schwanzspitze schwarz gefärbt ist, trotzdem sie in der Beschreibung richtig als weiss angegeben wird. Ich widme diesen bisher noch nicht benannten Geppard dem verdienstvollen Direktor des Berliner Zoologischen Gartens, Herrn Professor Heck zu seinem 25-jährigen Direktorjubiläum, und nenne ihn *Acinonyx hecki* n. sp. (Fig. 2.3)."

Heller (1913) described two subspecies of Cheetah from British East Africa [=Kenya]. *A. jubatus velox* was described from an adult male shot by Kermit Roosevelt on 12 June 1909 on the Loita Plains. It is preserved in the National Museum of Natural History, Smithsonian Institution, Washington D.C., register no. 163096. Heller (1913) characterised this subspecies as an African highland Cheetah with "large close set black spots, which predominate over the ochraceous tone of the ground colour, the boldly spotted hind legs, long pelage, and large body size." It is distinguished from *jubatus* by its larger dorsal spots, lighter ground colour and larger body size.

Heller (1913) described *A. j. raineyi* based on an adult male shot by Paul J. Rainey on 13th October 1911 at Ulu, Kapiti Plains. It is preserved in the National Museum of Natural History, Smithsonian Institution, Washington D.C., register no. 2639. Heller (1913) characterised this subspecies as "a pale coloured, short haired race…having a light pinkish-buff dorsal ground colour and large blackish spots", which apparently resembled *A. j. soemmeringii* except for its larger spots. It is distinguished from *A. j. velox* by its light dorsal ground colour with pinkish suffusion, fewer dark spots and less distinctly spotted hind feet.

However, *A. j. velox* was subsequently synonymised with *A. j. raineyi* by Meester (1971), although it is not clear why the term "*raineyi*" was selected over "*velox*". However, as first reviser, Meester's selection stands in giving *raineyi* priority over *velox*.

### *2.1.2. Phylogenetics*

The Cheetah is one of three living felid species that comprise the Puma lineage (Johnson & O'Brien 1997, Barnett et al. 2005, Johnson et al. 2006, Li et al. 2016, Zhou et al. 2017; but note Agnarsson et al. 2010). This lineage also includes the puma *Puma concolor*, the jaguarundi *Herpailurus yagouaroundi*, and the extinct American Cheetah *Miracinonyx* spp. Among the extant cats, the Cheetah is basal and its long fossil record in Africa indicates that this lineage has an Old-World origin (see also Van Valkenburgh et al. 2018). The genus *Puma* also occurred in the Old World, e.g., in Europe as *P. pardoides* (Hemmer et al. 2004, Madurell-Malapeira et al. 2010, Werdelin et al. 2010, Cherin et al. 2013). The oldest of this material stems from the Pliocene age and may be the oldest material of *Puma* on record. It pre-dates any records of *Puma concolor* in the New World, which is first known from the early-middle Pleistocene of the Miramar Formation, Argentina (Chimento & Dondas 2018). However, Ercoli *et al.* (2019) have described a calcaneus from a member of the *Puma* lineage from the Uquia Formation, Argentina, that also dates to the late Pliocene or early Pleistocene. *Miracinonyx* and *Herpailurus* are only known from the New World, both dating to about 2.5 million years ago (Mya) (Chimento et al. 2014, Werdelin et al. 2010, Van Valkenburgh et al. 2018).

There is an alternative scenario for the evolution of the *Puma* lineage, namely that it evolved in the New World and *Acinonyx* or its ancestors spread into Eurasia via the Bering Land Bridge (Dobrynin et al. 2015, O'Brien et al. 2017). A Bayesian analysis of the same data and the long fossil record of *Acinonyx* in Africa of almost 4 million years (see below), however, suggest an Old-World origin for this lineage (Li et al. 2016).

Divergence times of the Puma lineage from the Domestic cat lineage are estimated on average to range from 7.14 to 7.76 Mya, and between *Acinonyx* and *Puma* they are estimated to range from 4.42 to 5.11 Mya (Li et al. 2016). Johnson et al. (2006) estimated the divergence time between these two taxa to be 4.92 Mya (3.86–6.92 Mya confidence interval).

### *2.1.3. Fossil record*

The oldest known fossils of *Acinonyx* are dated around 3.8–3.4 Mya and originate from Laetoli, Tanzania (Werdelin et al. 2010, Werdelin & Dehghani 2011). These fossils are similar in size to today's Cheetah, although they differ slightly morphologically (Werdelin et al. 2010). Since then, there has been a widespread but sparse fossil record in Africa, and there is a long history of the genus in Eurasia. Lewis and Werdelin (2007) identified three time periods in Africa where *Acinonyx*-like fossils have been recorded, namely 3.6–3.3 Mya, 2.7–2.4 Mya and 1.8–1.5 Mya.

The so-called giant Cheetah *A. pardinensis*, was first known from Western Europe just over 3.5 Mya and is also recorded from India (as *A. brachygnathus*) and China (as *A. pleistocaenicus*) (Werdelin & Peigné 2010, Werdelin et al. 2010). *A. pardinensis* had the size of a small Lion *Panthera leo*, but the typical Cheetah body plan. The skull differed from that of today's Cheetah in having a less domed dorsal outline of the cranium, more developed sagittal and nuchal crests, and less bowed zygomatic arches (Cherin et al. 2014, Geraads 2014). Cheetahs evolved a smaller body size during the later Pliocene, and were then regarded as a separate species, *A. intermedius* (Thenius 1954). However, some Pleistocene specimens are similar in size to the larger Pliocene ones, resulting in this species no longer being recognised (Werdelin et al. 2010). It is unlikely that *A. pardinensis* is the ancestor of *A. jubatus* given its different skull morphology and the long evolutionary history of *Acinonyx* in Africa (Van Valkenburgh et al. 2018). The Eurasian Cheetah became extinct in the early Middle Pleistocene (c. 0.5 Mya), and it is unknown when the extant Cheetah, *A. jubatus*, recolonised South-Western Asia from Africa (Van Valkenburgh et al. 2018). Geraads (1997) described another Cheetah species, *A. aicha*, based on a skull from Ahl al Oughlam, Casablanca, Morocco, that dates from the end of the Pliocene (2.5 Mya). This is a large species, intermediate in size between a Leopard *P. pardus* and a Lion, with a more concave glenoid cavity (jaw articulation). The upper third and fourth premolars are similar to those of *A. pardinensis*.

*Miracinonyx*, comprising the so-called North American Cheetahs with two species, *M. inexpectatus* and *M. studeri* (Adams 1979, Van Valkenburgh et al. 1990), is not the sister taxon to *Acinonyx* (Barnett et al. 2005) and should be placed in the genus *Puma* (Werdelin et al. 2010; L. Werdelin, pers. comm.).

The first known fossils of *A. jubatus* are known from Southern Africa and date to at least 1.8 Mya, with slightly younger fossils from Eastern Africa (Werdelin & Peigné 2010).

### *2.1.4. Phylogeography*

The modern radiation of the Cheetah is estimated to have occurred within the past 200,000 years and probably within approximately the past 70,000 years (Charruau et al. 2011, Rai et al. 2020, Prost et al. 2022).

Based on microsatellites, Driscoll et al. (2002) estimated the divergence time between *A. j. jubatus* and *A. j. raineyi* as 4,253 or 4,514 years ago (ya), depending on different methods of calculation. Using mtDNA, estimates for the mean divergence time between *A. j. jubatus* and *A. j. soemmeringii* range from 66,500 to 72,296 ya (Freeman et al. 2001, Charruau et al. 2011), while microsatellite data suggested more recent divergence times of 3,200–32,400 ya and 1,600–15,600 ya depending on the method of estimation (Charruau et al. 2011). In contrast, estimated average divergence times between *A. j. jubatus* and *A. j. venaticus* ranged from 32,170–44,403 ya based on mtDNA, and ranged from 6,700–67,400 ya and from

4,700–47,200 ya ago using microsatellite data (Charruau et al. 2011). A recent study by Rai et al. (2020) estimated more ancient divergence times of 72,200 ya (50,000–108,300 ya) between *A. j. jubatus* and *A. j. venaticus* and 138,900 ya (100,000–205,600 ya) between *A. j. jubatus* and *A. j. soemmeringii*. Whole genome data suggested that the population of the ancestors of *jubatus* and *A. j. raineyi* expanded from c.131,000 ya and divided into two subgroups about 24,000 ya (Dobrynin et al. 2015). However, it should be noted that recent bottlenecks that have led to a few uncoalesced mitochondrial lineages prior to 50,000 ya complicate the estimation of subspecies divergence dates from mtDNA data (Rai et al. 2020).

Prost et al. (2022) investigated genome-wide single nucleotide polymorphisms (SNPs) and mitochondrial DNA (mtDNA) to examine the phylogeography of Cheetahs throughout their former range. They found five distinct populations that correspond to five Cheetah subspecies, including *A. j. raineyi* (Fig. 2.4 and 2.5), although it could be argued that *A. j. raineyi* being part of *A. j. jubatus* based on mtDNA (Fig. 2.4). There was some evidence of introgression between *A. j raineyi* and *A. j soemmeringii*, which are potentially occupying geographic areas that are partially overlapping (parapatric), and between *A. j. jubatus* and *A. j. raineyi*. Samples of *A. j. raineyi* shared mtDNA haplotypes with those of *A. j. jubatus*. Asiatic Cheetahs (*A. j. venaticus*) were the sister group to African Cheetahs, whereas *A. j. hecki* was distinct from other African Cheetahs. Prost et al. (2022) gave no estimates of divergence times between subspecies. However, it should be noted that the support for most of the putative Cheetah subspecies through statistics is poor (<81%) in the SNP-based phylogenetic tree (Fig. 2.5) with poor support for the Cheetah as a species compared with the puma. Additionally, a Principal Component Analysis (PCA) of the same SNP data shows that *A. j. venaticus* samples are distant from those of *A. j. jubatus* and closest to the putative *A. j. hecki* samples (Fig. 2.6).

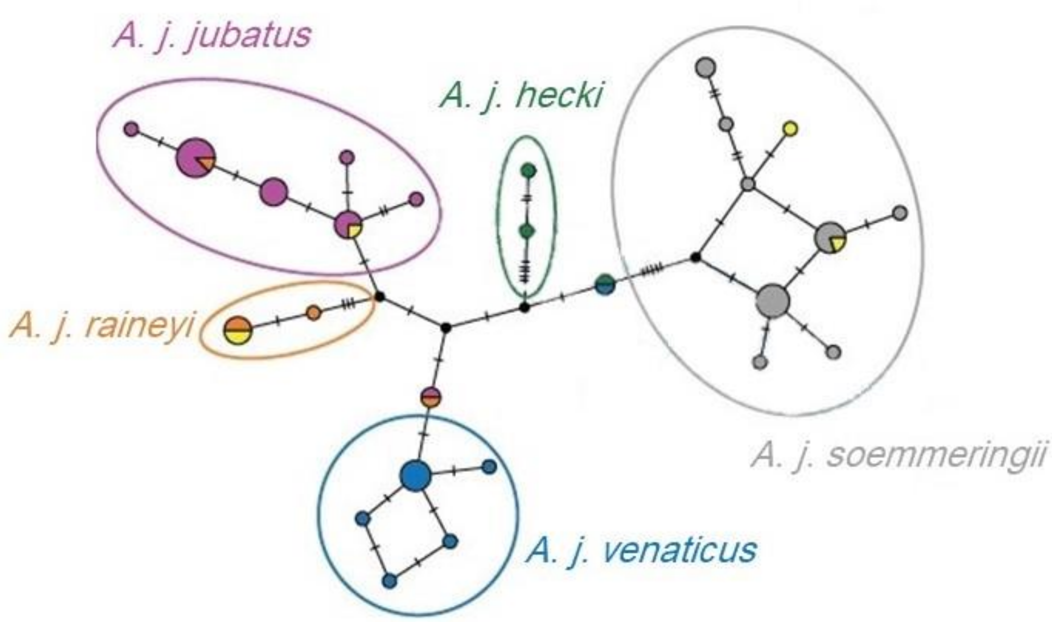


**Fig. 2.4.** Network of mitochondrial haplotypes. The graph shows a median-joining haplotype network reconstruction based on 929 bp of mitochondrial DNA from 58 individuals. Each coloured point represents one haplotype. The nominal haplogroups are circled in the colours of the subspecies they can be assigned to. Asterisks mark individuals that clustered with an unexpected group (for details see Prost et al. 2022). Short black dashes between haplotypes display the number of mutation steps. The size of the pie charts corresponds to the number of samples. The yellow sections of several haplotypes represent individuals of unknown origin. Source: adapted from Prost *et al.* (2022).

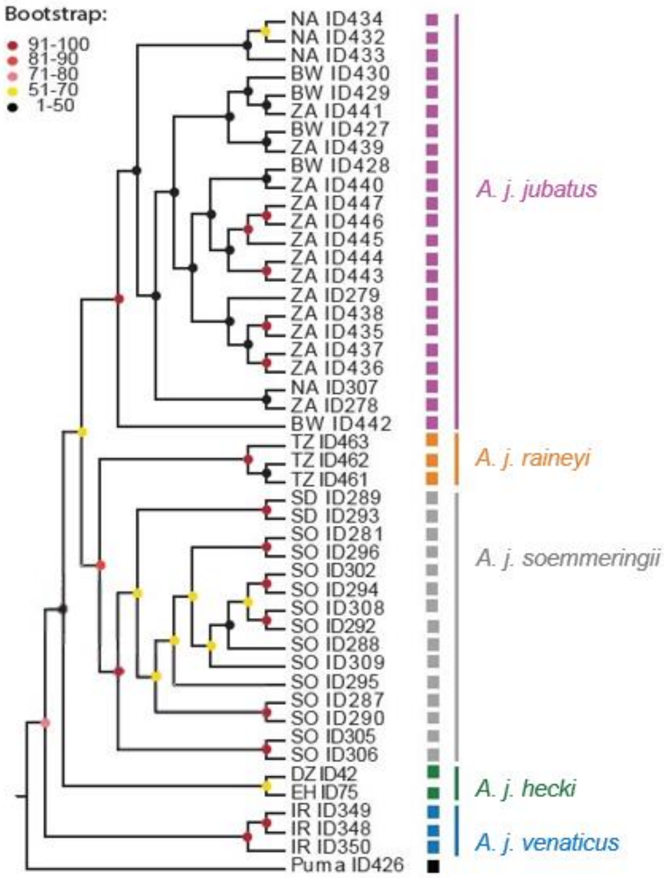


**Fig. 2.5.** Phylogenetic relationships of five classical Cheetah subspecies based on genome-wide nuclear single nucleotide polymorphisms (SNPs; 3,743 base pairs) data for 46 Cheetah individuals using genetic distances (using 100 bootstraps (repetitions), resulting in a per cent value, indicated in the legend at the top left). Source: adapted from Prost et al. (2022).

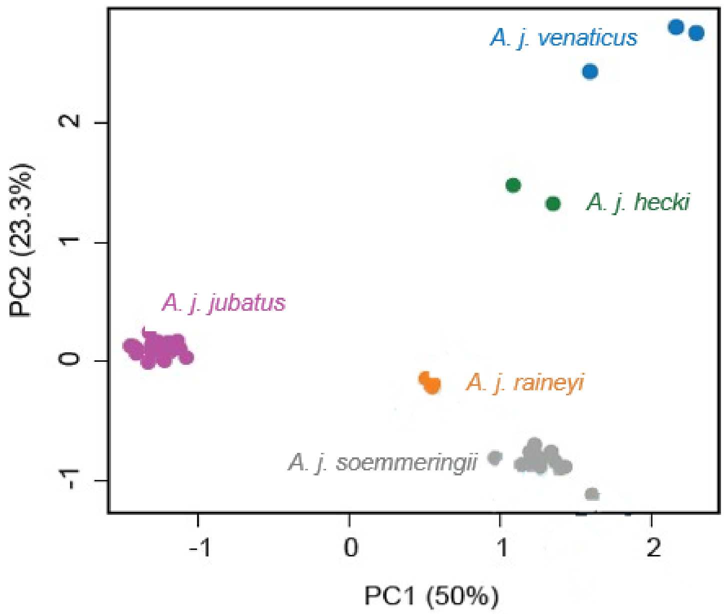


**Fig. 2.6.** A Principal Component Analysis (PCA) of genome-wide nuclear SNP (3,743 base pairs) data for 46 Cheetah individuals, showing degree of clustering between putative subspecies. Source: Prost et al. (2022).

Overall, there seems to be lack of sufficient data from enough samples to make firm conclusions about the intraspecific phylogeny of the Cheetah and the relationships between putative subspecies, although there is some evidence that samples of putative *hecki* specimens are most similar genetically to those of *A. j. venaticus* based on Prost et al. (2022; Fig. 2.6). A similar phylogenetic pattern was observed in Lions, where populations in West and North Africa occupy the same genetic clade as Asiatic Lions (Bertola et al. 2016).

### *2.1.5. Biogeography*

The biogeographical distribution of the four or five African Cheetah subspecies resembles that of many widespread savanna ungulates in Africa, although the patterns of distribution of the subspecies or genetic groups varies slightly between different species (Lorenzen et al. 2012). Looking in more detail at the Cheetah, it seems likely that the Rift Valley caused a separation of the ancestors of *A. j. soemmeringii* from *A. j. hecki* and *A. j. raineyi*, with subsequent partial overlap with *A. j. raineyi* (Prost et al. 2022). Ancestors of *A. j. hecki* may also have been separated from other Cheetahs by Megalake Chad and other large lakes and wetlands in the Sahara during the Green Sahara period, which ended in the mid-Holocene (Larrasoaña et al. 2013), although there are no estimated dates of divergence for this subspecies (Charruau et al. 2011, Rai et al. 2020). Subspecies *A. j. jubatus* may have been separated from the ancestors of *A. j. raineyi* by an almost continuous band of at least 80% forest cover that stretched across Southern Africa during the Last Glacial Maximum (21,000 ya), which could have been unsuitable habitat for Cheetahs (Cowling et al. 2008). Glaciers on East African mountains may also have played a role which also matches the apparent divergence date between the two subspecies (Groos et al. 2021).

The problems with trying to match the divergence times for the different subspecies to environmental and climatic events are the widely differing estimates of those divergence times between studies, estimation methods, and nuclear/mitochondrial DNA with very wide confidence intervals (Table 2.1) (Driscoll et al. 2002, Charruau et al. 2011, Dobrynin et al. 2015, O'Brien et al. 2017, Rai et al. 2020). For example, Charruau et al. (2011) estimated that the divergence time based on mtDNA between *A. j. venaticus* and *jubatus* is 41,900 ya (95% confidence intervals at 20,300–153,800 ya), while Rai et al. (2020) estimated the divergence time to be 72,200 ya (95% confidence interval 50,000–108,300 ya; Table 2.1). This is further complicated by a disparity in periods of aridity and humidity between different parts of Africa and the glaciations of the Northern hemisphere during the Pleistocene, i.e., 2,580,000–11,700 ya (Hoelzmann et al. 1998, Cowling et al. 2008, Blome et al. 2012, Ehrmann et al. 2017, Camuera et al. 2019, Kutzbach et al. 2020). With such wide confidence intervals, it is hard to match any possible separation of populations in different parts of Africa and Asia with known climatic and environmental events (Blome et al. 2012).

**Table 2.1.** Estimated divergence times of Cheetah subspecies from each other using different methods. Adapted from Schmidt-Küntzel et al. (2018).

| Subspecies divergence | Marker | Mean divergence time (ya) | 95% confidence interval (ya) | Reference |
|---|---|---|---|---|
| *jubatus – raineyi* | Microsats (82 loci) | 4,243<br>4,514 | | Driscoll et al. 2002 |
| | Whole genome | 24,000 | | Dobrynin et al. 2015 |

| Subspecies divergence | Marker | Mean divergence time (ya) | 95% confidence interval (ya) | Reference |
|---|---|---|---|---|
| *jubatus - venaticus* | mtDNA (912 nt) | 41,900 | 20,300–153,800 | Charruau et al. 2011 |
| | | 32,170 | 15,570–118,020 | |
| | | 44,403 | 27,420–379,222 | |
| | | 42,120 | 16,295–83,677 | |
| | mtDNA | 72,200 | 50,000–108,300 | Rai et al. 2020 |
| | | 86,100 | 33,300–172,100 | |
| | | 101,700 | 43,800–177,800 | |
| | | 103,000 | 45,000–173,100 | |
| | Microsats | | 6,700–67,400 | Charruau et al. 2011 |
| | | | 4,700–47,200 | |
| subspecies *venaticus* | | | 4,383–6,576 | O'Brien et al. 2017 |
| *jubatus - soemmeringii* | mtDNA (915 nt) | 66,500 | 32,200–244,000 | Charruau et al. 2011 |
| | | 55,085 | 26,660–202,100 | |
| | | 72,296 | 43,928–379,317 | |
| | | 66,698 | 24,067–117,615 | |
| | Microsats (18 loci) | | 3,200–32,400 | Charruau et al. 2011 |
| | | | 1,600–15,600 | |
| *soemmeringii - venaticus* | mtDNA | 138,900 | 100,000–205,600 | Rai et al. 2020 |
| | | 133,300 | 52,800–200,000 | |
| | | 171,700 | 103,600–244,900 | |
| | | 143,300 | 75,100–217,200 | |

## 2.2. Genetic differentiation and present subspecies delineation

The Cheetah *Acinonyx jubatus* is the only extant member of its genus *Acinonyx*. Based on morphological characters of a limited number of specimens collected in the 19th and early 20th centuries, several subspecies have been described (Smithers 1975, Kitchener et al. 2017; Table 2.2, 2.3 and Fig. 2.7 B; see also section 2.1).

**Table 2.2**. Cheetah subspecies described by authors, with locality, holotype and distribution.

| Subspecies and area | Author | Locality | Holotype | Distribution |
|---|---|---|---|---|
| *A. j. jubatus*: Southern Africa | Schreber (1775) | Cape of Good Hope | Skin seen by Schreber | Angola, Botswana, Democratic Republic of Congo (Southern), Mozambique, Malawi, South Africa, Tanzania (Southern), Zambia, Zimbabwe |
| *A. j. venaticus*: North Africa and Asia | Griffith (1821) | India | From a sketch of a live animal | **Africa**: Algeria, Djibouti, Egypt, Libya, Mali (Northern), Mauritania (Northern), Morocco, Niger (Northern), Tunisia, Western Sahara.<br>**Asia**: Afghanistan, India, Iran, Iraq, Israel, Jordan, Oman, Pa- |

| Subspecies and area | Author | Locality | Holotype | Distribution |
|---|---|---|---|---|
| | | | | kistan, Saudi Arabia, Syria, Russia and the Commonwealth of Independent States |
| *A. j. soemmeringii*: Central Africa | Fitzinger (1855) | From the steppes of the Kababish in the south of the Bayuda Desert, Sudan. | Male living in the Menagerie at Schönbrunn, Vienna | Cameroon (Northern), Chad, Central African Republic (Northern), Ethiopia, Nigeria (Northern), Niger (Southern), and Sudan |
| *A. j. hecki*: West Africa | Hilzheimer (1913) | Senegal | Live animal in Berlin Zoological Garden | Benin (Northern), Burkina Faso, Ghana, Mali (Southern), Mauritania (Southern), Niger, and Senegal |
| *A. j. raineyi*: East Africa | Heller (1913) | Ulu, Kapiti Plains, British East Africa [= Kenya] | USNM 182321 adult male skin and skull | Kenya, Somalia, Tanzania (Northern), and Uganda |

**Table 2.3**. Subspecies of Cheetah recognised by recent authors.

| Krausman & Morales 2005 | Wozencraft 2005 | Charruau et al. 2011, Kitchener et al. 2017 | Prost et al. 2022 |
|---|---|---|---|
| *A. j. venaticus* | *A. j. venaticus* | *A. j. venaticus* | *A. j. venaticus* |
| *A. j. hecki* | *A. j. hecki* | *A. j. hecki* | *A. j. hecki* |
| *A. j. soemmeringii* | *A. j. soemmeringii* | *A. j. soemmeringii* | *A. j. soemmeringii* |
| *A. j. raineyi* | *A. j. raineyi* | | *A. j. raineyi* |
| *A. j. jubatus* | *A. j. jubatus* | *A. j. jubatus* | *A. j. jubatus* |
| | *A. j. velox* | | |

The subspecies originally were described based only on morphological characters from different parts of the species distribution. The first comprehensive phylogeographical study that used genetic samples across the range of species, was the study of Charruau et al. 2011. Using mtDNA (NADH5, cytochrome b and control region) and 18 polymorphic nuclear microsatellites from historical and modern samples, they found (1) an absence of gene flow between Asiatic and African Cheetahs, (2) that all *venaticus* samples clustered in one monophyletic clade, and (3) that the subspecies *venaticus* has a unique evolutionary history (Fig. 2.7 C). Samples from North-East Africa tended to group together, whereas East African Cheetahs diverged into two different lineages from those of Southern Africa (Fig. 2.7 C). Charruau *et al.* (2011) also found that the separate lineages diverged quite recently. In fact, when ancient samples from North Africa and South-West Asia were included in the analysis, the distinction between North African and Asiatic Cheetahs was blurred (Fig. 2.7 C from Charruau et al. 2011), which is suggestive of isolation by distance (Kitchener et al. 2017).

Recently, Prost et al. (2022) showed clear separation of the five subspecies based on genome-wide analyses. In contrast, the median-joining haplotype network of mitochondrial DNA did not support a clear separation of subspecies (Fig. 2.7 D).

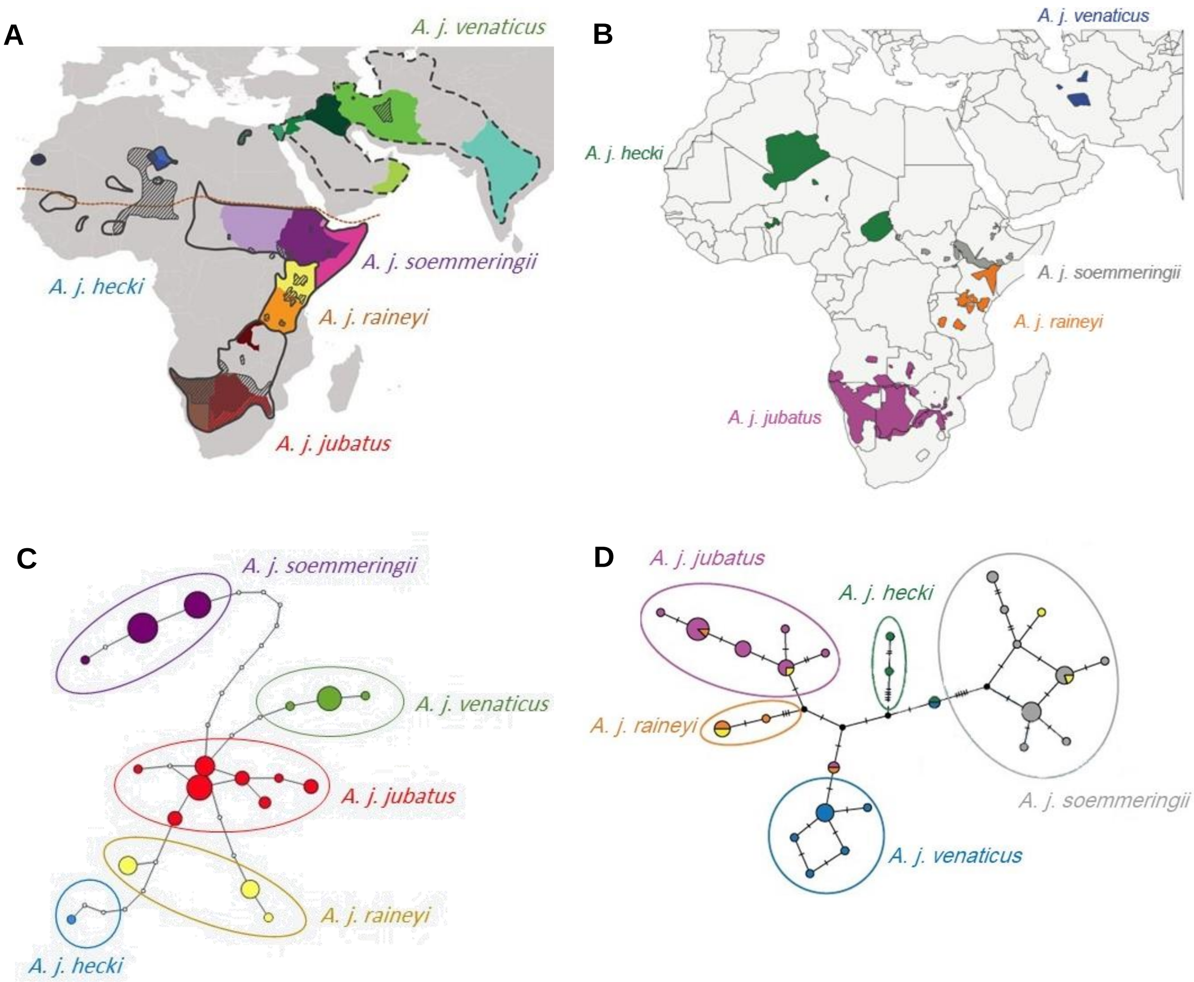


**Fig. 2.7.** Distribution maps and haplotype networks from two molecular studies of the Cheetah. Maps depict the possible range of each subspecies. Colours for the subspecies on each map in the top row correspond to the colours in the haplotype networks below, i.e., panel A to panel C, and panel B to panel D. Panel A: Geographical distribution of the cheetah subspecies and sample repartition of Charruau *et al.* 2011 data set. Solid and dashed lines represent the historical distributions of the African and Asiatic cheetah subspecies, respectively. Panel B: Current distribution of subspecies recognised by Prost *et al.* (2022). Panel C: The median-joining network was built using ND5, Cytb and D-loop sequences from GenBank and subspecies were assigned to each sample based on Charruau *et al.* (2011). Panel D: Median-joining haplotype network of five subspecies. Source: adapted from Prost *et al.* (2022).

### *2.2.1 Conclusion*

Given that in all of these studies the separation of some subspecies was not fully supported, that they have very few samples for *A. j. venaticus*, *A. j. hecki* and *A. j. raineyi,* and taking into account the species' vast historical distribution and its ability to move across large distances, it is possible that the observed separation of some subspecies resulted from isolation by distance. Therefore, the validity of some subspecies is now questioned and further genetic analysis, using more samples per subspecies, is needed to assess whether the subspecies designations are appropriate, or whether there needs to be further consolidation (Durant et al. 2022a). For instance, Kitchener et al. (2017) proposed: "It is possible that there are only two subspecies of Cheetah; Northern (*A. j. venaticus*) and Southern/Eastern (*A. j. jubatus*), or perhaps none if additional more comprehensive sampling of museum specimens is carried out". The current knowledge recognises genetic structure in the Cheetah. Therefore, it is important that this interpopulation genetic diversity, alongside the intrapopulation diversity, is maintained regardless of final subspecies status.

## 2.3. Range decline of the Cheetah in recent times and present distribution

### *2.3.1. Historical distribution*

The Cheetah was once one of the most wide-ranging large felids. Its historical distribution encompassed much of Africa and South-West Asia. In Africa, its historical range included the entire Southern part of the continent and northward to the Mediterranean Sea (Figs. 2.8 and 2.9). Across this vast range, the Cheetah occupied a broad range of habitats from wooded savanna to desert, but was absent from large sandy deserts in the Sahara and from montane and tropical humid forests of Western Africa (Heptner & Sludskii 1992, Kingdon et al. 2014).

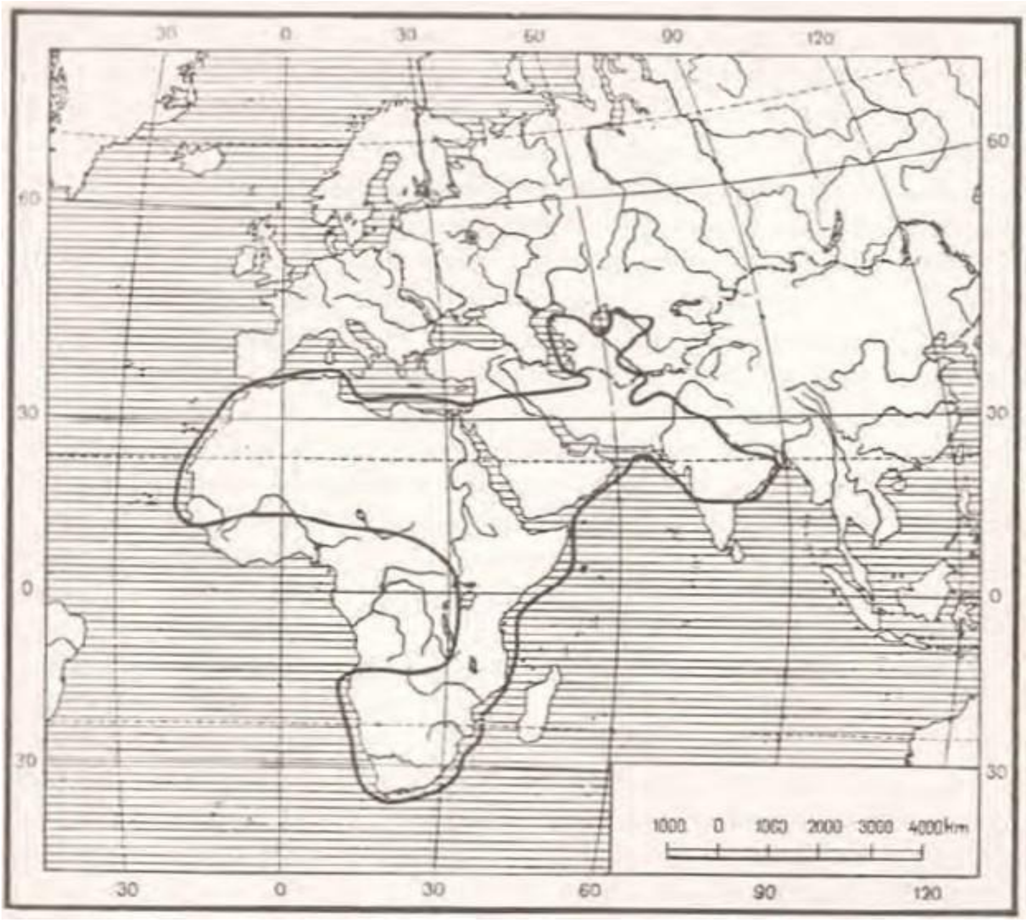


**Fig. 2.8**. Reconstructed historical range of the Cheetah (black line). Source: Heptner & Sludskii 1992).

The Cheetah's historical distribution in Asia extended from the Eastern shores of the Mediterranean Sea to the Arabian Peninsula in the south, the Western coasts of Caspian Sea in the Northwest, and through Iran to Central Asia in the Northeast and India in the East (Fig. 2.10). In Iran, the Cheetah's distribution was restricted by the shores of the Persian Gulf and the Oman Sea but extended through to the Indian subcontinent via the Baluchistan region of Pakistan and through the Central Basin to Afghanistan (except the Hindu Kush), and continued to the shores of the Aral Sea and Caspian Sea in the East.

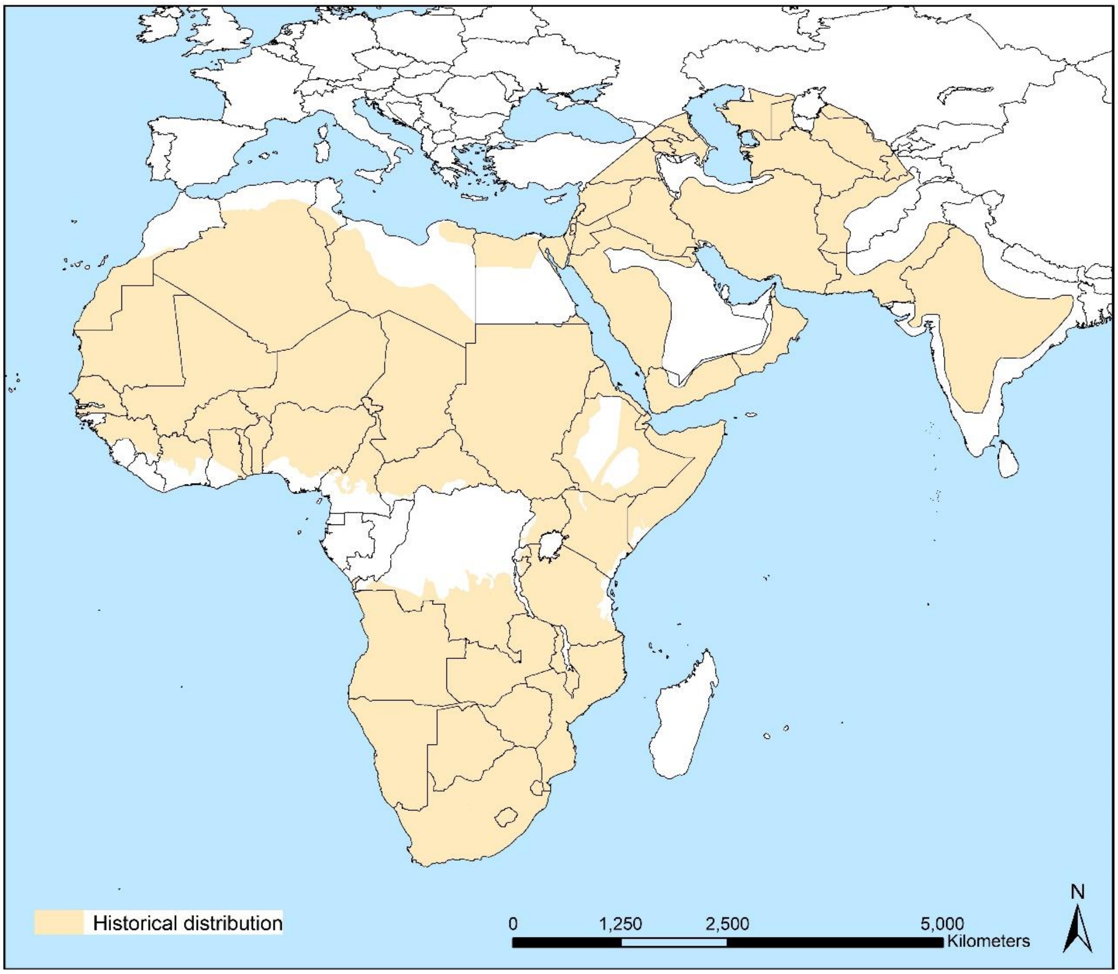


**Fig. 2.9.** Historical range of the Cheetah (yellow). Source: Durant et al. 2022a.

Cheetahs were distributed in most parts of the wooded grasslands and deserts of Syria and Iraq. In Iraq they reportedly occurred in the lowland districts of the Tigris and Euphrates, but not in the mountainous regions of Kurdistan (Harrison & Bates 1991). On the Arabian Peninsula Cheetahs were probably distributed across Western areas as far south as Yemen and Oman and they were likely absent from the Southwestern shores of the Persian Gulf, Ad-Dahna, and the large sandy deserts of the Rub' al-Khali. In Iran Cheetahs were distributed across vast parts of the country, except for very dry central parts of Dasht-e-Lut and Dasht-e-Kavir, the high Alborz Mountains, and the dense Hyrcanian mixed forests on the Southern coast of the Caspian Sea and Caucasus regions in the northwest of the country. In Pakistan their range extended from the Baluchistan region and continued to the Western parts of the Indus River and from there to India. In India the Cheetah used to be widespread across the north, south of the Ganges, and from Rajasthan to Bengal, Punjab and Sind, Central India, and the Northern Deccan. The Northern limit of the Cheetah's historical range in Central Asia extended from the North-Eastern shore of the Caspian Sea in the area of the Mangyshlak Peninsula (Kazakhstan) and the Northern escarpments of Ustyurt and across the Kyzyl Kum (Uzbekistan) and Kara Kum deserts (Turkmenistan), and possibly further east, perhaps reaching the foothills of the Karatau Mountains (Kazakhstan), then continuing to the middle and lower parts of the Syr Darya and Zeravshan Valleys (Uzbekistan and Tajikistan) in the south (Fig. 2.10 and 2.11; Heptner & Sludskii 1972, Mallon 2007 and references therein: Bannikov 1984).


**Fig. 2.10.** Approximate limits of the historical distributional range of the Cheetah in Central Asia: Turkmenistan, Kazakhstan and Uzbekistan (dotted line). Source: Heptner & Sludkii 1992).

During the Middle Ages (from the 5th to the late 15th century), Cheetahs were also present west of the Caspian Sea in Transcaucasia. According to Vereshchagin (1959), Cheetahs may have survived in the Kura-Araks lowlands of Azerbaijan until the 18th century (Fig. 2.11; Mallon 2007).


**Fig. 2.11**. Reconstructed historical range of the Cheetah in Central Asia (probable: green hatching, confirmed localities: green dots). Adapted from Bannikov (1984). Probable range in Transcaucasia in 17th–18th centuries (question marks). Source: Mallon 2007.

In Africa, Cheetahs were widely distributed and were absent only from extensive sand deserts and coastal regions of North Africa, and the lowland forest of Western and Central Africa (Fig. 2.12). Before human activity modified substantial portions of the region's natural habitats, Cheetahs are presumed to have occupied nearly the entire region (IUCN SSC 2012, Durant et al. 2017).

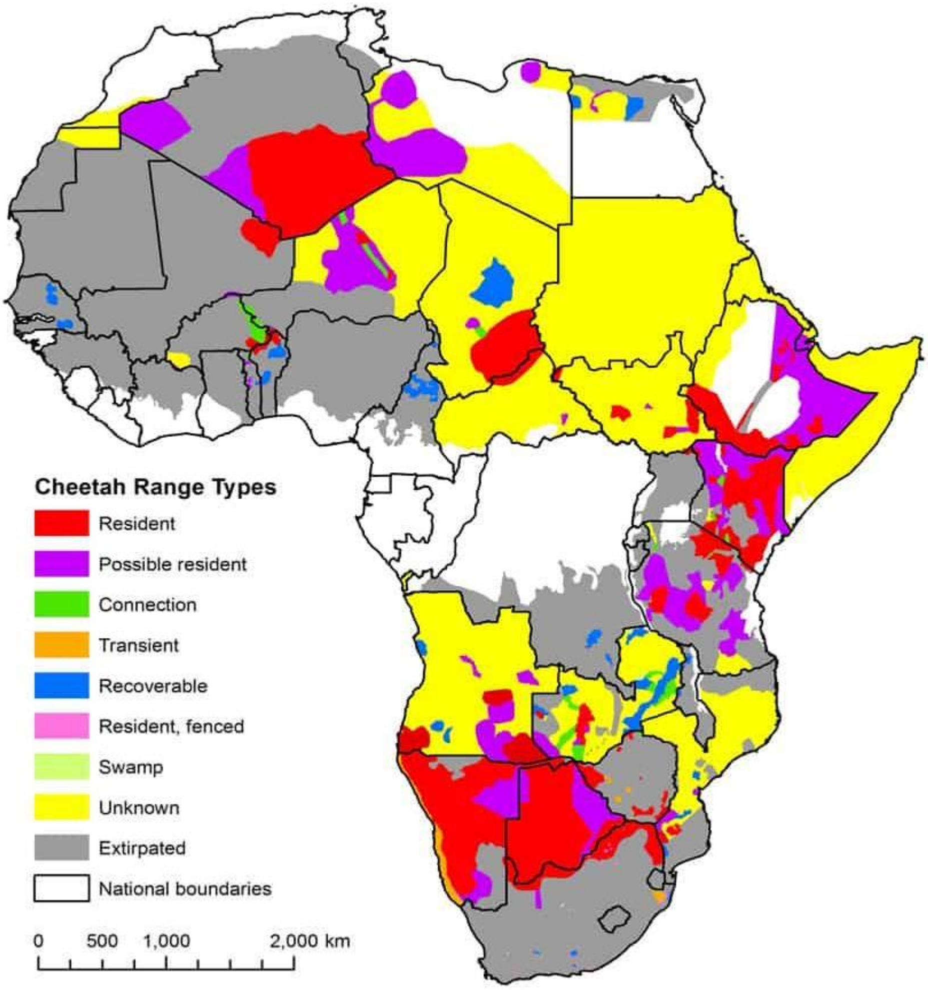


**Fig. 2.12.** Historical and current range of the Cheetah in Africa. Source: IUCN SSC (2007a, b, 2012).

### *2.3.2. Current distribution*

At the current time, Cheetahs are known to occur in only 9% of their past global distributional range (Fig. 1.1). In Eastern Africa, they are distributed across several different centres of population, namely Tanzania, Kenya and Ethiopia, as well as in South Sudan and northern Uganda. The largest population occurs in the transboundary areas between Northern Tanzania and Southern Kenya. They are also reported to occur, albeit likely at low population densities, across the Southern boundary of Ethiopia, stretching into Northern Kenya with connectivity into South Sudan. Other important subpopulations of Cheetah survive in Tanzania, Kenya, Ethiopia, South Sudan and Northern Uganda, but these are notably fragmented across the region. Their presence in Eritrea, Djibouti, Somalia and Sudan is mostly unknown, although it is likely that they have been extirpated across much of this area (IUCN SSC 2007a, Durant et al. 2022a).

Most of the Cheetahs surviving in Southern Africa are in a single transboundary population, stretching across Namibia, Botswana, Southern Angola, Northern South Africa, South-Western Mozambique and Southern Zambia. Small isolated populations (<100 individuals) also survive elsewhere in Central Angola, Zambia, Zimbabwe and Mozambique (IUCN SSC 2015, Durant et al. 2015, Weise et al. 2017, Durant et al. 2022a).

The Cheetah's distribution has retracted particularly precipitously across Western, Central and Northern Africa (IUCN SSC 2012, Durant et al. 2017). The subspecies found in North-West Africa, *A. j. hecki*, is listed as Critically Endangered. Much of its remaining range is within the Sahara, where Cheetahs occur at very low population densities, estimated as low as 2.3 individuals per 10.000 km² (Belbachir et al. 2015). There are five known Cheetah subpopulations in this region (IUCN SSC 2012; Durant et al. 2017): i) South-Central Algeria, stretching through to north-Eastern Mali, and possibly into Western Libya (Belbachir et al. 2015); ii) two tiny connected subpopulations around the Termit massif in Niger; iii) South-Eastern Burkina Faso and South-Western Niger, iv) the W-Arly-Pendjari Complex of protected areas (PAs) in Northern Benin; and v) South-Eastern Chad and North-Eastern Central African Republic. Cheetahs have been extirpated from their historical range in Western Sahara, Senegal, Nigeria, Mauritania, Tunisia, Guinea, Côte d'Ivoire, Cameroon, Democratic Republic of the Congo, and Ghana (Brugiere et al. 2015, Durant et al. 2017). The last reliable Cheetah sighting in Cameroon was in the 1970s (de Iongh et al. 2011), and no tracks were found in extensive searches in 2007 and 2010 of the Benoue Complex, which was their last refuge in the country (de Iongh et al. 2011). Recent extensive surveys for Lions in the best-preserved PAs in the Democratic Republic of the Congo, Côte d'Ivoire, Guinea, Senegal, Ghana and Nigeria found no evidence of Cheetahs (Henschel et al. 2014a, b). It is also unlikely that any Cheetahs are remnant in Egypt. Reports from local hunters and park authorities suggest that Cheetahs may persist in South-Western Libya and South-Eastern Chad (IUCN SSC 2012), but the status of Cheetahs in much of Southern Libya, Northern Niger, Northern Chad, and Central African Republic remains unknown (Durant et al. 2022a).

In Asia, the Cheetah has been extirpated from nearly all of its range, except Iran. The last sighting in India was in 1948, in Iraq in 1949, in Saudi Arabia in 1950, and in the Sinai Peninsula in 1960. Persistence in Pakistan is unlikely (Husain 2001). Habibi (2003) considers Cheetahs extinct in Afghanistan, although a Cheetah skin of unknown origin was found in a marketplace in Western Afghanistan in 2006 (Manati & Nogge 2008). By 1970, the Asiatic Cheetah *A. j. venaticus* was limited to Iran, and is now Critically Endangered (Jowkar et al. 2008a). The Asiatic Cheetah population was until recently considered to be divided into three subpopulations: in North-Eastern Iran, in Central Iran and in Kavir National Park (NP) (Khalatbari et al. 2018a); but the last confirmed record in Kavir NP was from 2013. For more details on the distribution and abundance of the Asiatic Cheetah, see section 4.1.

#### *2.3.3. Main reasons of population decline*

The main reasons for the Cheetah's population decline are generally habitat loss and fragmentation, human-wildlife conflict, prey loss due to unsustainable exploitation of bushmeat, and illegal trade (Durant et al. 2017). Unsustainable rangeland management, including overstocking, is also a key cause of habitat degradation and loss of wild prey.

*Africa*

In Western, Central and Northern Africa habitat loss and fragmentation, conflict with livestock farmers, prey loss, hunting for live trade, accidental snaring and road accidents are the main threats to the population, especially for small and isolated populations (IUCN SSC, 2012a). In Eastern, Southern and Western Africa habitat loss and fragmentation have been identified as primary threats (IUCN SSC 2007b, 2012).

Cheetahs are hunted for their skins in many parts of their distributional range for traditional local use as well as for the international trade. Additionally, substantial illegal trade in Cheetah cubs to Gulf States poses a significant threat to populations in the Horn of Africa, which is closest to these consumer countries. In the desert habitats of Northern Africa and those areas subject to high levels of bushmeat extraction, a depleted wild ungulate prey base is a particular concern (Durant et al. 2022a, Belbachir et al. 2015). Cheetahs may also be captured in indiscriminate snare traps set for ungulates, another cause of mortality in Africa. Conflict with farmers due to livestock depredation, either perceived or real, is a widespread and serious problem across most of the Cheetah's range in Africa. High-speed roads constitute another threat to Cheetah populations in Africa, particularly in countries with high and increasing levels of infrastructure development. Unregulated tourism may also pose a threat, as tourists may disrupt hunts and separate mothers from their cubs. Infectious diseases, including anthrax, can affect Cheetahs, but given their low population densities, these are not expected to be a major threat to the viability of free-ranging Cheetah populations (Durant et al. 2022a).

*Asia*

The main reason for the historical decline in India is thought to be the live capture of Cheetahs for hunting between the 16$^{th}$ to 19$^{th}$ centuries. Captured animals were trained to hunt deer and gazelles as a hobby/sport for the aristocracy (Divyabhanushinh 1995). In Central Asia depletion of wild prey, especially Goitered gazelles *Gazella subgutturosa*, live capture for hunting and collections, occasional killing by shepherds' dogs (Heptner & Sludskii 1972, Bannikov 1984, Sadykov 1988, Azimov 2003), direct killing, and anthropogenic changes to and fragmentation of their habitats mainly due to agricultural expansion and intensification, are likely to be the key causes of the regional disappearance of Cheetahs (Mallon 2007). In Pakistan, anecdotal observations suggest that killing Cheetahs for skins and overhunting of gazelles were main causes of local extinction (Husain 2001).

In Iran, the development of mechanised agriculture in the early 20$^{th}$ century led to the conversion of habitat for agriculture, especially in the central plateau of Iran. This is thought to be the main reason for the decline in Cheetahs. The transformation and fragmentation of arid grasslands (key habitats for Cheetah and their prey) resulted particularly in significant population declines in gazelles and consequently in Cheetahs. At the same time, increasing use of four-wheel, drive vehicles and modern weapons allowed poachers to hunt in previously inaccessible areas and in larger numbers, decreasing refuges for wildlife (Firouz 1974). According to Lay (1967), the arrival of the Jeep after World War II marked the beginning of a decrease in Cheetahs, largely due to the slaughter of their essential prey, gazelles, by humans now able to drive off-roads. It is not very well understood when hunting Cheetahs was prohibited in the country for the first time, but it very likely happened when (or even before) the Game and Fish Department (former name of the Department of Environment - DoE) declared a number of gazelle habitats as protected by law in 1967. This regulation was enacted in response to the severe decline of gazelle numbers since the late 1940s and early 1950s. This action resulted in the re-establishment of the remaining gazelle populations in several PAs and unprotected areas in early 1970s. In this period legislation was strengthened by banning hunting inside many PAs and regulating hunting to make it sustainable in PAs where hunting continued to be permitted. As a result, population increases in some other endangered species were reported, including Cheetahs and onagers *Equus hemionus* (Asiatic wild ass; Firouz 1974, 2005). However, as a consequence of legal uncertainties after the Islamic Revolution in 1979 and the war with Iraq (1980–1987), nature conservation was not a priority and protection in many PAs was non-existent. This period saw a resurgence in uncontrolled hunting of wildlife and habitat degradation. As a result, the already fragmented and small populations of gazelles and Cheetahs went locally extinct in many protected and unprotected areas (see Figs. 4.1 and 4.2 in section 4.1; Ziaie 2008). Overhunting after the 1980s led to further population declines in gazelles, and currently most of the remaining populations are surrounded by areas of human settlement and road networks. There are still viable populations of both Goitered gazelle *Gazella subgutturosa* and Chinkara *G. bennettii* in PAs and several regions outside these areas, though the populations are not high and are estimated to be around 2,650 (Goitered gazelle) and 1,000 (Chinkara) across known Cheetah habitats (DoE unpublished data). These population sizes are substantially below what is needed to support a viable Cheetah population.

In 2001, the Conservation of Asiatic Cheetah and its Natural Habitats Project (CACP) was initiated in Iran, and Cheetah mortality started to be more systematically documented. Road mortality was the most often reported direct cause of death of Cheetahs. These deaths mainly happened on the roads passing through PAs. Direct killing of Cheetahs by livestock herders or their herding dogs is also recognised to be a significant threat and cause of direct mortality (Farhadinia et al. 2017). However, prey depletion remains the main threat, as it prevents recovery of the Cheetah population, lowers the carrying capacity of habitats, and increases the Cheetah's vulnerability to other threats. In recent years, resource extraction and extensive infrastructure development, such as mining, oil, pipelines, roads and railways, have further exacerbated the threats to the Cheetah. These developments risk further fragmenting the remaining subpopulations into increasingly smaller groups, which may no longer be viable (Durant et al. 2022a and references therein).

While the threats outlined above constitute the proximate causes of Cheetah decline, they are a consequence of many ultimate drivers. These drivers include constraints, such as lack of land-use planning, site insecurity, and a lack of awareness or commitment to foster species conservation. Many Cheetah Range States suffer from a lack of capacity and financial resources to support conservation, and there is a general lack of incentives for local people to conserve wildlife. Meanwhile, a lack of environmental awareness, rising human populations, and social changes are leading to ever-increasing subdivision of the land leading to habitat fragmentation. These underlying drivers also need to be addressed if the immediate threats are to be reduced (Durant et al. 2022a).

### *2.3.4 Projections for the future*

Continuing threats have reduced Cheetah population densities from naturally low levels (maximum natural population densities of Cheetahs are not much more than 2 per 100 km$^2$). This has exacerbated the challenges of monitoring and protecting the remaining populations. The finding that the majority of known global Cheetah range (77%) and most of the remaining known Cheetah populations (67%) are on unprotected lands, and that their populations are extremely fragmented, are causes for grave concern, given that Cheetahs on unprotected lands face elevated threats. The population projections conducted by Durant et al. (2017) show that if Cheetahs outside PAs are subject to increasing levels of threat, as might be expected on the African continent where rapidly increasing human populations are expected to be accompanied by accelerating consumption (United Nations 2017), then the global Cheetah population may decline by more than 50% over the next 15 years, or three generations. As such, preventing continuing rapid decline in the face of a continuing period of rapid growth in Africa's human population over the next few decades will pose a serious challenge to the conservation of this species and its prey (Durant et al. 2022a).

Climate change is also likely to negatively influence Cheetahs across their range due to habitat change and changing patterns of agricultural land conversion (Durant et al. 2022a). In particular, the reduction in land due to rising sea levels, large-scale movements of human populations and increased variability in rainfall will exacerbate negative impacts of rapidly rising human populations (United Nations 2017). In Iran, models of climate-change impacts suggest that lowland areas, which support the Cheetah and its main prey, have the highest risk of exposure to extreme climates (Yusefi et al. 2021). Accordingly, models predict that gazelles will lose over 50% of their current suitable habitat due to climate change (Malakoutikhah et al. 2020). This prey decline, in turn, is likely to impact Cheetahs and other carnivores via food scarcity. For Cheetahs, it has been predicted that 22% (8,000 km²) of their current habitat will be lost in the future, mainly due to prey population declines and climate change (Khalatbari et al. 2018a; Fig. 2.13). The long-term survival of the Asiatic Cheetah depends not only on the recovery of remnant habitats and prey, but also on effective action to mitigate the impacts of climate change.

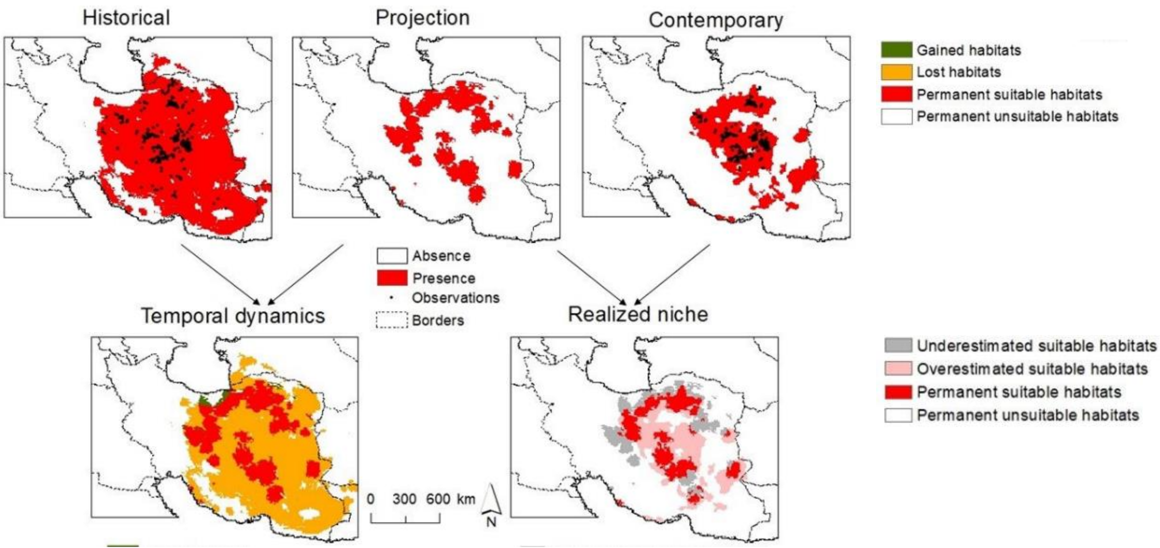


**Fig. 2.13**. Historical, contemporary and projections of suitable habitats and dynamics of habitat suitability from historical to contemporary time period for the Asiatic Cheetah. Source: Khalatbari et al. 2018a.

# 3. Morphology and ecology of the Asiatic Cheetah compared to the African subspecies

**Chapter summary**

Cheetahs are slender cats, with a small head, long legs, a narrow waist and a wide chest. While males and females are similar in appearance, there is sexual dimorphism in body measurements. As the only living species of the monospecific *Acinonyx* genus, Cheetahs have unique morphological characteristics adapted for their specialised high-speed hunting strategy. After killing prey, Cheetahs are vulnerable to loose their kill as they are built for speed but are not well adapted to defend their kill from other large carnivores. There are reported inter-subspecies differences in terms of body size and coloration (Table 3.1, and Appendix II), with *A. j. venaticus* being the smallest subspecies with a longer, denser, and paler coat than the African subspecies. However, the differences between subspecies, should be treated with caution due to small sample sizes, especially for the Asiatic subspecies, and the lack of data for *A.j.hecki* (section 3.1). Across their distribution Cheetahs occupy a wide range of habitat types outside of forests, where they can utilise their specific morphological and behavioural adaptions (i.e., their slender body specialised for fast running). Cheetahs are only absent from three major habitat types: mountainous areas, tropical rainforests, and sand dunes. Competitors include Lions, Leopards, Striped *Hyaena hyaena*, Brown *Parahyaena brunnea* and Spotted Hyaenas *Crocuta crocuta*, African Wild Dogs *Lycaon pictus*, and Grey Wolves *Canis lupus,* against which they are poorly adapted to defend themselves or their kills (section 3.2, and Table 3.2). Where Cheetahs live alongside these competitors, they adopt an avoidance strategy and avoid hunting when they detect other predators, meaning that they lose only a small proportion of their kills to these predators (up to 14%). Most information on the Cheetah's diet comes from Africa, where the cheetah's preferred prey consists of small to medium-sized ungulates with body masses of 15-65 kg. Cheetahs also take smaller prey, such as hares (*Lepus spp*.) Although they primarily consume wild prey, they can also prey on livestock, particularly when wild prey is scarce. Prey choice is dependent on prey abundance, competitor presence and the Cheetah's sex. Males are able to kill larger prey than solitary females, especially when they form hunting coalitions, but females with dependent cubs may take down larger prey as well. In Iran, the Cheetahs' main prey was reported to consist of Chinkara *Gazella bennettii*, followed by Goitered Gazelle *G. subgutturosa*, wild sheep *Ovis vignei,* and wild goat *Capra aegagrus*, but they also prey on wild pig *Sus scrofa*, Cape Hare *L. capensis* and livestock (sheep *Ovis aries*, goat Capra hircus and dromedary Camelus dromedarius), of which they preferred Chinkara. Recently, relatively higher predation on wild sheep (which live in the hills and highlands) consumption were detected; possibly a consequence of human pressure on the lowland habitats has decreased gazelle populations significantly and forced Asiatic Cheetahs to occupy suboptimal habitats where gazelles are less abundant and where they are sympatric with competing Leopards.

### 3.1. Morphology

Cheetahs are slender cats with a small, rounded head, long legs, a narrow waist and a wide chest. Their tail is long and their ears are small. Cheetahs have narrow paws with four toes on both their front and hind paws, but there is also a large dew claw on the inside of the lower foreleg. Males and females are similar in appearance, but significant sexual dimorphism is apparent in body measurements (Marker 2002). As they are the only living species of the monospecific genus *Acinonyx*, Cheetahs have unique morphological characteristics, which are adaptations for specialised hunting. Their hunting strategy is based on a high-speed chase of prey, during which they try to throw it off balance using their enlarged dew claws on their front legs, and finally bite their prey's throat to suffocate and kill it (Caro 1994). Small prey, such as hares *Lepus* spp., may be dispatched with a bite to the skull. The Cheetah's anatomy, physiology, and behaviour are highly specialised for their hunting strategy. They have a light-weight and thin-boned skeleton, powerful hind legs, flexible shoulders and spine, and a long muscular tail that counterbalances the body weight while turning fast. Their semi-protractile claws, lacking cutaneous sheaths, provide good grip while running at high speeds; their en-larged nostrils and extensive air-filled sinuses allow for maximum air intake and brain cooling during high-speed chases (Sicuro and Oliveira 2011); and their relatively flat face with a re-duced muzzle length allow their large eyes to have maximum binocular vision. However, this characteristic means the small skull and enlarged nasal cavity do not leave room for long root canals, leaving the jaws weak, and resulting in small canine teeth relative to other large cats. Moreover, the skull and neck need to be as light as possible. Therefore, Cheetahs have less musculature than similar-sized cats, resulting in weaker jaws in comparison to other large felines. As a result, Cheetahs are not very efficient when it comes to defending themselves or their kills against other, more powerful carnivores. Where Cheetahs live alongside these com-petitors, they adopt an avoidance strategy, and do not hunt when they detect other predators, which means that they lose only a small proportion (up to 14%) of their kills to these predators (Scantlebury et al. 2014).

There are slight differences in body size and colouration between subspecies. *A. j. jubatus'* coat generally is short and dense, but longer on the underside, with a mane along the shoul-ders and back. Body coloration is tawny-cream to pale fawn, covered with more or less uniform rounded black spots. *A. j. soemmeringii* looks similar to the south and east African subspecies, but is slightly smaller, darker, brightly coloured, and has thinner fur. Its coat and body colora-tion are similar to those of *A. j. jubatus*. The Asian subspecies, *A. j. venaticus*, is a small subspecies, with a longer, denser and paler coat than the African subspecies. Its winter mane is long and dense and is less developed during the summer. Its overall body colour ranges between a pale yellow to a reddish-ochre, slightly more intense on the back. They are covered in small black spots, which are arranged in lines on the head and nape, but are irregularly scattered on their body and legs. Their mane is usually darker in colour (Castelló 2020).

Only limited information is available on the Cheetah's body measurements. The Cheetah's body mass varies between 30 and 65 kg, its head and body length from 110 to 150 cm, and its tail length from 65 to 90 cm. These measurements vary among individuals and populations from different localities, as well as between sexes and different subspecies (Table 3.1).

The means of the main body measurements are lower in *A. j. venaticus*, compared to *A. j. jubatus,* which is the largest subspecies, and *A. j. raineyi*, which is slightly smaller than *A. j. jubatus* (Fig. 3.1). These size differences should be interpreted with caution due to the small sample sizes, especially for the Asian subspecies. There are some skull measurements of Cheetahs in Africa and Asia, but too few to draw any conclusions about subspecies variation.

**Table 3.1.** Mean body masses (kg) and body measurements (cm) of Cheetah subspecies. Sample sizes for each parameter vary greatly. For original data and references see Appendix II.

| | Subspecies | | |
|---|---|---|---|
| **Body measurement** | ***A. j. jubatus*** | ***A. j. raineyi*** | ***A. j. venaticus*** |
| Body mass (kg) | | | |
| Male | 52.10 | 42.18 | 31.00 |
| Female | 45.05 | 37.43 | 31.10 |
| Unknown sex | - | - | - |
| Head and body length (cm) | | | |
| Male | 125.31 | 122.88 | 116.75 |
| Female | 120.00 | 124.11 | 113.75 |
| Unknown sex | - | - | 125.30 |
| Tail length (cm) | | | |
| Male | 76.54 | 68.01 | 70.00 |
| Female | 69.35 | 65.87 | 65.50 |
| Unknown sex | - | - | 70.00 |
| Total length (cm) | | | |
| Male | 201.85 | 190.89 | 191.32 |
| Female | 192.00 | 190.05 | 180.23 |
| Unknown sex | - | - | 187.65 |

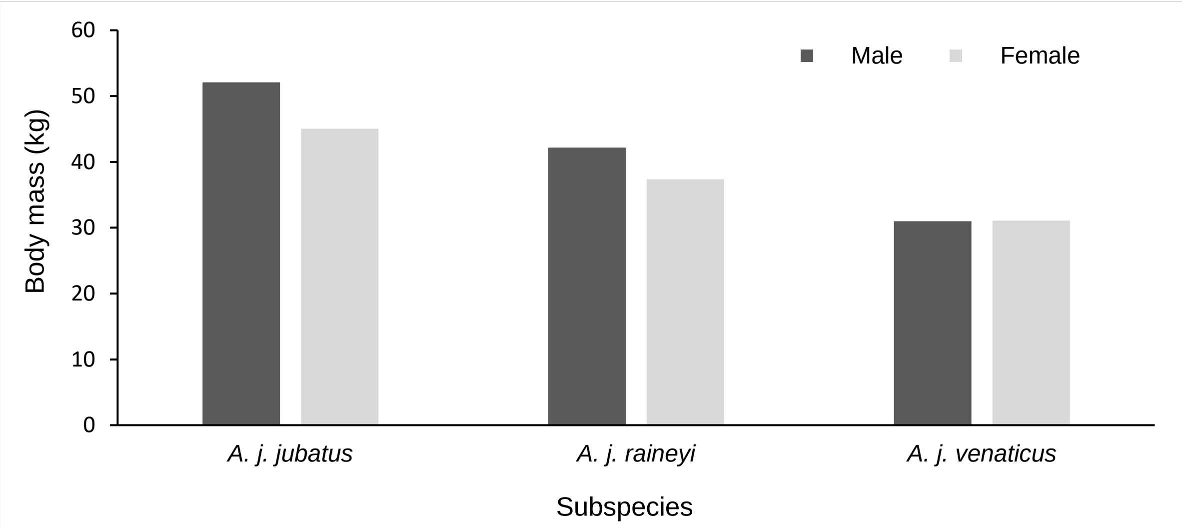


**Fig. 3.1**. Mean body mass (kg) of Cheetah subspecies. See Table. 3.1 and Appendix II for the data.

## 3.2. Ecology

Across their distribution in Africa and South-West Asia, Cheetahs occupy a wide range of habitat types, outside of forests, where they can utilise their species-specific morphological and behavioural adaptations (i.e., their multiple adaptations for fast running). Cheetahs are only absent from three major habitat types: Mountainous areas, tropical rainforests, and sand dunes. Therefore, Cheetahs are absent from the mountainous areas of Africa (including the

Ethiopian Highlands and the Atlas Mountains) and South-West Asia (including the Alborz and Zagros Mountains in Iran), but they (nowadays) use rugged terrains in some of the PAs in Central Iran. Cheetahs are absent from tropical forests, e.g., from the Congo Basin in Central Africa, and from the extensive sand dunes in the Sahara, the Arabian Peninsula and in Central Iran, although they have been observed along the margins of these places and in less extensive sand dunes. Cheetahs occupy the following habitats: Savannas, grasslands, bushlands, woodlands, steppes, semi-deserts and deserts. In many of these habitats the climate is arid, semi-arid, subtropical, or partly Mediterranean with hot summers and little rainfall. However, these arid areas vary greatly in topography, climatic regime, and ecological communities, including prey and competitors (Table 3.2). For example, the central basin of Iran differs in topography from the many flat habitats in different parts of Africa. Although this region is generally defined as flatland and is less mountainous compared to Alborz and Zagros regions, it is a complex area with a partly rugged topography. Across these habitats, Asiatic Cheetahs are able to move across vast distances (Farhadinia et al. 2016b; Khalatbari 2021).

Cheetah competitors include Lions, Leopards, Spotted, Brown and Striped Hyaenas family *Hyaenidae*, African Wild Dogs and Gray Wolves, against which they are poorly adapted to defend themselves or their kills due to weak jaws. Cheetahs compensate for losses of their kills to stronger competitors by being more successful hunters. Where Cheetahs live alongside these competitors, they adopt an avoidance strategy, avoiding hunting when they detect other predators, so that they lose only a small proportion of their kills to these predators (up to 14%).

Most information on the composition of the Cheetah's diet comes from Africa, where it has been reported to prey on a large variety of species from large ungulates to small rodents (Marker et al. 2018, Caro 1994). Cheetahs' preferred prey consists of small to medium-sized ungulates with body masses in the range of 15 to 65 kg (and a mode of 36 kg) (Mills et al. 2004, Hayward et al. 2006). Hares can be an important prey for Cheetahs; in Namibia Cheetahs rely on hares and other rodents when alternative prey are not available, whereas in the Serengeti in Tanzania adolescent Cheetahs depend on Hares, which are much easier to catch than larger prey (Marker et al. 2018, Caro 1994). Cheetahs also prey on livestock, including sheep, goats and camels (Wacher et al. 2005, Thuo et al. 2020), but primarily consume wild prey when it is available (Marker et al. 2003, Broekhuis et al. 2018). Prey choice depends on prey abundance, presence of competitors, and the Cheetah's sex (Cooper et al. 2007). Male coalitions are able to kill larger prey (Mills 2015, Caro 1994), while solitary females usually hunt smaller prey (Mills et al. 2004, Rostro-García et al. 2015, Caro 1994). However, when females have dependent cubs, they may also take larger prey, particularly when they face the energetic demands of lactation (Laurenson 1995). Cheetahs can also kill and eat other carnivores, such as Jackals *Canis* spp. and *Lupulella* spp. and Foxes *Vulpes* spp. (J. S. Hunter et al. 2007).

**Table 3.2.** Geographical range, home range, population sizes, habitat features, prey and competitors of the five recognised subspecies of Cheetah.

| **Subspecies, Countries** | **Home range (km²)** | **Pop. size[1]** | **Habitat** | **Main available prey items** | **Possible competitors** |
|---|---|---|---|---|---|
| *A. j. hecki* | | | | | |
| Algeria, Benin, Burkina Faso, Central African | 1,583[2] | <250 | Deserts and semi deserts; savannas, hot summers; day | Barbary Sheep *Ammotragus lervia*, Dorcas Gazelle *Gazella dorcas*, Duiker *Sylvicapra* spp., Hares, Kob *Kobus* | Leopard, Lion, Spotted Hyaena, Striped Hyaena |

| Subspecies, Countries | Home range (km²) | Pop. size[1] | Habitat | Main available prey items | Possible competitors |
|---|---|---|---|---|---|
| Republic, Chad, Mali, Libya, Niger) | | | temp. >40°C; <200 mm rain | *kob,* Red-fronted Gazelle *Eudorcas rufifrons* | |
| *A. j. jubatus* | | | | | |
| Angola, Botswana, Mozambique, Namibia, South Africa, Zambia, Zimbabwe | 190–310 (S Africa)[3], 1,600 (Namibia)[4], 668 (Botswana)[5] | 4200 | Savannas, woodlands, semi-deserts, deserts; varied temperatures and rainfall in different parts | Springbok *Antidorcas marsupialis,* Bushbuck *Tragelaphus* spp., Greater Kudu *Tragelaphus strepsiceros,* Gemsbok *Oryx gazella,* Reedbuck *Redunca* spp., Blesbok *Damaliscus pygargus* | Leopard, Lion, Brown Hyaena , Spotted Hyaena, African Wild Dogs |
| *A. j. raineyi* | | | | | |
| Kenya, Tanzania, Uganda | 700–800 males/ Serengeti[6] | 2500 | Savannas, woodlands, semi-deserts; moderate temperatures (15–30°C) and rainfall (≈ 1000 mm) | Grant's Gazelle *Nanger granti*, Thomson's Gazelle *Gazela thomsonii,* Impala *Aepyceros melampus,* Reedbuck, Waterbuck *Kobus ellipsiprymnus* | Leopard, Lion, Striped Hyaena, Spotted Hyaena, African Wild Dogs |
| *A. j. soemmeringii* | | | | | |
| Ethiopia, Djibouti, Somali, Somaliland, South Sudan | ? | 1170 | (Semi) deserts, hot summers, day temp. >40°C; low rainfall <400 mm | Dorcas Gazelle, Grant's Gazelle, Bushbuck *Tragelaphus scriptus*, Waterbuck, Soemmerring's Gazelle *Nanger soemmerringii* | Leopard, Lion, Striped Hyaena, Spotted Hyaena, African Wild Dogs |
| *A. j. venaticus* | | | | | |
| Iran | 1.137 (coalition of two males/Bafq)[7] | <50 | (Semi) deserts, steppes, hot summers (day temp. >40°C), cold winters, <200 mm rain | Chinkara, Goitered Gazelle wild sheep, wild goat, wild pig *Sus scrofa* | Leopard, Striped Hyaena, Wolf |

[1]Durant et al. 2015, [2]Belbachir et al. 2015, [3]Broomhall et al. 2003, Marnewick & Cilliers 2006, Welch et al. 2015,[4]Marker et al. 2008a, [5]Houser et al. 2009, [6]Caro 1994, [7]Cheraghi et al. 2019

In Iran, a few regional studies have reported on the Asiatic Cheetah's diet, which includes Chinkara, Goitered Gazelle, wild sheep, wild goat, wild pig and livestock (sheep, goat and dromedary) as main prey items (Farhadinia & Hemami 2010, Farhadinia et al. 2012, Zahedian & Nezami 2019, Zamani et al. 2017). Except Farhadinia et al. (2012), these studies identified the Chinkara as the preferred prey of Cheetah. However, a recent study assessed the Cheetah's diet across its range using metabarcoding to identify both predator and prey species (Khalatbari et al. 2022). It found wild sheep, wild goat and Goitered Gazelle to be primary prey animals, but did not detect livestock; Chinkara were also not detected and Goitered gazelles were only detected in Miandasht Wildlife Refuge (WR). In hilly areas, wild sheep was the species found most frequently in the diet, even in rugged terrains, where wild goat was typically taken. The high level of wild sheep consumption in comparison to that of Goitered Gazelle suggests that human pressure on lowland habitats has decreased the population of Gazelles significantly, and has possibly forced Asiatic Cheetahs to occupy suboptimal habitats where Gazelles are less abundant. It is suggested that protection of flatlands and the removal of livestock are needed to ensure the long-term survival of Asiatic Cheetah (Khalatbari et al. 2022). The shift of the diet towards mountain species, which live in the hills and highlands, could bring the Cheetah closer to the Leopard, which could increase competition for prey and expose the Cheetah directly to a dominant co-predator (Cheraghi et al. 2019).

**Fig. 3.1**. Male Asiatic Cheetah, Kooshki, carrying a hare it hunted, in Miandasht WR. Photo: Fariborz Heydari.

# 4. Conservation of the Cheetah in Iran


**Chapter summary**

After the Cheetah had gone locally extinct in many parts of Asia, a population of about 200–400 individuals may have persisted in Iran in the 1970s (section 2.2, and Fig. 4.1). But the population had decreased significantly by 2001 (Fig. 4.2). In 2008, Cheetah presence had been confirmed in several additional areas (Fig. 4.3). However, despite a substantial increase in conservation efforts, the Cheetah's distribution range further contracted over the following years and the Cheetah has now disappeared from several PAs with previous confirmed records (Fig. 4.4). While no systematic study was conducted to identify the causes of local extinction, the expansion of the Yazd-Kerman highway, mining activities, and other activities near Kavir National Park may have played a role in these local extinctions (section 4.1). The population size was estimated to be "fewer than 50 individuals" in 2017, but recent camera trapping in 2021-2022 identified only 13 adult individuals, among which only three are reproducing females (Table 4.1). The main threats to the Cheetah in Iran are summarised in Table 4.2 and include direct killing of Cheetahs and their prey, road and railroad mortalities, nomadic grazing (conflicts with livestock, pressure on wild prey), and the lack of protection/law enforcement in several PAs. Habitat loss is expected to be exacerbated as climate change progresses (section 4.2). In Iran, the Cheetah was declared as an endangered and protected species in 1959, and the fines for capturing or killing of Cheetahs and their prey was augmented repeatedly over the past years (section 4.3.1). Cheetah habitats in Iran are protected under four different categories: national parks, wildlife refuges, protected areas and hunting prohibited areas (section 4.3.2, Fig. 4.5 and Table 4.3). To protect the Asiatic Cheetah, several conservation programmes and projects have been initiated, among which the Conservation of the Asiatic Cheetah Project (CACP; section 4.4.1) and projects funded by the Small Grant Programme (SGP) of the Global Environment Facility (GEF; section 4.4.2 and Appendix V) were the main ones that were implemented through collaboration between the United Nations Development Program (UNDP), the GEF and the Department of Environment of Iran (DoE). Additionally, several NGOs such as the Iranian Cheetah Society (ICS) and the Persian Wildlife Heritage Foundation (PWHF) carried out Cheetah conservation activities (section 4.4.3, Appendix VI and VII). The Asiatic Cheetah is a subspecies considered under CMS CAMI and is subject to species-specific measures in the CAMI Programme of Work (Appendix I). Beside other important conservation themes, such as the monitoring of Cheetahs and their prey, and protection of Cheetahs and prey from illegal killing, three conservation activities received special attention: livestock husbandry and sustainable rangeland management within the PAs, mitigation of losses of Cheetahs due to road mortality, and captive breeding of Cheetahs (section 4.5). Threats resulting from livestock grazing include competition over forage with wild herbivores, transmission of pathogens from livestock and herding dogs to wildlife, poaching and direct killing of wildlife by shepherds and herding dogs, and retaliatory or precautionary killing of Cheetahs (section 4.5.1). Consistent with this information, 50% of reported Cheetah mortalities in Iran between 2001 and 2012 were caused by the direct killing of Cheetahs by poachers or herders and their dogs. Moreover, overgrazing resulted from unsustainable use of rangelands can lead to desertification and degradation of rangelands. In Iran, areas with the highest livestock numbers within Cheetah habitats are Touran BR, Miandasht WR, and Khosh-Yeylagh WR (Figs. 4.9 and 4.10). Since 2000s, several efforts have been undertaken to reduce livestock pressure, which included limiting the annual number of (vaccinated) livestock and dogs entering Touran by the Livestock Control Committee (LCC), attempting to establish livestock-free zones within Touran BR through negotiations to buy-out grazing rights by the Cheetah Forever cam-

paign, DoE and ICS (Fig. 4.10), and restricting dromedary access to water sources (Fig. 4.13). In order to optimise allocation of the limited available funds, Cheetah habitat suitability was modelled to prioritise buyouts of grazing rights according to their impact on Cheetah survival (Fig. 4.14). The removal of livestock from core Cheetah habitat remains an urgent priority to support the recovery of the Cheetah population. However, the issue has not (yet) been resolved due to a lack of financial resources and complicated legal and administrative processes. A holistic approach, which considers the benefits and constraints of all stakeholders, can provide a flexible and practical framework that can be adapted to dynamic local socio-ecological contexts and provide the long-term solution for this issue (section 4.5.1). Between 2004 and 2016, approximately 30% (i.e., 14 Cheetahs) of reported Cheetah mortality resulted from collisions with vehicles. These losses are affecting Cheetah movements between different subpopulations. Based on studies predicting collision hotspots, and locations of corridor habitats, optimal locations for wildlife warning signs on roads have been proposed (Figs. 4.13B, 4.14 and 4.15). Additionally, it has been proposed (and in some cases implemented) to reduce the maximum speed on roads passing within and between PAs. Both sides of parts of one of the roads with highest reports of Cheetah mortality over recent years have been protected by fences that funnel Cheetahs to large culverts passing under the road, but this was not enough to stop road mortality. Captive breeding as an additional rescue strategy was discussed for a long time. A specific conservation breeding plan was not included in the action plans of CACP I and II due to concerns about the potential impacts of the removal of Cheetahs for breeding purposes on the remaining wild population. In the action plan of CACP III, it was recommended to restrict captive breeding to animals that are “rescued, injured, or orphaned”, but respective trials were not successful. Currently, there are three confiscated Cheetahs (two females and one male) and one deliberately captured male in captive facilities in Touran PA (section 4.5.3). The deliberately captured male and one confiscated female mated in January 2022, and on 1 May 2022 three male cubs were born by caesarian section (Fig. 4.18). After their birth, the mother did not accept her cubs and they were hand-reared. Two of the cubs died soon after the birth; the third one survived so far (October 2022), although with some health problems (section 4.5.3). Further conservation challenges are management of water resources, conservation of prey, conservation of habitat corridors, and mitigating the impact of expansion of mine excavation (section 4.6). Management of water sources was among the foremost implemented conservation activities by the DoE and NGOs in Cheetah PAs during the past five years, compared to other conservation activities (section 4.6.1). Wild goat, Goitered Gazelle, Chinkara, and two species of wild sheep are among the primary prey of the Cheetah. The populations of these five ungulate species have been declining both in number and range over the past century, due to overhunting/poaching, habitat degradation including droughts, competition with livestock and transmission of pathogens from livestock to ungulates (Appendix VIII). Moreover, spreading diseases such as Peste des petits ruminants (PPR) has impacted significantly the populations of wild sheep and wild goat. Climate change is predicted to pose additional pressure on the population of these herbivores (section 4.6.2). Long-term survival of Cheetahs is only possible by providing secure landscape inside and outside of PAs. Therefore, conservation of habitat corridors and stepping-stones is of utmost importance. Several stepping-stones were identified between the current network of PAs (Fig.4.19), which are in need for proper conservation (section 4.6.3). Mine excavation is mentioned as one of the most important threats to the survival of Cheetah, especially in the Southern habitats, but the effects of mines on Cheetahs’ survival, habitat and prey abundance have not been systematically observed (section 4.6.4).

## 4.1. Distribution and abundance of the Asiatic Cheetah

In the 1970s, when Cheetahs had already gone locally extinct in many parts of Asia (section 2.2), a population of Cheetahs was still living in Iran, and was distributed across considerable parts of the country (Fig. 4.1; Farhadinia et al. 2017 and references therein).

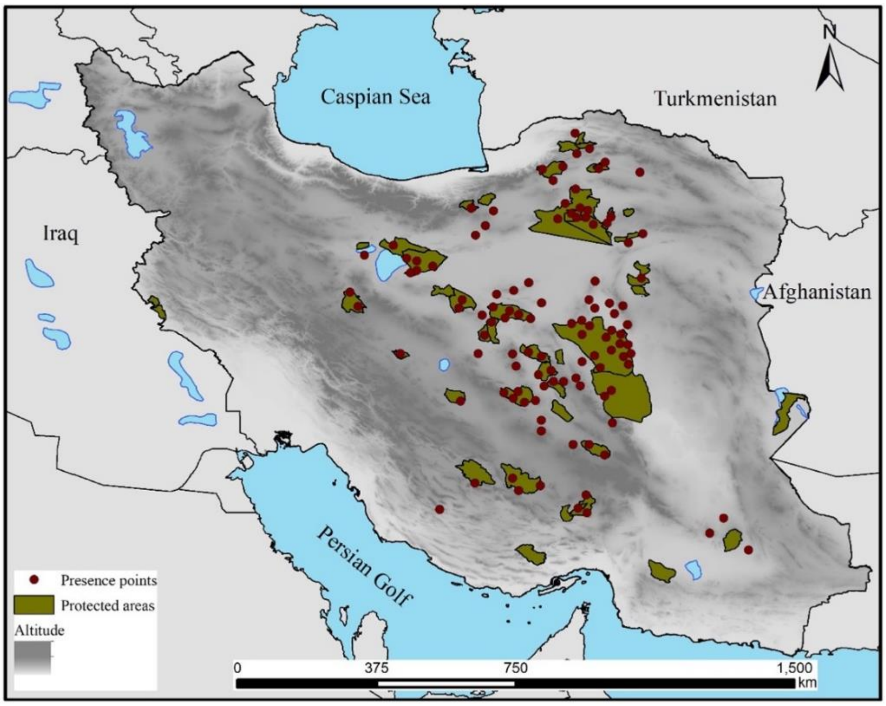


**Fig. 4.1.** Reconstructed distribution of Cheetah in Iran in the 1970s. Red dots indicate confirmed records of Cheetahs, and polygons represent present-day PAs, where Cheetah presence was confirmed in 1970s. Adapted from Farhadinia et al. (2017).

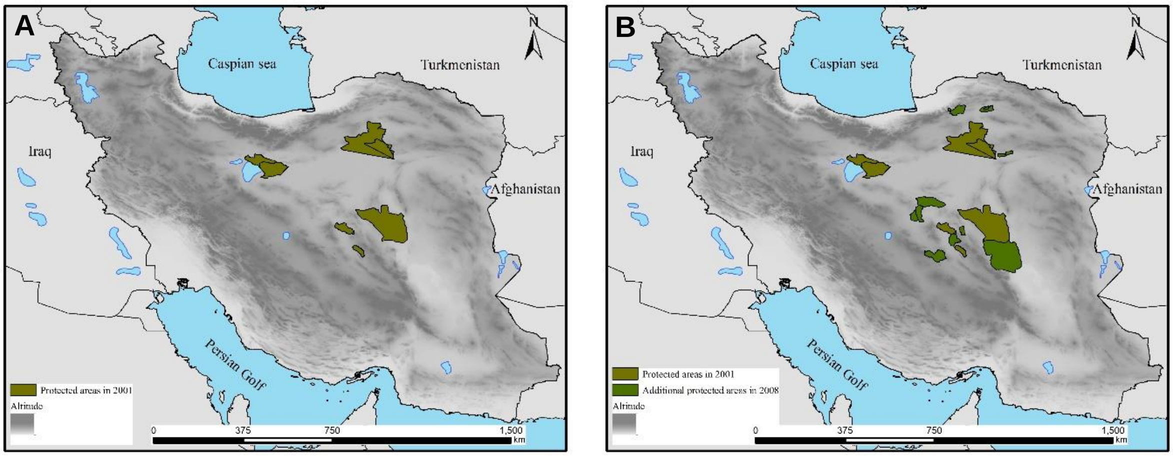


**Fig. 4.2.** A: PAs with confirmed presence of Cheetahs in 2001. Adapted from CACP (2008); B: PAs with confirmed presence of Cheetahs in 2008 (additional PAs appear in dark green). Adapted from CACP (2008).

As was explained in section 2.2, the populations of Gazelles and Cheetahs decreased significantly after the Iranian Revolution and the war with Iraq to the extent of being considered extinct in some areas (H. Ziaie, pers. comm.). In 2001, Cheetahs were confirmed in only five PAs (Fig. 4.2.A), but surveys might have been incomplete. In 2008 Cheetah presence was confirmed in additional areas (Fig. 4.2.B), primarily as a result of increased detection efforts (e.g., use of camera traps; CACP final report 2008).

Despite a substantial increase in conservation efforts after 2001, the distribution range of the Cheetah in Iran was perceived to contract after 2010. An assessment of the status of the species in 2017 found that Cheetahs had not been observed since 2014 in several PAs which had confirmed Cheetah records in 2008 (red areas in Fig. 4.3).

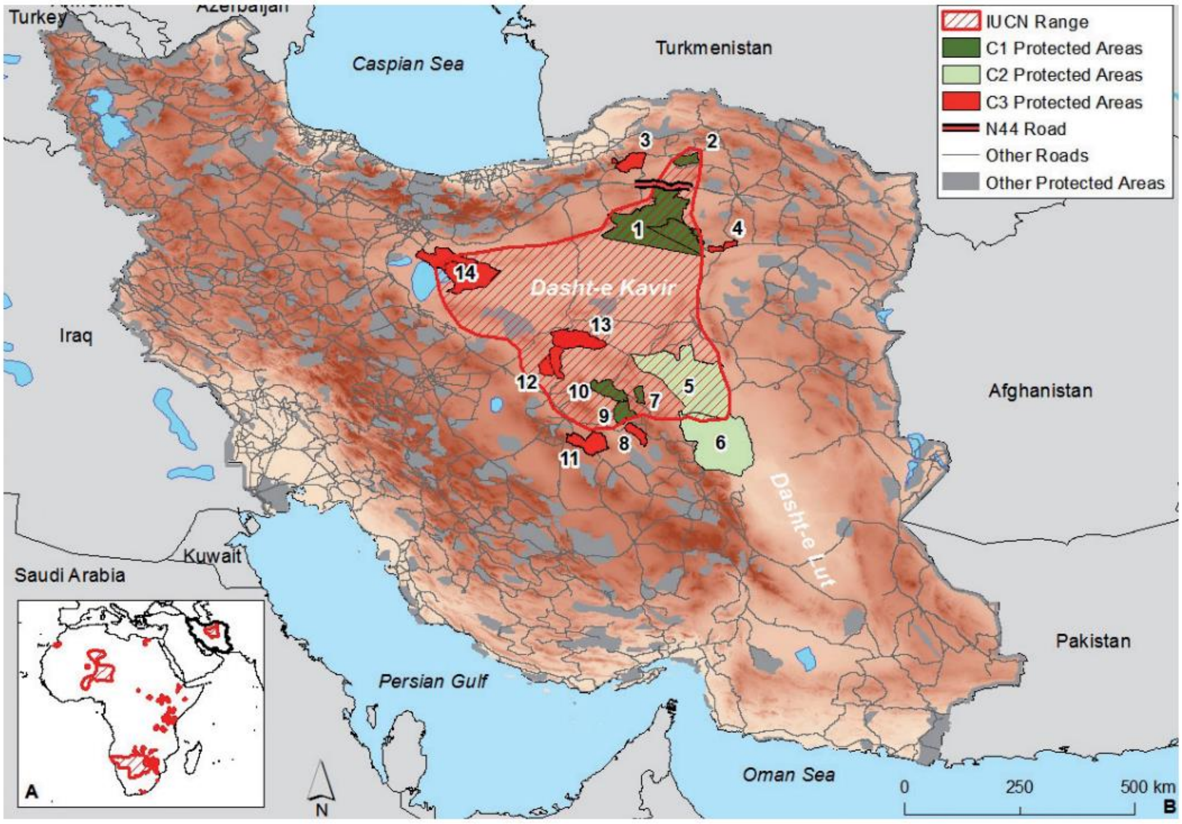


**Fig. 4.3.** Distribution of Cheetah in 2017. Coloured areas indicate PAs with Cheetah observations since 2001, dashed area indicates the range of the species adapted from the IUCN Red List (Durant et al. 2015). Areas with confirmed recent records (C1 PAs), with confirmed and unconfirmed records, but in need of additional sampling to assess population status (C2 PAs), and with no confirmed records after 2014 (C3 PAs) were identified. Northern subpopulation: 1) Touran BR; 2) Miandasht WR and Zamen e Ahoo NP; 3) Khosh Yeylagh WR; 4) Darooneh PA; Southern subpopulation: 5) Naybandan WR; 6) Darband e Ravar WR; 7) Kamki Bahabad Hunting Prohibited Area HPA; 8) Bafgh PA; 9) Ariz HPA; 10) Dareh Anjir WR; 11) Kalmand PA; 12) Siah Kooh NP & PA; and 13) Abbas Abad WR; Western sub-population: 14) Kavir NP & PA. Source: Khalatbari et al. 2017.

Several reasons have been proposed for this range contraction and likely population decline: the expansion of Yazd-Kerman Highway, was reported to have led to the extirpation of the Cheetah population in Kalmand PA (No 11 in Fig. 4.3; see also Table 4.3.), expansion of mining activities was reported to negatively affect habitat security and quality in Yazd Province, and expansion of military activities in the vicinity of Kavir National Park and PA (No 14 in Fig. 4.3.; Nezami 2017, Shams 2017, H. Zohrabi & L. Khalatbari, pers. comm.). However, no comprehensive investigations have been carried out to investigate the causes of range decline in each of these areas. Speculatively, increasing arid conditions, resulting from increased human use of water sources and climate change, may have also contributed to past and future declines. When projecting habitat suitability maps against environmental conditions, it was predicted that Cheetahs will lose an additional 22% of suitable habitats in the next century mainly due to the consequences of climate change (Fig. 4.4C; Khalatbari et al. 2018a).

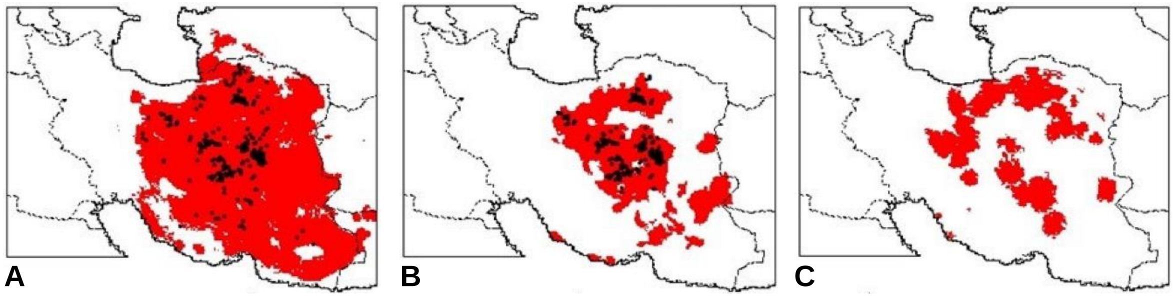


**Fig. 4.4.** Predicted suitable habitats for Asiatic Cheetahs (red polygons) in A: historical times (1966–1990), B: today and C: a projection to the future. The black dots indicate records of Cheetah occurrence in each time period. Source: Khalatbari et al. 2018a.

The size of the Cheetah population in Iran has never been comprehensively and rigorously estimated, owing to a lack of appropriate technology in the early days, vastness of the area to survey (>300,000 km$^2$), and a lack of resources. Nevertheless, indicators of presence point toward a dramatic decline of the Asiatic Cheetah during the past century. In the 1970s the population size was "guesstimated" to be 200–400 individuals, although some estimations of the population size were as low as 100 individuals (Farhadinia et al. 2017 and references therein). The already small population seemed to have experienced a further severe decline in the 1980s, to approximately 50–100 individuals in seven subpopulations (Asadi 1997). From the 1980s to 2017 different studies have reported different estimations of population size, without providing precision of the estimates (Table 4.1).

**Table 4.1.** Published estimations of Asiatic Cheetah population size from 1971 to 2022. Adapted from Farhadinia et al. (2017).

| Time | Estimated population size | Reference |
|---|---|---|
| 1930s | 400 | Harrington 1971 |
| 1970s | 200-300 | Firouz 1974 cited in Goodwin and Holloway 1974 |
| 1970s | 100 | Joslin 1984 |
| 1990s | 50–100 | Asadi 1997 |
| 1999 | >40 | Jourabchian 1999 |
| 2001 | >60 | Schaller and O'Brien 2001 |
| 2004 | 50–60 | Farhadinia 2004 |
| 2008 | 70–120 | Jourabchian and Farhadinia 2008 |
| 2008 | 60–100 | Jowkar et al. 2008a |
| 2008 | 70–100 | Ziaie 2008 |
| 2014 | <70 | Farhadinia et al. 2014 |
| 2016 | <40 | Farhadinia et al. 2016a |
| 2017 | <50 | Khalatbari et al. 2017 |
| 2022 | 12 (adult Cheetahs) | DoE 2022 unpublished data (France24 2022) |

In a recent study using molecular markers, Khalatbari (2021) confirmed 14 individuals (11 males and 3 females) from 138 Cheetah faecal samples collected in eight PAs in 2017. In early 2022 the DoE reported the results of camera-trapping surveys carried out mainly in Touran and PAs in Yazd province, during which no more than 12 adult Cheetahs were detected, of which only two were females (France24 2022).

The lack of robust population monitoring may have resulted in inaccurate estimations of the numbers of Cheetahs in the past. However, regardless of how steep the decline of the population in the past four decades may have been, Iranian Cheetah experts concur that in 2022 the remnant population is likely extremely low and probably on the brink of extinction.

## 4.2. Main threats to the Cheetah in Iran

Farhadinia et al. (2016a), analysed the cause of death for 47 records of Cheetah mortality between 2001 and 2016 and found that 21 of them were killed by livestock herders (and their dogs), 14 died due to vehicle collisions on roads and five were killed as a result of intentional poaching.

At a workshop in Tehran in 2017, recognised Asiatic Cheetah experts from Iran and abroad, CACP staff, and DoE experts identified the main threats to the survival of the Asiatic Cheetah. Threats were identified for each subpopulation based on field assessments and experts' opinions, and were listed following the IUCN Threats Classification Scheme (Version 3.2) (IUCN 2012); codes are presented in the final column when available (Khalatbari et al. 2017; Table 4.2).

**Table 4.2.** Overview of threats and their respective IUCN Threats Classification Code per region.

| Region | Threats | IUCN Code |
|---|---|---|
| Northern habitats | Nomadic livestock grazing | 2.3 |
| | Roads and railroads | 4.1 |
| | Direct killing of Cheetahs and their prey | 5.1.1 & 5.1.2. resp. |
| Southern habitats | Disturbance, increased intrusion and associated poaching linked to mining and quarrying | 3.2 |
| | Lack of protection in large PAs | |
| | Small size of several Pas | |

Climate change is increasing the frequency and severity of extreme weather events, including droughts and prolonged periods of high temperature (IUCN code 11.2 and 11.3), resulting in poor habitat quality for Cheetahs and their prey, and increasing the risk of mortality and conflicts with humans.

### *4.2.1. Illegal trade of Cheetah in Asia*

There has been suspicion, but no confirmed report, of Cheetahs captured in the wild and smuggled from or to Iran. In the case of recently confiscated individuals (see section 4.5.3), the person who captured male 'Kooshki', "had no plan in mind when he ran down the cub except that he thought it was valuable" (Jowkar et al. 2008b). However, female 'Iran' was taken from the wild with the intention to trade it (Mehrnews 25.12.2017). In 2021, there was also a report of a Cheetah cub in the south of Iran being kept in a private place, but it was not clear if it was smuggled into Iran (African subspecies), or if it was taken from Iran (L. Khalatbari pers. comm.). Genetic analyses have shown that none of the known captive Cheetah holders in the Middle East held Cheetahs from Iran (S. McKeown, pers. comm.). Yet, over the past 20 years, there have been rumours of wild-born Cheetah cubs confiscated from people trying to smuggle them out of Iran, usually linked to other forms of illegal trade (S. McKeown, pers. comm.).

In Arabian countries, there are many private Cheetah holders. Most of these Cheetahs are smuggled from the Horn of Africa or adjacent areas. It is estimated that annually, approximately 300 Cheetahs are reported to be smuggled out of this region and trafficked as pets for private collections in the Middle East. This trade poses a serious threat for Cheetahs in Eastern Africa (Tricorache & Stiles 2021).

### 4.3. Legislation and designation of protected areas for Cheetah conservation

#### *4.3.1. Wildlife protection legislation*

In Iran, wildlife conservation started with the establishment of the Game Council of Iran in 1956. Its first activities to control and regulate hunting in Iran included campaigning for the issue of hunting and fishing licenses, and campaigning for the recognition of appropriate open seasons. Later, the Council decided to allocate the limited conservation resources to areas of special ecological importance, which were the first PAs in the country. The Game and Fish Department was established by act of Parliament in 1967. In 1971 the Game and Fish Department was incorporated into the Environmental Conservation Department, which itself became the Department of the Environment (DoE) in 1974 after the Environmental Protection and Enhancement Act was passed. This law is still in effect. The Game Council designated the Cheetah as endangered and recognised it as a protected species in 1959 (Firouz 2005). The first law for regulating hunting and fishing was passed in 1967, in which several herbivore (including Cheetah prey species) and carnivore species were recognised as protected. This law was revised in 1996. The fine for capturing or killing Cheetahs increased from IRR 20,000,000 to IRR 200,000,000 by 2009 (from about USD 2,010 to about USD 20,100; Breitenmoser et al. 2009). In 2014, as a result of DoE-CACP recommendations, it increased again to IRR 250,000,000 and to IRR 1,000,000.000 in 2015 (then about USD 25,000; Durant et al. 2015). In 2019 the fine for killing a Cheetah was doubled to IRR 2,000,000,000 (about USD 14,800), the highest fine ever set for any wildlife species in Iran.

Although this huge fine, which often exceeds the annual income of a livestock keeper, was intended to prevent the killing of individual Cheetahs, it remained relatively ineffective, because of a lack of law enforcement, or lenient court judgements (ISNA 2019).

The fine for illegally hunted wild sheep, wild goat, Goitered Gazelle and Chinkara was increased from IRR 100,000,000 to 200,000,000 IRR (from about USD 370 to USD 740) in 2020.

#### *4.3.2. Delineation of PAs and ranger system*

A good share of the identified Cheetah distribution range in central Iran is nowadays protected in a network of national parks (IUCN category II), wildlife refuges (IUCN category IV), protected areas (IUCN category V), and hunting prohibited areas (HPA), all managed by the government, and a few private reserves (Fig. 4.5, Table 4.3). The definition and regulations of PAs in Iran do not follow strictly IUCN categories, for detailed explanation of each category see the atlas of the protected areas of Iran (Darvish Sefat 2006).

NPs have the highest level of protection. Grazing of livestock is generally banned, permission is needed to visit the area, and any destructive activity, such as the development of roads and extractive industries, is prohibited. In case of conflict between the DoE and developers, the Presidential Office ultimately decides. One fifth of each WR and PA is mandatorily designated as a core or safe zone. Within WRs and PAs, grazing livestock, rural and nomadic settlements and farming are prohibited in the designated core/safe zones. In all other protected lands traditional grazing and settlements are allowed, but changing land use is forbidden and developing extractive activities needs approval from the DoE. In HPAs, which are usually listed for 3 to 5 years and then upgraded to either a PA or a WR, all activities are permitted except hunting.

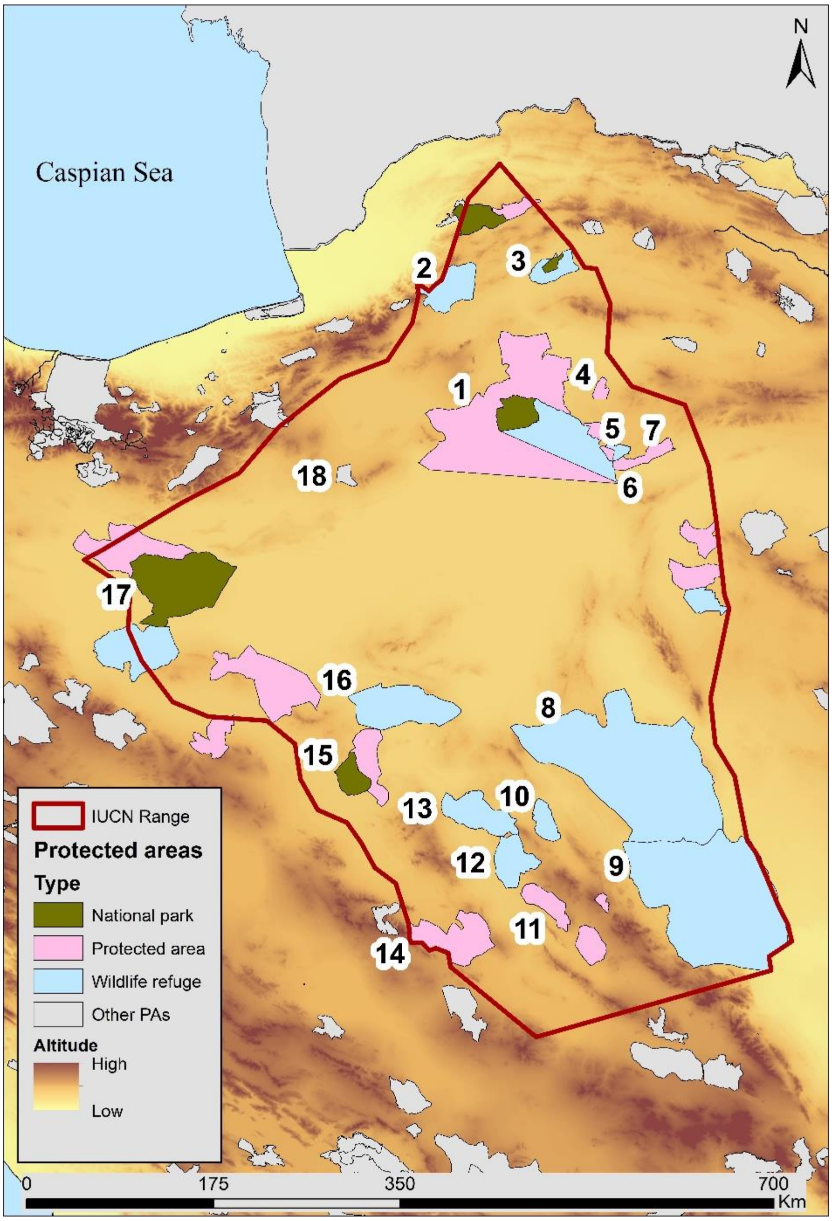


**Fig. 4.5.** PAs by category within Cheetah range in Central Iran (details in Table 4.2 and Appendix III; the red line represents the range of the Cheetah in Iran adapted from IUCN Red List (Durant et al. 2022b).

**Table 4.3.** PAs within the Cheetah range in Iran. The codes correspond to those in Fig.4.5. For more details on estimated number of herbivores and livestock, and competitor species, see Appendix III). Sources: 1) DoE unpublished reports, 2) Khalatbari *et al.* 2017, 3) DoE provincial offices reports, 4) Khalatbari *et al.* 2022; types of evidence: C1) camera trap photos, C2) direct observation, C3) signs, C4) reports from local people.

| Code | Name of PA | Category | Size (ha) | No. of Rangers | Most recent Cheetah observation (reference, type) |
|---|---|---|---|---|---|
| 1 | Touran BR | PA, WR, NP | 1,464,992 | 32 | 2022 (1,C1) |
| 2 | Khosh Yeylagh | WR | 150,050 | 13 | 2013 (2, C2) |
| 3 | Miandasht | WR, NP | 84,500 | 9 | 2022 (3, C2) |
| 4 | Parvand | PA | 17,000 | NA | - |
| 5 | Dasht - Laghari | WR | 26,213 | 0 | - |

| Code | Name of PA | Category | Size (ha) | No. of Rangers | Most recent Cheetah observation (reference, type) |
|---|---|---|---|---|---|
| 6 | Darooneh | PA | 71,698 | 3 | - |
| 7 | Sirkhoon & Khaf | HPA, PA | 54,382 | NA | - |
| 8 | Naybandan | WR | 1,517,000 | 5 | 2021 (3, C2& C4) |
| 9 | Darband-e Ravar | WR | 1,368,596 | 5 | 2021 (3, C3 & C4) |
| 10 | Kamki | WR | 65,000 | 3 | 2021 |
| 11 | Bafq | PA | 88,500 | 2 | 2017 (4, C3) |
| 12 | Ariz | WR | 131,340 | 2 | 2021 (1, C2?) |
| 13 | Dare Anjir | WR | 175,300 | 4 | 2022 (1, C2 & C3) |
| 14 | Kalmand | PA | 229,100 | 11 | 2011 (2, NA) |
| 15 | Siah kooh | NP | 200,000 | 4 | 2012 (2, NA) |
| 16 | Abbas Abad | WR | 305,855 | 6 | 2010 (2, NA) |
| 17 | Kavir | PA, NP | 422,200 | 17 | 2013 (2, C1) |
| 18 | Chah Shirin | HPA | 68,280 | 0 | 2019 (1, C2) |

In 1976, PRs were defined and the regulations related to them were passed by the parliament in the "law on hunting and fishing". These reserves are essentially private conservancies and were defined as natural landscapes, such as forest, rangeland, mountain, dykes or bare lands, on which the rights for conservation, hunting, and fishing are delegated to a person or a group of persons for a certain duration. Designating PRs needs approval from both the DoE and the FRWMO. Since 2005 several local stakeholders (mainly groups of hunters), in response to the observed decline of wildlife in their traditional hunting areas, have started to protect these areas on their own, sometimes by forming NGOs, which resulted in increases of wildlife populations. Following recommendations and bylaws developed by the DoE/CACP, the High Council of Environment defined the duties and rights of the conservancy holders as well as approving five PRs in 2016 (M. Zohrabi, pers. comm.).

PA rangers are employed by the DoE. The number of rangers in each area in 2022 are given in Table 4.3. Rangers' shifts and patrolling procedures are organised by the chief ranger of a PA and vary between areas. Patrols include wildlife observation and intercepting illegal activities. Ranger observations are reported daily by means of logbooks, containing information on patrol routes, observations and controls. Routes are reported by landmarks and local geographical names, not by means of GPS tracking. Park managers occasionally cross-check patrol routes with the rangers or visit with them (Ghoddousi et al. 2022).

### *4.3.3. Monitoring of wildlife in Iran*

Current population estimates of ungulates in Iran are mainly based on total counts, i.e., censuses (Buckland et al. 2015), and have focused on large herbivore species inhabiting open landscapes. They are routinely conducted by rangers within each PA (i.e., IUCN categories II, IV and V), including in no-hunting areas and unprotected areas that receive some level of law enforcement. These biannual counts are managed by the DoE (Egli 2014, Soofi et al. 2022) and conducted twice a year, depending on the geographical zone, usually in winter (November-December) and spring (May-June). During censuses, the PA is divided into distinct sampling routes (often focusing on areas where ungulates are abundant) of known areas that are surveyed by at least 2–3 experienced rangers. Surveys take approximately 1–4 days, depending on the size of the PA, logistics, and species (Egli 2014, Soofi et al. 2022). Numbers, sex and age groups of the observed animals are recorded on standard forms provided by the DoE (NUMP 2016).

As a consequence of the review by Egli (2014), the DoE commissioned the PWHF to conduct a scientific National Ungulates Monitoring Techniques Assessment Project (NUMP 2016), in order to improve the survey design, monitoring techniques and population size estimation across the country. The final report (NUMP 2016) provided a decision tool for wildlife managers/rangers to choose appropriate monitoring methods depending on different circumstances and conservation goals. These methods provide practical alternatives for the total-count approach used until now. The NUMP project has proposed several recommendations to improve monitoring, but may also reduce monitoring costs over the long run and so increase the effectiveness of population monitoring. The techniques have been presented to Iranian rangers and wildlife experts at a national workshop in 2016 (M. Soofi, pers. comm.), but have not yet been implemented.

Implementation of standardised monitoring techniques may require substantial investment in training, equipment and capacity development. The main barriers include a lack of equipment (e.g., range finders, GPS trackers, and vehicles), insufficiently trained rangers and experts for study design, data collection, management, analysis, and interpretation, and a lack of financial resources. Additionally, park managers and rangers lack awareness and understanding of the importance of standardised monitoring.

Monitoring data are currently recorded by rangers in logbooks without any geo-referencing. However, recent developments in wildlife monitoring provides digital tools with automatic geo-referencing, such as the Smart Monitoring and Reporting Tool (SMART; Hötte et al. 2016). Tools such as SMART improve the speed and accuracy of data collection, they allow real-time monitoring, and provide synthesised information that allows PA managers to plan, distribute, and adjust patrols more efficiently, and hence increase the efficacy of law enforcement.

A pilot project for using SMART was carried out in Touran by CACP and PWHF. This included workshops to introduce the project to the regional DoE and training in the use of SMART for park managers and rangers. However, the system was never implemented in Cheetah PAs after the halt of CACP III. However, SMART was implemented as part of the management of Golestan National Park, and preliminary results show that wildlife monitoring has improved and demonstrate increasing trends in wildlife populations, alongside increasing motivation amongst rangers (M. Soofi pers. comm.).

### 4.4. Conservation programmes and projects

In 1997, Hormoz Asadi, an Iranian member of the IUCN SSC Cat Specialist Group, assessed the conservation status of Cheetahs in Iran. He concluded that there were between 50 and 100 Cheetahs living in seven subpopulations in the central plateau of Iran. Asadi's assessment identified habitat and prey base destruction, poaching, mining and livestock grazing as the main threats. The Iranian wildlife authorities were aware of these problems, but beyond legal protection, no specific measures for Cheetah conservation were implemented. This lack of implementation was partly due to a lack of (trained) staff and training opportunities, but also meagre resources and institutional shortcomings (Asadi 1997).

Following Asadi's review, late Peter Jackson, then Chair of the IUCN SSC Cat Specialist Group, visited Iran in 1998 to evaluate the situation of Cheetah and concluded that "*the Cheetah is in dire straits in Iran, but all is not lost. The Department of Environment (DoE), although its resources are meagre, has the organizational structure and is open to international aid. Determined efforts by all concerned can ensure future of this fascinating wild cat. As a charismatic large carnivore, dependent on a vast range and on flourishing gazelle and other wildlife populations, it can serve as the flagship for conservation in Iran*" (Jackson 1998).

This mission led in 2001 to the project "Conservation of the Asiatic Cheetah, its Natural Habitat and Associated Biota in the I.R. of Iran" (CACP), funded by the Global Environment Facility (GEF), implemented by the United Nations Development Programme (UNDP), and executed by the DoE with the technical support of national and international partners, including for the latter, the Wildlife Conservation Society (WCS), the Cheetah Conservation Fund (CCF), and the IUCN. CACP became the central programme for conservation of the Asiatic Cheetah. It prompted many other conservation efforts (e.g., the GEF SGPs, section 4.4.2) and provided mentorship and training to a young generation of motivated conservationists.

#### ***4.4.1. Conservation of the Asiatic Cheetah Project (CACP)***

*CACP I (2001–2008)*

CACP I was originally planned for four years, but was extended several times until early 2009 (Breitenmoser et al. 2009). The total budget was USD 1,457,600 (UNDP/GEF, USD 732,600; UNDP in-kind, USD 210,000; other international organisations, USD 522,600).

The goal was to secure the conservation of the Asiatic Cheetah (*A. j. venaticus*) and the related complex of rare and endangered wild species and their natural habitats in Iran with the support and collaboration of local communities. Concrete objectives (CACP final report 2008) included:

- Better understanding of crucial biotic territories for the Asiatic Cheetah and related species in Iran, and enhanced knowledge of Cheetah population dynamics, behaviour and survival factors;
- Improved management of the crucial biotic territories by governmental and non-governmental entities with relevant interests and concerns (stakeholders) in order to rehabilitate overgrazed habitat and ensure better protection for Cheetahs and their prey;
- Enhanced and sustained wellbeing of the human communities living within or in proximity of such natural habitats;
- Enhanced awareness and support of the government and civil society of the I.R. of Iran on relevant issues and concerns, in particular regarding the prevention of non-habitat-related threats to the Asiatic Cheetah (e.g., illegal hunting, and killing of Cheetah and related species) among most relevant groups (local semi-desert communities, nomadic herders, hunters, youths).

The main activities of the project are summarised below (CACP final report 2008, Breitenmoser et al. 2009):

- Research and monitoring: Creating data banks and baseline information through developing digital maps; extensive surveys and camera trapping for estimating Cheetah population size in the five CACP sites; developing new protocols for collecting systematic information from rangers, camera traps, etc.; organising several workshops on application of camera traps and radio-telemetry in wildlife research, use of anaesthetics on carnivores, GIS techniques, and use of sampling protocols in prey censuses; perform prey censuses to estimate the prey base of the Cheetah in the five project sites. Academic research (five BSc and six MSc students and 15 articles, including a radio-telemetry study of two male Cheetahs and one leopard) was performed in cooperation with the CACP, Iranian universities and international NGOs.

- Protection: Root-cause analysis for identification of threats and root causes in each of the five CACP sites; site protection and regulation through collaborating with other governmental organisations to control negative effects of extractions from mines, road development; upgrading PAs; development of conservation strategies and implementation of law enforcement; capacity development and infrastructure by educating and equipping rangers; surveillance for controlling illegal grazing and monitoring by rangers.
- Co-management: The NGO Cenesta was contracted to investigate the socio-economic situation of local communities in the vicinity of the CACP sites, including human population situation, main occupations, livestock husbandry, poachers, industries, mines, local awareness and attitude, etc. However, due to several disagreements Cenesta never concluded this project and the results were not made available. (Some GEF SGP projects took over parts of the activities, see below.)
- Awareness and education: Authorities, administration and experts through high-level advocacy to policymakers including sensitisation of the President of Iran, and including increasing penalty for illegally killing Cheetah; local people and stakeholder groups through workshops, seminars, publication of books, etc.; general public and media through producing news, documentaries, education material, and declaring 31 August as "Asiatic Cheetah Day".

The CACP generated awareness among DoE staff (including park administration and guards), among media representatives, and the Iranian public. The CACP has successfully promoted Cheetah conservation in Iran and that the project itself was considered positive and important. Further achievements have been as follows: (1) surveys of good Cheetah habitats (including the species distribution areas beyond the five CACP sites) and its most important prey have been carried out; (2) improved management (protection) of the remaining Cheetah areas started immediately as an emergency activity and was implemented successfully during the initial years of the project; (3) the creation of new PAs or upgrading of existing ones soon after the beginning of CACP; and (4) the hiring of 32 new guards according to a well-defined selection system, which granted a certain advantage to local candidates. These guards were educated in physical protection and survey techniques throughout several training workshops. These four measures halted the decline of the Cheetah population, at least temporarily. It was suggested that the Cheetah population may even have increased in these years, but neither the initial baseline information nor the subsequent population estimates were reliable enough to assess this assumption.

The terminal evaluation of CACP I (Breitenmoser et al. 2009) revealed that the four project outcomes had either partially or insufficiently been fulfilled. CACP I suffered from fast turnover of DoE and CACP senior managements, and imprecise definitions of methods and procedures to be applied. However, the Terminal Evaluation also concluded that the expectations/objectives had been too ambitious considering the available funding, capacity, and time. Nevertheless, CACP I established the Asiatic Cheetah as a symbol for wildlife conservation, not only in Iran, but also at the international level.

*CACP II (2009–2018)*

After discussing the conclusions of the terminal evaluation, the IUCN SSC Cat Specialist Group, with the support of the Swiss Federal Office for the Environment (FOEN), organised and facilitated in April 2010 an expert workshop in Gstaad, Switzerland, to develop the "Action plan 2010-2014 for the Conservation of the Asiatic Cheetah in I.R. Iran." for a second phase of the Cheetah conservation programme in Iran (i.e., CACP II). DoE, UNDP, national and international conservation organisations participated in its development (CACP 2010). Between 2010 and 2016, UNDP, PWHF, WCS and Dana Insurance (the latter enrolled through a 'win-win' partnership brokered by CACP manager) provided USD 905,906 of financial support for the implementation of this plan (Fig. 4.6).

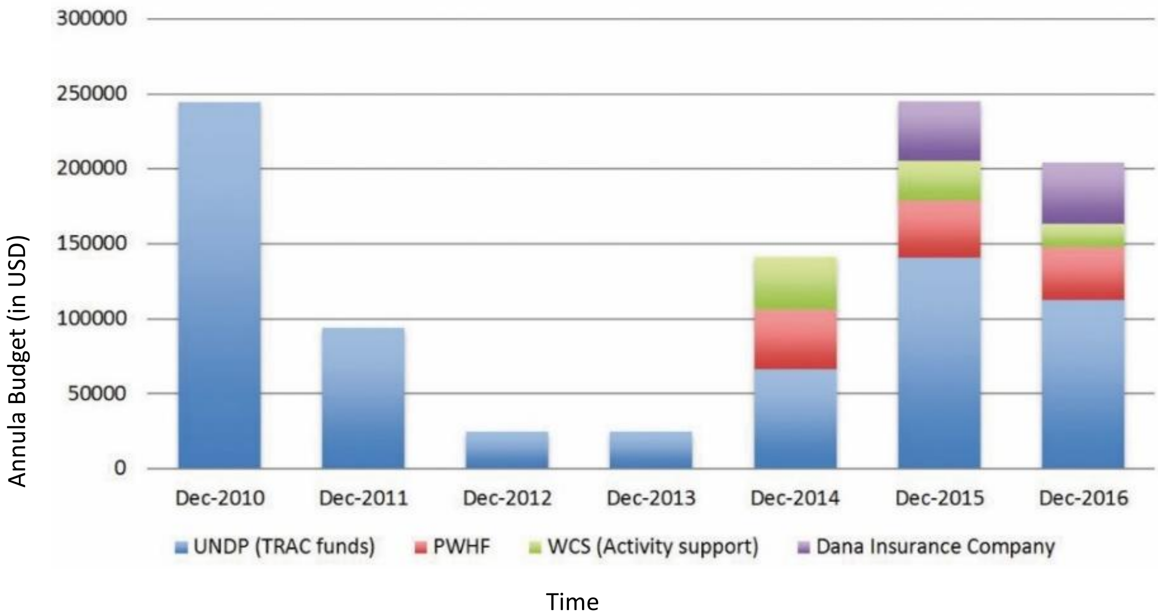


**Fig. 4.6.** Annual budgets (in USD) of CACP II 2010– 2016 and contributions of main donors. WCS staff costs between 2010 and 2016 are not included. Source: adapted from Ostrowski 2017, based on CACP data.

The Vision of the strategy and action plan for CACP II was to "*secure a viable and sustainable population of Asiatic Cheetah in Iran and possibly the historic range in adjacent countries*. The Goal of CACP II was that *The Cheetah population in the 10 priority areas is at least 100 individuals in 10 years, and at least 150 individuals in the entire central-Eastern Iranian population*"[3]. The related Objectives were (CACP 2010):

- To enhance the technical and scientific capacity and the motivation of the DoE and relevant partners;
- To convey accurate information and recommendations to relevant audiences to influence policy in support of Cheetah conservation;
- To effectively control threats and manage the Cheetah, its habitat and associated fauna;

[3] This vision was based on an uncertain estimate of the population. Therefore, as an alternative Goal, the same relative increase was expected if the present estimate of 50–75 individuals in the 10 priority areas would turn out to be wrong. Looking back, it is likely that the estimate then was too optimistic.

- To effectively apply existing laws by all departments and stakeholders in order to preserve habitat for both wildlife and livestock.

Main activities of the project according to Ostrowski (2017) and Nezami (2017) were:

- *Assessing Cheetah and prey population status and other studies*: Camera trapping to estimate population size; improving and updating the database of identified individuals; evaluating reasons of population decline in Southern habitats; evaluating habitat suitability of the Cheetah across the country and identifying habitat corridors; assessing genetic status of Asiatic Cheetahs; several training workshops, e.g., on the application of GPS radio telemetry, wildlife capture and tranquilisation; collaborating with the wildlife office of DoE for initiating a captive breeding programme.
- *Increasing physical protection*: Hiring 10 rangers, buying new 4WD vehicles and motorcycles, upgrading several protected areas, improving survey and anti-poaching equipment; constant monitoring of protected areas using new documentation system; identifying hotspots of vehicle collisions in Touran BR and installing 60 road warning signs, and fencing part of the Semnan-Mashhad Road.
- *Increasing rangers' education, motivation and conditions*: Providing new equipment; collaborating with an insurance company (Dana Insurance Company) for providing additional insurance for rangers, their families and ranger stations; providing medical care to rangers in protected areas used by Cheetahs through the insurance company; securing rangers' annual contracts; incentivising rangers and increasing their motivation through honorary and cash awards for outstanding professional performance; giving updates and feedback of the activities to provincial DoE offices and rangers; and holding several workshops to increase rangers' and managers' knowledge, including on wildlife monitoring and health.
- *Improving habitat quality*: Negotiating solutions to administrative issues for reducing livestock conflicts in Touran, and controlling and reducing livestock overgrazing in Miandasht (section 4.5.1); re-establishing Livestock Control Committee; collaborating with *Cheetah Forever Campaign* to buy some of the grazing rights in Touran (section 4.5.1); improving water sources.
- *Increasing awareness*: Collaborating in the production of several short documentaries and awareness-raising films, including one with National Geographic; including a paragraph on the Cheetah in some national textbooks for schools; publishing several handbooks for rangers, including information on Cheetahs and their prey; camera trapping, ranger activity documentation, etc.; publishing a series of books about Cheetah habitats; publishing a book on the Ecology and status of the Asiatic Cheetah (Nezami 2017); publishing the first book on wildlife diseases in Iran for practitioners and biologists (Memarian 2017); facilitating the agreement between Iran and FIFA to authorise the use of a Cheetah image on the Iran national football team T-shirt (Fig. 4.7);


**Fig. 4.7.** Iranian national football team shirts displaying a Cheetah. Source: Radio Varzesh 2018

- *Engaging local communities in conservation and reducing conflicts*: Supporting local NGOs with small funds from (Cheetah Small Grant Program); involving local communities in monitoring surveys; raising funds from private donors for conservation activities (e.g., building water sources and ranger stations, and buying forage); defining tourist carrying capacity in Ghala-Bala village; collaborating with *Dana Insurance Company* to pay compensation to herders in case of livestock losses due to Cheetah attacks.
- *Influencing and improving conservation policy*: Facilitating the establishment of private reserves to protect habitat corridors; proposals for improving management of some protected areas; collaborating with development plans to reduce their impact (roads, mines, etc.); proposing changes in national land use plans to increase protection of Cheetahs; creating models for participatory tourism in Eskambilo area of Saghand and Bararig of Bafq; creating models for sustainable productions of Private Reserves in Kallot Sorkh-Abi, Mehriz; conducting socio-economic surveys in Touran BR; facilitating tourism-based activities in villages around Touran.
- *Fund raising*: Collaborating with *Dana Insurance Company* to fund a Cheetah conservation fund (administered by UNDP) endowed with insurance indemnities for each Cheetah accidentally killed (e.g., roadkill); engaging with national and international possible donors.

In 2017, CACP activities were evaluated by Dr Stephane Ostrowski from WCS, who found that by 2016 it had reached a degree of achievement for 63% of the activities proposed in the 2010–2016 Action Plan. The objectives related to capacity building, protection and law enforcement could be considered reached, whereas those linked to policy, economics, monitoring and land use planning showed less progress. Similar to CACP I, change of managers at CACP and the DoE during the time of CACP II resulted in inconsistency of activities. International economic sanctions against Iran resulted in considerable difficulties in channelling funds and, as a result of monetary inflation, increased conservation costs (e.g., equipment, fuel). Other problems included the weak responsiveness of administrations, and a lack of collaboration between national partners with regard to the implementation of a rather complex Action Plan (Ostrowski 2017).

CACP II did not succeed in saving Asiatic Cheetahs from further decline due to several shortcomings, and hence did not achieve its overall Goal. Nevertheless, the activities of CACP secured the persistence of the remaining population of Cheetahs.

*CACP III (2019–2024)*

After several meetings in Tehran in 2016-2017 with Cheetah conservation actors, during which the status of the Cheetah and the performance of CACP were reviewed (Breitenmoser et al. 2009, Eslami et al. 2017, Khalatbari et al. 2017, Ostrowski 2017), the process of developing an action plan for the third phase of CACP (i.e. CACP III) was initiated by the IUCN SSC Cat Specialist Group, with the aim to protect and increase the population of Asiatic Cheetahs throughout the species' range and to increase multi-institutional cooperation relevant for the conservation of Cheetah habitat. Unfortunately, due to political circumstances the process could not be moved forward with IUCN SSC Cat Specialist Group and long-standing international organisation partners. Thankfully, an action plan for the period 2019 – 2024 could still be developed by CACP staff with the participation of DoE experts in 2018, which delineated four core components:

- *Component 1*: Enhanced management and monitoring of Cheetah populations and their prey in natural habitats and corridors as well as through *ex situ* conservation;
- *Component 2*: Strengthened engagement of local communities in Cheetah conservation through community empowerment, awareness raising, and promotion and adoption of sustainable livelihood models;
- *Component 3*: Enhanced multi-stakeholder coordination and management to mainstream Cheetah conservation in development activities and up-scale the results of the project;
- *Component 4*: Effective project management.

As the review of CACP II concluded that without a considerable increase of activities, capacity, and hence funding, the conservation of Cheetah in Iran would be unsuccessful (Ostrowski 2017), CACP III had a forecasted budget of USD 3,976,000 over five years, of which USD 200,000 would come from UNDP TRAC and USD 350,000 from the DoE, with 86% of the budget remaining to be fundraised. A major Asiatic Cheetah conference in Tehran scheduled in December 2018, to which international institutional donors were to attend, failed to happen because of political circumstances beyond project stakeholders' control. An agreement between the DoE and UNDP on UNDP's contribution was signed, yet political circumstances deterred any potential large international donor to invest in the project (UNDP 2019). This situation was pivotal in derailing the positive momentum of Asiatic Cheetah conservation initiated two decades ago.

CACP III was indeed minimally funded. Some "soft" actions were implemented, according to the Action Plan (Nezami 2020), including:

- Preparing an emergency action plan for the conservation of the Asiatic Cheetah (Farhadinia 2019);
- Assessing and studying threats to the Cheetah and its prey species through participatory methods in four priority areas (Touran, Naybandan, Ravar and Miandasht);
- Advising private reserve holders on protecting Cheetah corridors;
- Preparing guidelines for the DoE for a herbivore census;
- Assessing needs for conservation equipment in Cheetah protected areas;
- Education workshops for rangers in Yazd and Semnan provinces;
- Educating managers of Cheetah habitat and running workshops for aligning conservation activities;

- Studying and identifying conflicts between wildlife and local communities in selected Cheetah habitats through participatory methods (Abangah Consulting Engineer Company. 2019a);
- Baseline socio-economic study and defining effective groups for developing foundations of participation of local communities in conservation of Miandasht (Abangah Consulting Engineer Company. 2019b);
- Several meetings and visiting protected areas.

Owing to the lack of national funding, limited capacity remaining available in country, and lack of visibility and safety for international collaborators to engage, CACP III closed in December 2019, less than one year after its start (Nezami 2020).

*Continuing and future plans*

The emergency action plan for the conservation of Asiatic Cheetah, prepared under CACP III, proposed that conservation of Cheetah in Iran should follow two approaches simultaneously: (1) conservation of the Cheetah in natural habitats to overcome direct threats to Cheetahs, including herders (livestock), roads and poachers; (2) active intervention through semi-captive breeding to create a back-up population (Farhadinia 2019).

More recently the DoE developed a plan for “Conservation and recovery of the Asiatic Cheetah in Iran”, to continue the conservation efforts for the Cheetah. The timing and budget of this plan are not defined but it comprises 18 activities regrouped in four outcomes (See Appendix. IV for the actions, H. Akbari pers. comm.).

*Outcome 1*: Cheetah prey populations in Cheetah habitats and neighbouring areas are reinforced.
*Outcome 2*: Quality and suitability of Cheetah habitats are increased.
*Outcome 3*: Education and research are improved and conflicts reduced.
*Outcome 4*: A population of captive Cheetahs is created through captive and semi-captive breeding programmes.

### ***4.4.2. Small Grant Programme projects***

CACP established the Asiatic Cheetah as the outstanding flagship species for wildlife conservation in Iran and motivated many Iranian scientists to engage more proactively in wildlife conservation. Several conservation NGOs were founded (see also section 4.4.3), namely the Iranian Cheetah Society (ICS, 2001; see below), Eco-Researchers (2005), Plan for the Land (2005) and Mohitban Society (2005) to support the CACP with specific projects through the GEF Small Grant Programme (SGP) in the years 2003–2009 (Appendix V).

As a first step, a project was launched for teaching participatory approaches and techniques to members of three existing target national NGOs, selected community members, local NGOs and important stakeholders. Two of these NGOs, the ICS and Eco-Researchers, were provided with grants for projects to start their activities in Touran and Bafq. Their main activities were to raise awareness with local communities and to teach classes about wildlife, its conservation and the value of biodiversity, with emphasis on Cheetah conservation in schools. Two additional projects with a similar scope of work in Touran and Naybandan were granted to Plan for the Land and Mohitban Society NGOs. An important outcome was to facilitate the formation of NGOs or Community Based Organizations (CBOs) associated with activities related to Cheetah conservation in local communities. Members of these NGOs and CBOs were local women, aiming to raise funds by producing and selling handicraft products, and local men to sell their farming, livestock or medical plant products. As these projects were successful, two similar projects were granted to ICS and Eco-Researchers to facilitate the formation of local NGOs and CBOs. Two of these NGOs in turn managed to write a successful proposal and win a small grant from SGP to continue their activities (No. 9 and 10 in Appendix V).

Target communities, numbers of students, formed NGOs, villages and cities covered by activities, duration of project and social characteristics of target societies all varied between these projects.

It is difficult to compare and evaluate the impact of these SGP projects on Cheetah conservation and how successful and sustainable they were, as the themes, approaches, people and institutions involved, etc., differed vastly, the projects often lacked proper monitoring and evaluation, and more importantly there was no baseline information and long-term evaluation available. It would be interesting to re-visit the SGPs to understand if they had a lasting effect on Cheetah conservation in local communities. At the time of their implementation, they were an important start for involving local communities in conservation (e.g., Breitenmoser et al. 2009). Villages around Touran BR are now among the pioneer communities with regard to development of eco-tourism as an alternative livelihood to livestock grazing in the vicinity of Touran.

### *4.4.3. Involvement of national Non-Governmental Organisations (NGOs)*

Non-governmental organisations (NGOs) have supported the conservation of Cheetahs, their prey and habitats and have engaged with local people in awareness raising and education actions throughout the years when CACP was active. Several NGOs were established with the intention of contributing to Cheetah conservation (see section 4.4.2 and Appendix V).

*Iranian Cheetah Society (ICS)*

The Iranian Cheetah Society (ICS) is a non-governmental, non-profit organisation established in 2001. ICS was one of the first national NGOs to start working on the Asiatic Cheetah and has been working on a broad variety of topics related to Cheetah conservation, often in direct cooperation with the DoE and as CACP contractee. ICS's main achievements regarding the conservation of Cheetahs are listed in Appendix VI.

*Persian Wildlife Heritage Foundation (PWHF)*

The Persian Wildlife Heritage Foundation (PWHF) started a collaboration with the DoE/CACP in 2012. Between 2013 and 2016, in addition to their own *in situ* activities, they funded USD 100,000 of Cheetah conservation actions, implemented by CACP/DoE. PWHF's main achievements regarding the conservation of Cheetahs are listed in Appendix VII.

### *4.4.4. Activities under the Central Asian Mammals Initiative (CAMI) of the Convention of Migratory Species (CMS)*

The Asiatic Cheetah is included in the Central Asian Mammals Initiative (CAMI) of the Convention on Migratory Species (CMS) and is a subject of "species-specific measures" in the Programme of Work (POW) 2021−2026 for CAMI (annexed to Resolution 11.24 (Rev.COP13)). The CAMI POW contains many cross-cutting issues for all wildlife species considered under the CAMI, including the Cheetah (e.g., activities proposed related to fund raising). The Cheetah-specific items of the CAMI POW are listed in Appendix I.

## 4.5. Specific conservation challenges

In addition to implementing science and monitoring activities, to better understand the status of Cheetahs and their prey, increasing the effectiveness of their protection, and raising awareness among local people and the general public about their importance in Iran, three conservation activities have received special attention; management and control of livestock within protected areas to support functional rangeland and reduce competition with wild ungulates, identification of roadkill hotspots and development of mitigation measures, and the development of captive breeding of Cheetahs.

### *4.5.1. Conservation challenges related to livestock*

Livestock grazing is one of the most wide-spread types of land use that occurs even in many protected areas, and because of unsustainable increase and management, livestock has become a threat to wildlife worldwide (Feng et al. 2021). Threats resulting from livestock include (1) competition for forage with wild herbivores (Schieltz & Rubenstein 2016), (2) transmission of pathogens from livestock to wildlife (Jäger et al. 1990, Marashi et al. 2017), (3) poaching of wildlife by shepherds, and (4) disturbance and direct killing of wildlife by guard dogs. In addition, predation of livestock by large carnivores often leads to retaliatory or precautionary killing of large carnivores (Broekhuis et al. 2017). As a result, half of the reported Cheetah mortalities in Iran between 2001 and 2012 were perceived as caused by direct killing by poachers or by herders and their dogs (Farhadinia et al. 2017). Moreover, overgrazing resulting from unsustainable use of rangelands can lead to their desertification and degradation. In arid habitats unsustainable livestock husbandry and overgrazing are more likely to contribute to irreversible desertification, which is likely to be exacerbated by climate change. In Iran, areas within the Cheetah's range with the highest numbers of sheep, goats (small livestock), and dromedaries, are Touran BR, Miandasht WR, and Khosh-Yeylagh WR (Fig. 4.8).

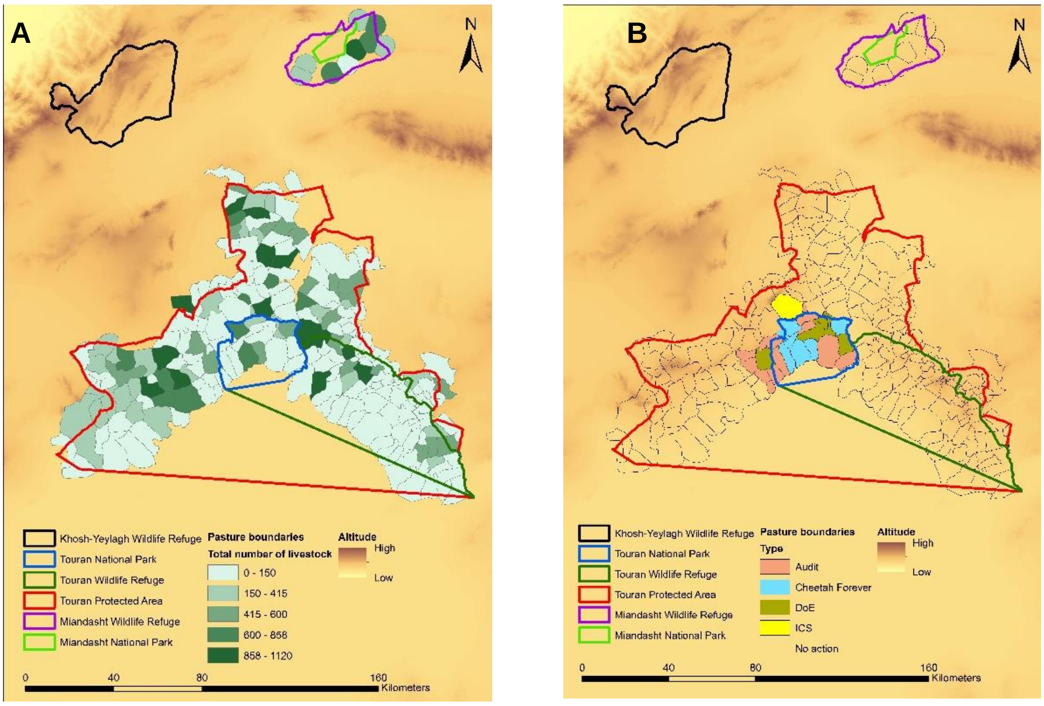


**Fig. 4.8.** Pasture's status in Touran BR and Miandasht WR. A: Pasture boundaries, darker colours show higher numbers of livestock. B: Pastures' status in Touran BR: Orange = pastures abandoned following an audit by the DoE in 2006; blue = bought out by the Cheetah Forever Campaign in 2017; olive = bought out by funds allocated by the DoE in 2017; yellow = bought out by ICS in 2021.

Livestock overgrazing in arid habitats is especially problematic as it may lead to lasting habitat deterioration and desertification (Fig. 4.9), with climate change exacerbating the problem. Furthermore, the growth of extensive livestock husbandry is often unsustainable, is not providing adequate livelihoods to local communities, increasing conflicts with their development and wellbeing, and cannot sustain the needs and lifestyle of modern Iran. Yet, livestock husbandry remains a component of many people's traditional livelihoods that includes inherited rights for using the lands for grazing. In the context of increasing numbers of livestock and resulting unsustainable use of rangeland, conservation conflicts –especially those concerning large carnivores– are then difficult to solve because there are underlying societal and economic problems, which are often not addressed properly or take a long time to settle. A holistic approach, which considers benefits and constraints of all stakeholders, could provide a flexible and practical framework that could be adapted to dynamic local socio-ecological contexts aslong-term solution for solving this issue.

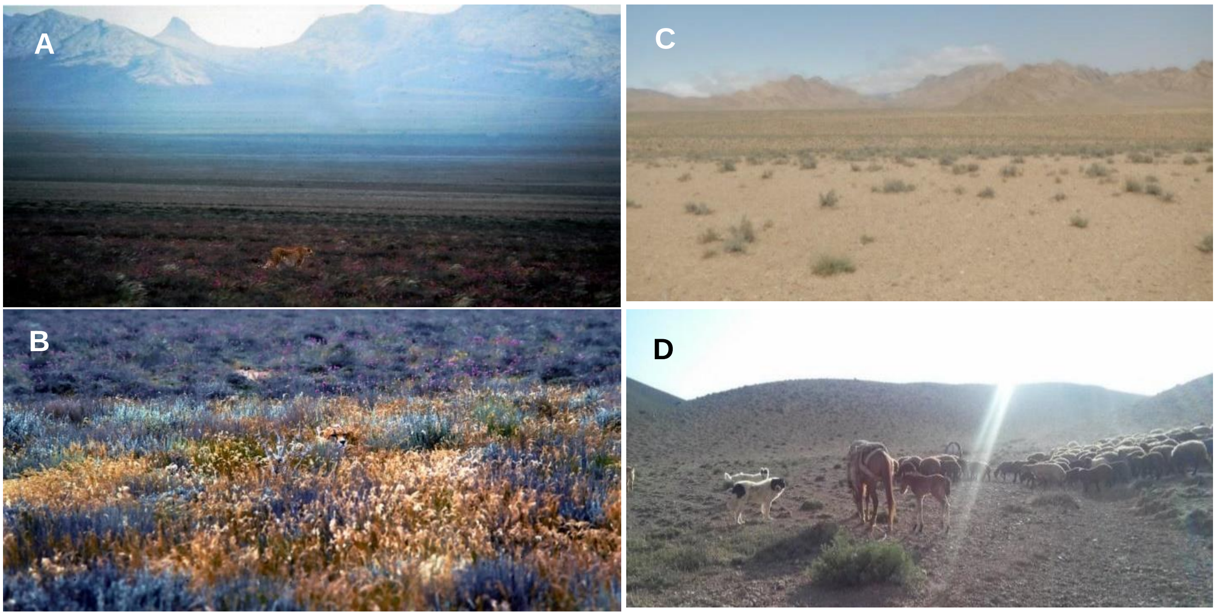


**Fig. 4.9.** The landscape of Khosh-Yeylagh Wildlife Refuge in the 1970s (A and B) (Photo: B.F. Dareshouri) and in 2017 (C and D), showing the degradation over time caused by livestock overgrazing (Photo: G.H. Yusefi).

*Khosh-Yeylagh Wildlife Refuge*

An example of lasting and underlying conflicts hampering Cheetah conservation in Iran occurred is the Khosh-Yeylagh Wildlife Refuge, which was gazetted and upgraded to a Category IV protected area in the 1960s. The status of protected area meant that local livestock breeders were no longer allowed to graze their livestock inside the protected area. This decision was taken and enforced without consultation with the local communities.

After the Iranian Revolution in 1979, the DoE lost control over protected areas, and local people started to graze their livestock in the WR again, referring to their traditional rights to use these pastures. However, in contrast to Touran and Miandasht, livestock owners in Khosh-Yeylagh did not have formal grazing licenses, and pastures were considered as communal lands.

In the 1980s, the DoE tried to regain control over the WR, resorting even to military forces. These attempts largely failed and in order to regain social peace, the Director of Shahroud

DoE accepted, as a “tolerance”, livestock grazing in this area. Since then, the DoE and livestock owners continue to have conflicts over protected area management (e.g., illegal building of corrals within the wildlife refuge borders, non-compliance of livestock numbers), and challenge each other in court (Payamema 2021).

*Touran Biosphere Reserve and Miandasht Wildlife Refuge*

Touran PA is composed of a national park (IUCN category II), a wildlife refuge (category IV) and a PA (category V). In 1976 the entire Touran PA was declared a UNESCO Biosphere Reserve.

This area has been legally protected since 1981, and its central part was upgraded to a national park in 2002 (a flagship achievement of CACP I) but local people retained the right to graze the area, although livestock grazing is not permitted in national parks. While the DoE has the legal mandate to solve conflicts of private grazing rights within protected area borders, the legal procedures are not defined by law and hence no financial resources are allocated to this task. With increasing urbanisation, many herder families holding livestock grazing permits in Touran settled down in surrounding villages, in Mahdishahr (sang-e-sar) town or even in Tehran.

Within Touran NP livestock owners had 12 grazing licenses for pasturing their own livestock (a maximum allowance of 7,487 head), but these were sometimes illegally rented out to other livestock owners. In the rest of the Touran Biosphere Reserve, an additional 77 grazing licenses authorise grazing of as many as 36,944 sheep and goats (Fig. 4.8).

*Efforts for reducing livestock pressure*

In 2006 in response to a request from the DoE the Natural Resources and Watershed Management Organization (NRWMO, currently the FRWMO) audited rangelands use in Touran National Park. Twelve grazing licenses were terminated as the total number of livestock in the area exceeded the authorised capacity (Fig. 4.8, orange pastures).

A “Livestock Control Committee” (LCC) was put in place to control the number of livestock entering Touran annually, and the time of entering and exiting, their vaccination status and the numbers of dogs (limited) accompanying the herds. However, LCC controls came to a halt after the change of Touran management in 2007. DoE-CACP re-activated the LCC between 2015 and 2019, then it was again abandoned, and Semnan DoE re-started it in 2022 after a three-year gap.

In 2008, DoE-CACP started a project to identify the boundaries of each pasture, their ownership and number of livestock and dogs (Khaleghi 2008). In 2015 CACP contracted Abangah Consulting Engineer Company to conduct a livestock census and produced a comprehensive database of livestock owners, numbers of livestock and dogs, and the status of each Grazing License (Abangah Consulting Engineer Company 2015). Another study by the same company proposed guidelines for the LCC (Abangah Consulting Engineer Company 2017) and possible alternative livelihoods to livestock husbandry, such as ecotourism, local handicrafts, local food and products for local people in Miandasht (Abangah Consulting Engineer Company 2019b. So far, the recommendations for alternative livelihoods have not been implemented.

Considering the increasingly arid conditions and long-lasting effects on vegetation, PWHF initiated an assessment of Touran’s livestock carrying capacity, in order to re-evaluate grazing licence allowances in the context of the recent increases in duration of droughts in the Touran area. However, this work was abandoned when PWHF activities were stopped in 2018.

In 2013, the Iranian Cheetah Society (ICS) and IUCN Netherlands partnered to establish a livestock-free zone within the Touran Biosphere Reserve. This action could not be realised for several years and ICS reallocated funds raised by IUCN Netherlands to purchase grazing rights from livestock owners in Miandasht WR, which again proved impossible (A. Tak Tehrani, pers. comm., IUCN NL 2020). Following another unsuccessful attempt in Touran in 2018, ICS succeeded in 2021 to purchase the permit for a 5,600-ha grazing area on the Northern edge of Touran National Park, with an allowance of 498 livestock (Fig. 4.8, yellow pasture; ICS 2021).

In 2017, the Cheetah Forever campaign was launched by Iranian actress Hedieh Tehrani, with the goal to provide funds to acquire the grazing rights and remove livestock from Touran National Park (ISNA 2017). The campaign collected IRR 6.2 billion (USD 148,000 at the time). These funds were used to purchase grazing rights and enabled the removal of 5,536 livestock from the area (Fig. 4.8, blue pastures), or 74% of the total livestock number allowance in 12 pastures in the NP (Tehran Times 2018). This campaign succeeded and demonstrated how to negotiate with licence holders and how to overcome the associated bureaucratic obstacles. Consequently, the DoE allocated funds to buy the remaining grazing licences within the national park borders (Fig. 4.8, olive pastures).

Daberger (2020) modelled habitat suitability for Cheetahs and prioritised the grazing rights according to their impact on Cheetah's survival for further buyouts in Touran and Miandasht. The spatial model was then used to propose a plan and estimate a budget for the buyout of priority pastures in the protected areas (Fig. 4.10). For an estimated cost of USD 300,000 (in 2020) the analysis prioritised 10 priority pastures (73,800 ha) for buy-outs, of which 80% represent priority Cheetah habitat. The buy-out of the selected pastures should result in the relocation of 3,742 head of livestock. Six of these identified priority pastures (2,780 livestock heads) are located in the Touran Biosphere Reserve, and would result in 47,600 ha of livestock-free area, 93% of which is priority habitat for Asiatic Cheetahs. Three of these six pastures were connected to the pastures acquired in the previous buy-out campaigns, which are in close proximity to the NP and which would form a large livestock-free area of 139,000 ha. The remaining four selected pastures are located in the Miandasht Wildlife Refuge (962 head of livestock) and cover an area of 26,200 km², of which 58% is priority Cheetah habitat. These models help to set priorities in buy-outs of grazing rights in the light of limited funds. Removing livestock from core Cheetah habitats is an urgent measure to reduce direct threats, and to allow the recovery of wild prey populations and hence increase the carrying capacity for Cheetahs.

*The dromedary camel problem*

In addition to sheep and goats, there are about 1,500 Dromedary Camels in Touran and 400 in Miandasht, which range freely throughout most of the year. Dromedaries are no longer used as transport animals, and their importance in food production (meat, milk) is limited. Yet, their owners still measure their personal wealth in terms of the numbers of animals owned. No particular management action has been taken to limit the number of dromedary camels in Touran. In addition to consuming large amounts of vegetation, this species has a negative impact on available water sources by consuming large amounts and variety of water at one time, leaving a water source empty for several hours/days before they replenish. In Miandasht ICS has protected six water sources from use by camels (ICS 2014; Fig. 4.11).

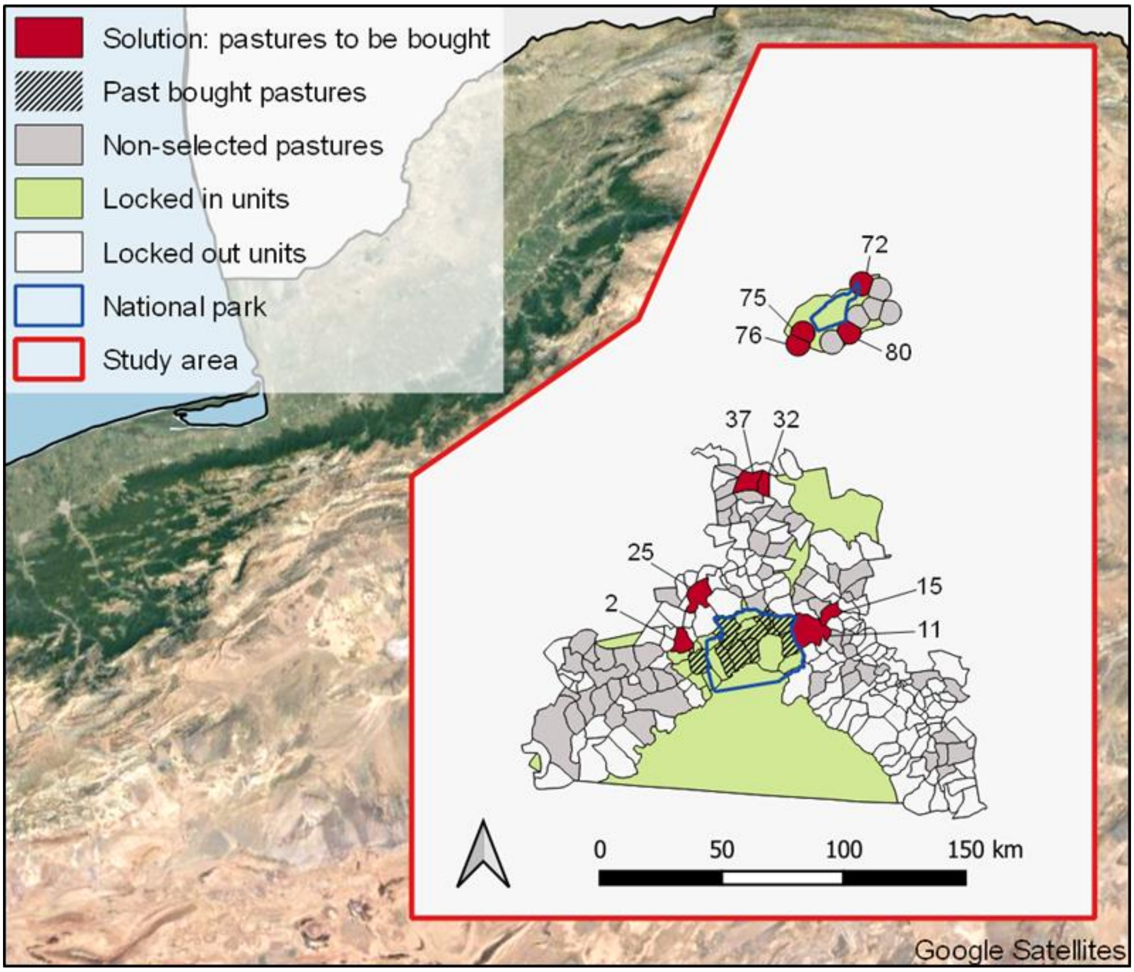


**Fig. 4.10.** Priority pastures to purchase from livestock owners in Touran and Miandasht (red; pasture ID in Abangah Consulting Engineer Company 2015) as proposed by Daberger (2020).

In Naybandan, there are about 1,640 free-ranging Dromedaries. The South Khorasan DoE has ear-tagged only 300 of them and report that they control their grazing according to pasture boundaries (South Khorasan DoE, unpublished data).

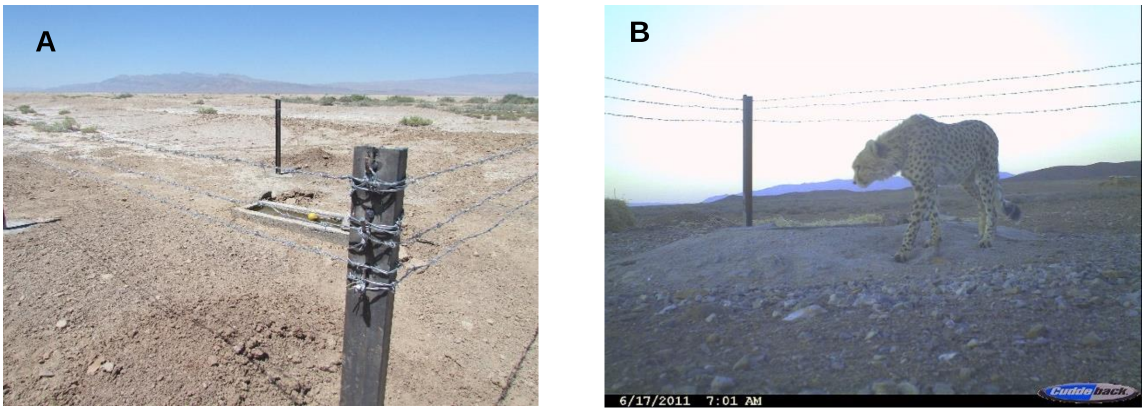


**Fig. 4.11.** A: Dromedary-exclusion fencing around a water source in Miandasht WR, B: A Cheetah accesses a dromedary-excluded water source (ICS 2014).

*Economic challenges*

Livestock owners face several challenges, including a rise in frequency of droughts that force them to stay in areas longer than anticipated, and purchase of fodder, adding significant costs to their activities. The difficult economic situation limited governmental subsidies (Payamema 2021), inflation of prices, increased husbandry costs and lowered demand for livestock products render this activity no longer profitable (F. Babakhani, pers. comm.).

Economic hardship complicates the negotiations over grazing rights. Several years after livestock owners had willingly sold their grazing licenses in Touran National Park, they were dissatisfied with their current situation as the lifestyle they had been accustomed to across generations had changed and there was no alternative income (H. Mirzadeh, pers. comm.). However, their frustration might also have come from the fact that, as a result of a lack of coordination between the DoE and several NGO actors, prices for grazing-right buyouts had increased and those who sold their grazing licenses first felt under-paid (A. H. Khaleghi, pers. comm.).

Most livestock owners that used to graze their own livestock on rangelands in the core of Touran had to move their herds beyond the limits of the national park once they sold their rights, but still they remained within the Touran BR boundaries. In these cases, the problems of overgrazing, competition with wildlife and risks for Cheetahs just moved elsewhere as the entire Touran PA complex is suitable Cheetah habitat and the most important last stronghold for the species.

Considering the long-term struggle to address threats incurred by unsustainable rangeland management through the purchase of grazing licenses, some livestock owners consider engaging in intensive livestock husbandry with the support of the government entities and collaboration of local livestock owners. They expect that the government will develop the infrastructure needed and the livestock owners will bring their livestock into these facilities and benefit from the profit according to the number of livestock defined in their grazing licenses. Such an approach may solve the problem only partially, as long as these facilities are within the PAs. Moreover, climate change is expected to further decrease carrying capacity. Given that these areas are progressively less able to support livelihoods of local communities by livestock breeding, alternative, possibly wildlife-based livelihoods need to be considered, which are able to provide long-term sustainable incomes, while conserving the natural heritage of Iran.

### *4.5.2. Safe road crossings*

Cheetahs can move large distances (Farhadinia et al 2016a) and there are several records of individuals moving between distant protected areas (Khalatbari 2021). In all Cheetah areas in Iran there are roads along the fringes of or within protected areas (Nezami 2018), which increase the risk of vehicles colliding with Cheetahs when moving within or between protected areas (Fig. 4.12). Between 2004 and 2016, at least 14 Cheetahs were killed on roads in Iran (Farhadinia et al. 2016a), equivalent to approximately 30% of reported Cheetah mortalities in the same time period. However, it is important to note that road mortality is substantially easier to detect than other types of mortality, and hence has a higher rate of reporting, thus the real proportion of roadkill in total mortalities may be much lower (Farhadinia 2019). Nonetheless, between 2004 and 2012, at least seven Cheetahs were killed on the Yazd-Kerman Road and this mortality was reported as the main reason for the local extinction of Cheetahs in Kalmand PA (Yazd DoE, unpublished data).

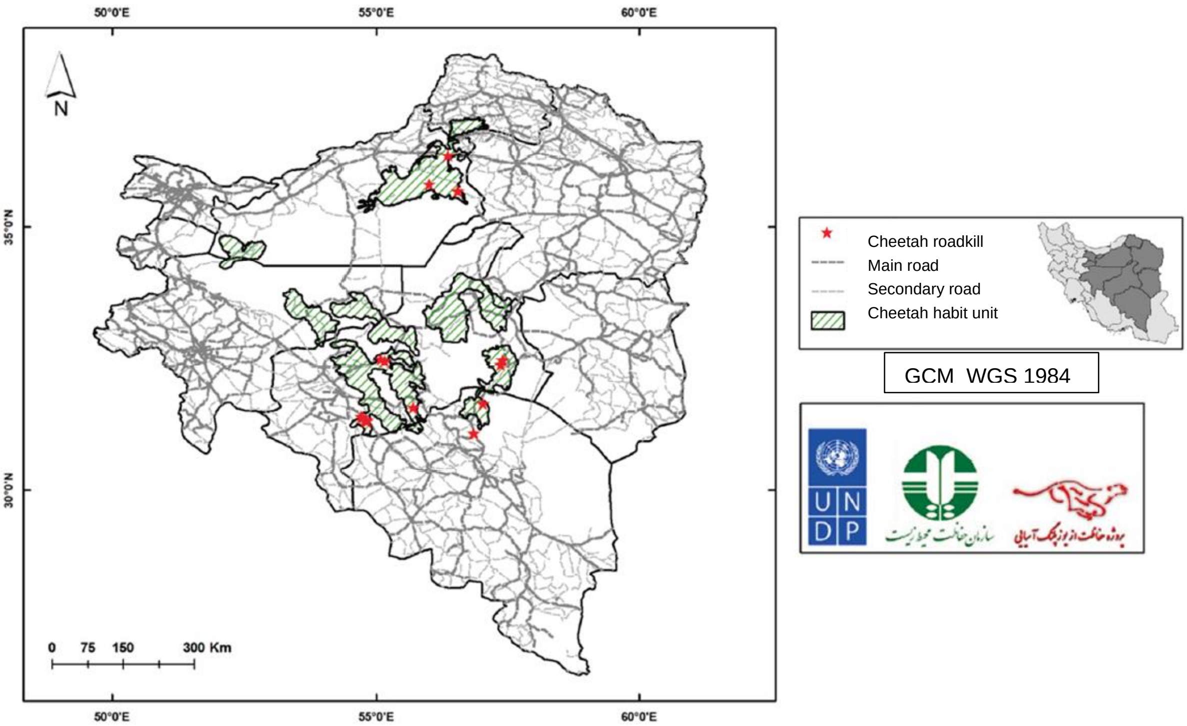


**Fig. 4.12.** Cheetah road kills in Iran until 2014. Red stars show Cheetah collisions, green dashed areas indicate Cheetah habitats, thick grey lines indicate main roads and narrow lines indicate secondary roads. Source: Nezami 2018 and references therein: Ahmadi & Heidari 2014.

Several models have been developed to identify connectivity between Cheetah core areas (Ahmadi et al. 2017) and collision hotspots. Mohammadi & Kaboli (2016) used a Kernel Density analysis of wildlife-vehicle collision hotspots to predict hotspots and proposed optimal locations for wildlife warning signs on Yazd-Kerman Road. Mohammadi *et al.* (2018) used MaxEnt modelling to predict corridors between Miandasht and Touran, and used the Distance Method and Kernel Density Estimation to predict the location of hotspots of road collisions, which coincided with the larger-scale species distribution models and landscape-connectivity predictions (Ahmadi et al. 2017; Fig. 4.13).

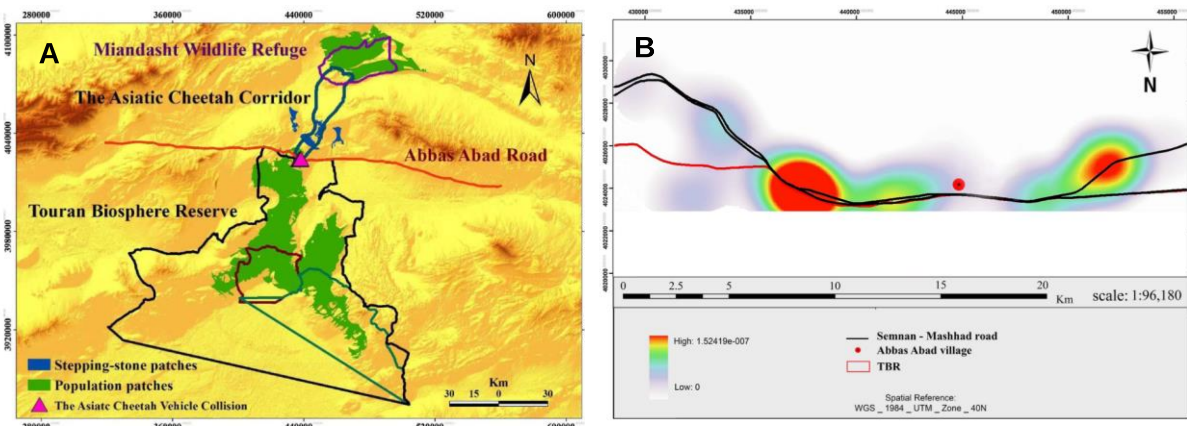


**Fig. 4.13**. A) Predicted suitable habitats (green areas) and stepping-stone patches (blue areas) between Touran and Miandash. B) Hotspot locations of road collision on Semnan-Mashhad Road. Source: Mohammadi et al. 2018.

A recent study used circuit theory and predicted the locations of habitat corridors connecting current Cheetah habitats. The predicted corridors intersected with roads at several locations, and in many cases these locations were close to previous collision points (Fig. 4.14; Khalatbari 2021).

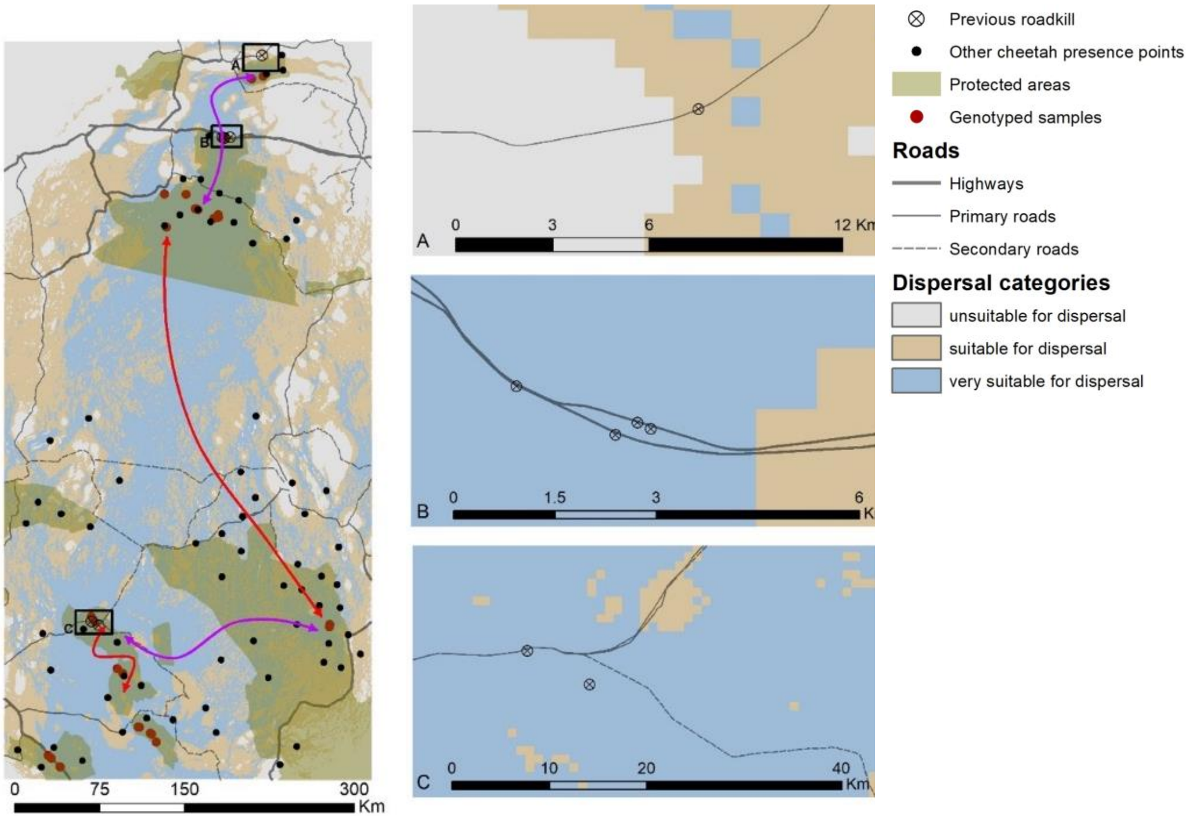


**Fig. 4.14**. Different categories of Cheetah dispersal between protected areas with confirmed presence of Cheetahs. Blue indicates very suitable dispersal categories, which are most likely corridors in the landscape. Red arrows show indications of dispersal based on genetic studies; purple arrows show dispersal based on camera-trapping studies; and crosses depict road-killed individuals. Small insets show closed-ups of collision localities and their overlap with the possible corridors. Source: Khalatbari 2021.

Road collisions were reported as one of the most important threats to Cheetahs in Southern habitats after the expansion of the Yazd-Kerman Road to a two-lane road. Yusefi (2004) suggested decreasing the speed limit from 110 to 60 km/h in areas where the roads are passing within and between protected areas. This required approval from Ministry of Roads and Urban Development, but was however never approved in Yazd province. CACP and the provincial DoE offices placed warning signs along the roads where Cheetahs had been killed previously. Locations of the signs were later optimised, according to Mohammadi & Kaboli (2016).

Reducing the maximum speed in Semnan-Mashhad highway and building underpasses were proposed to decrease road collisions in the Northern habitats. Governmental funding to fence a much longer stretch of this road and funnelling Cheetahs to existing underpasses along this road was available since 2017, but was never realised. In the absence of fencing and underpasses, several signs were placed along this road, but this has not been enough to stop the collisions (Fig. 4.15). Lately, in 2019, through collaboration with Ministry of Roads and Urban Development, Semnan DoE obtained the reduction of the maximum speed from 110 km/h to 80 km/h between Miamai Karvansara and Abbas Abad Village on the M44 highway (Semnan-

Mashhad). In the same 8-km stretch of this road, which intersects with a key corridor habitat of Cheetah (Fig. 4.13), both sides of the double road were fenced to funnel Cheetahs through existing underpasses (IRNA 2021a). As there is no control of the speed limit (e.g., installing Traffic Speed Control Cameras), drivers are still passing with high speed. In August 2022, a one-year-old female Cheetah was killed on the same road, but outside of the predicted hotspots for collisions (Fig. 13) (Shargh 2022). No follow-up monitoring was conducted to observe whether Cheetahs are using the underpasses in fenced areas or not, what would be crucial to understand before fencing a longer stretch of this road. There is a plan for expanding this road to a three-lane highway.


**Fig. 4.15.** A two-year-old female Cheetah killed on Semnan-Mashhad Road in 2014, where her mother was killed two nights before (the animal was placed by the sign for the photo). Photo: Bagher Nezami.

In conclusion, although most Cheetah core areas are very remote, Cheetahs' long-distance movements put them at risk of collision when crossing roads that carry large volumes of traffic and where vehicles drive fast. In the situation of Cheetahs in Iran, where any loss pushes the species closer to extinction, it is of utmost importance to avoid any road-kills.

### *4.5.3. Conservation breeding*

*Background*

Since 1970, more than 10 Cheetah cubs were captured illegally in Iran, mostly by livestock herders, and were kept in captivity in Iran (Farhadinia at al. 2017). The first well documented case is that of the female Cheetah named Marita, one of the three cubs of an adult female, all attacked by people on 31 August 1994, close to Bafq PA, while they were drinking water. The mother escaped, two of the cubs died and the third one (Marita) was captured by locals and delivered to Yazd DoE. She was then transferred to Tehran and kept in the Pardisan Eco-Park facilities in Tehran where she eventually died of intestinal occlusion on 23 December 2003 (Fig. 4.16, Asadi 1997, Farhadinia 2004, I. Memarian pers. comm.).

Since the 1980s, captive breeding has surfaced on several occasions in discussions related to Asiatic Cheetah conservation. In general, Cheetah experts expressed concerns about the impact that the intentional removal of Cheetahs for captive breeding purposes could have on the wild population (U. Breitenmoser, pers. comm.; see also Khalatbari et al. 2021). Therefore, at an international workshop in Mehdishahr in 2004, it was recommended to “use captive Cheetah programme only as a plan to manage animals that are found, injured, or orphaned” (Marker & Olson 2004). Therefore, a comprehensive conservation breeding programme was not included in the action plans of CACP I and II. However, in 2012, when a male (Kooshki) and a female (Delbar) were brought to captivity, the DoE, in coherence with the recommendation to attempt breeding with non-releasable specimens, started activities for captive breeding.

**Fig. 4.16.** Female Cheetah ‘Marita’ in Pardisan Eco-Park. Photo: Fariborz Heidari.

At an expert workshop in 2017 conservation priorities and management actions for future conservation of Cheetahs were defined. One proposed activity was to “Perform a population viability analysis (PVA) to understand if the [free-living] metapopulation is still demographically and genetically viable and is able to recover”. Furthermore, following a thorough feasibility study, the consideration of a conservation breeding programme in special facilities or in a very large (>1,000–2,000 km²) enclosure in the Cheetah habitat was proposed as a “mid- to long-term measures that needs further data and discussion before implementation” (Khalatbari et al. 2017).

However, this nascent captive breeding programme in Pardisan Eco-Park, Tehran was stopped following the abrupt suspension of CACP activities in 2018. The PVA and proposed breeding programme were never implemented.

### *Current captive Cheetahs in Iran*

Currently, there are three confiscated and one intentionally captured Cheetah maintained captive in Touran, Iran. There are the only known specimens of captive Asiatic Cheetahs in the world (Table 4.4 and Fig. 4.17).

**Table 4.4.** Background history of captive Cheetahs in Iran in 2022.

| Name (sex) | Background |
|---|---|
| Kooshki (male) | In 2008 a landowner from Touran area found out about the capture of a male Cheetah cub by a local shepherd. The cub was kept chained in the herder's farm until the landowner intervened and convinced him to hand it over to the DoE, which transported it to Pardisan Eco-Park (Jowkar et al. 2008b; Fig. 4.17.A). In November 2008 the cub was transferred to a 12-hectare enclosure in Miandasht WR where it remained until December 2014, when it was transferred back to Pardisan Eco-Park for the captive breeding programme (see next section). |
| Delbar (female) | In spring 2011 a lone female Cheetah cub was captured by herders in Touran NP. When the rangers became aware of this cub, they attempted to reunite it with its mother, which could not be found, and DoE decided to keep the cub (M.S. Farhadinia, pers. comm.) in a small enclosure close to the main ranger station (Fig. 4.17.B) until it was moved to Pardisan Eco-Park, Tehran, in December 2014. |
| Iran (female) | In December 2017 the security section of the DoE and the Iranian Public Security (IPS) and Intelligence Police were informed about a female Cheetah, being kept in a private place and about to be sold (Fig. 4.17.C). DoE and IPS confiscated the animal and transported it to Pardisan Eco-Park (Fig. 4.17.D). Later investigations showed that the cub had been captured in Miandasht (ISNA 2019). It was kept in Pardisan Eco-Park until later moved to Touran's captive breeding facilities in 2020, where she still lives. |
| Firouz (male) | Following the initiation of a new captive breeding programme in Touran in 2020, Semnan DoE decided to capture one of the resident wild males in the area to mate with the two adult females available in captivity. This male, 'Firouz', whose territory and marking areas were known through long-standing camera-trapping efforts, was targeted and captured using snare traps on 17 March 2021 (Fig. 4.17.E). He was translocated to the Touran's captive breeding facilities (Mizan News 2021a). |
| Pirouz (male) | Following successful mating of 'Iran' and wild-captured male 'Firouz', on 1 May 2022.three male cubs were born by caesarean section (Fig. 4.17 F; Etemad 2022). This male was the only surviving so far (August 2022), although with some health issues (e.g. kidney problem) (ISNA 2022, I. Memarian pers.comm). |


**Fig. 4.17.** Asiatic Cheetahs currently kept in captivity. A) Anesthetized male cub 'Kooshki', examined in Pardisan Eco-Park, 2008. Photo: Luke Hunter. Source: Jowkar et al. 2008b. B) Female Cheetah 'Delbar' in an enclosure in Touran NP. Photo: Alireza Shahrdari. C) Female Cheetah cub 'Iran' being kept as a pet for sale in a private place in Tehran, September 2017. D) Female Cheetah cub 'Iran' brought to the wildlife veterinary centre of Pardisan Eco-Park, DoE, December 2017. E) wild male Cheetah 'Firouz', trapped in a foot snare. Photo: Danial Nayeri. F) Captive-born male 'Pirouz' in Pardisan Eco-Park. Photo: Alireza Shahrdari. Source of C,D and E: Mehrnews 2017.

*Captive breeding attempts and achievements*

**Pardisan Eco-Park, Tehran, (2014 – 2020):** In order to attempt breeding in the "Asiatic Cheetah Research and Husbandry Headquarters", female Delbar (then four years old) and male Kooshki (then six years old) were transferred to Pardisan Eco-Park in Tehran in December 2014. They mated soon after being introduced to each other in late December 2014, but Delbar aborted. The abortion was possibly a consequence of kidney problems due to an inadequate diet (I. Memarian, pers. comm.), or high levels of minerals in the drinking water (S. McKeown, pers. comm.). She was thereafter under treatment for one year but failed to reproduce. Intensive monitoring and several examinations conducted by specialists from the Leibniz Institute for Zoo and Wildlife Research, sperm collection and examination from Kooshki, hormone therapy and artificial insemination of Delbar did not result in any further pregnancies (Lueders et al 2019, Tehran Times 2017, I. Memarian, pers. comm.).

**Touran captive-breeding centre, Semnan Province (2020–present):** as of 2020 Semnan DoE started rather independently a new captive-breeding programme with the aim to "recover the Cheetah population in natural habitats by introducing captive-born Cheetahs to the wild". The current plan has four phases: (1) capturing a male from the wild, (2) breeding the wild male and the younger female already in captivity, (3) rearing their cubs for two years, and (4) rewilding them. Semnan DoE has developed a breeding facility (IRNA 2021b), in which Cheetahs are kept in different enclosures that are connected to each other. When signs of oestrus are observed in the female, doors to the “love line” (an enclosure open to both sexes) are opened. A 700-ha site will be available for the rearing of cubs. Currently, in the captive breeding facility hares are bred to be fed alive to Cheetahs. In the future, wild sheep should also be bred and released into the 700-ha enclosure.

As Kooshki, who was transported to Touran facility, did not mate with the young female ‘Iran’, Semnan DoE decided to remove a wild male present in Touran to support the captive-breeding efforts (Firouz, see table 4.4; (Mizan News 2021a). After measuring the faecal hormones of the female scats and observing her behaviour carefully in order to predict time of oestrus, Firouz was introduced to her at the proper time. She accepted the male and they mated in January 2022. On 1 May 2022·three male cubs were born by caesarean section (Fig. 4.18; Etemad 2022). However, the female did not accept the cubs and they had to be hand reared. One of the cubs died a few days after birth and another one at the age of 17 days (ISNA 2022). The last cub survived so far (August 2022), although with some health issues (including kidney problems) and is now hand-reared in the Pardisan Eco-Park (I. Memarian pers. comm.).


**Fig. 4.18.** A: The first captive born Asiatic Cheetahs in Touran, delivered through caesarean surgery, May 2022. Source: DoE. B: The two-month-old male ‘Pirouz’. Photo: Alireza Shahrdari.

## 4.6. Further conservation challenges

### *4.6.1. Water sources management*

Management of water sources, i.e., the construction and maintenance of troughs, installation of wind and solar pumps for retrieving water from wells for these troughs, and safeguarding them against dromedaries *Camelus dromedarius*, were among the foremost implemented conservation activities by the DoE and NGOs in Cheetah protected areas during the past five years, compared to other conservation activities. Such activities are undertaken at a national scale. Among 69 projects on a fundraising website dedicated to conservation activities, 27% (N=19) were for water management, 39% (N=27) were for providing forage for herbivores and only 4% (N=3) were related to hiring or supporting rangers (Nazretabiat 2022).

### *4.6.2. Conservation of prey*

Distribution and abundance of carnivores is mainly determined by prey availability (Hayward, O'Brien & Kerley 2007). The vast central Iranian plateau, which is bordered by mountain ranges provides suitable habitats for five ungulate species that are the primary prey of the Cheetah. These include the wild goat, Goitered Gazelle, Chinkara, and two species of wild sheep. Maintenance of Cheetah populations relies on abundant and healthy populations of these ungulates in all habitats used by Cheetahs. However, populations of these five ungulate species have been declining both in number and range over the past century, due to over-hunting/poaching, habitat degradation, competition with livestock and transmission of pathogens from livestock to ungulates. The IUCN Red List categorizes wild sheep *O. vignei* and Goitered Gazelle globally as Vulnerable (VU), wild goat and wild sheep *O. gmelini* as Near Threatened (NT) and Chinkara as Least Concern (LC) (mainly because of Thar desert stronghold in Western India) (IUCN SSC Antelope Specialist Group 2017a, b, Michel & Ghoddousi 2020a, b, Weinberg & Ambarli 2020). However, with a population estimated at about 2200 individuals (DoE unpublished data 2020), Chinkara is the rarest antelope species in central Iran. The regional IUCN Red List (Yusefi et al. 2019), categorizes wild sheep *O.vignei* and *O. gmelini* as VU and Goitered gazelle and Chinkara as EN. Currently, most of these ungulate populations concentrate in the relative safety of protected areas. Gazelle species are the preferred prey of Cheetahs, but wild sheep and wild goats are currently most often predated upon by Cheetahs (Farhadinia & Hemami 2010, Zamani et al. 2017, Zahedian & Nezami 2019, Khalatbari et al. 2022). A shifting prey-base for Cheetahs, could be due to a decreased availability of gazelles declining across most of Iran, and/or gazelle habitat avoidance because of the higher risk of poaching, dog attacks and other forms of persecutions in flatter areas. Goitered gazelles occasionally forage in farmlands, relatively close to human settlements which are generally avoided by Cheetahs, whereas Chinkara which generally prefer areas distant from human settlements are declining. Appendix VIII, presents detailed information on the current status of prey population in Iran, focusing on protected areas with previous records of Cheetah.

In a questionnaire survey of DoE experts in all provinces with gazelle populations (Hemami, Esmaeili & Shahriari, unpublished data, 2014), poaching (44%), drought (31%), land-use change (14%) and road development (11%) were reported as the main causes of Goitered gazelle decline. The same questionnaire assessed the population trend and distribution of the two gazelle species across PAs in Iran (Tables VIII.1. and VIII.2.). Table VIII.3. presents the latest available population trends of herbivores in protected areas supporting Cheetah, where enough data for an assessment were available.

Currently, there are five captive breeding centres for Goitered Gazelle, two for Chinkara, and two for wild sheep, of which four are located in Cheetah areas (indicated by the asterisk in table VIII.4). Recent population size of herbivores in these breeding centres can be found in Table VIII.4. None of these centres adhere to professional standards in terms of structure, maintenance, breeding management, health surveillance, and none of them support the development of the ungulate populations according to management plans.

The range of the Cheetah is now restricted to the most arid parts of the central plateau, which are seemingly more suitable for Chinkara than for Goitered Gazelle (Ahmadi et al. 2017). Therefore, it may be most productive to prioritise recovery of Chinkara populations in Cheetah habitats. The human footprint in the most arid areas of central Iran is relatively low (Karimi & Jones 2020), and this may have helped the conservation of many wildlife species. However, these vast and remote unprotected landscapes also provide opportunities for hunters. Large plain-dwelling mammals are often the first victims of poachers.

Some diseases have also posed problems for the recovery of prey populations. Peste des petits ruminants (PPR) has been spreading in wild ruminants in central Iran since 2014, and has significantly impacted wild sheep and wild goat populations (Marashi et al. 2017). This livestock-born disease should be considered as a potential serious threat to Cheetah's primary prey populations and its control by vaccinated livestock from which it may spill over to wildlife must be carried out in priority across Cheetah habitats and more globally as part of an eradication process (Fine et al. 2020).

Climate change is expected to exacerbate drought across the habitats used by Cheetahs, which are likely to put primary prey populations at higher risk of decline. Projections for Iran predict that climate change could result in a 55% loss of suitable habitat for Goitered gazelle, 69% for wild sheep, and 76% for wild goat within the next 50 years (Malakoutikhah et al. 2020). Therefore, conservation should be prioritised according to geographic predictions of resilience to climate change.

Because of the unpredictability of rainfall in arid landscapes, the survival of Cheetahs and their prey depends on their ability to move freely across the landscape (Durant et al. 2015). Therefore, habitat connectivity is critically important for the survival of the Cheetah and its prey, particularly in a changing climate. Isolation of populations will eventually decrease genetic variability and affect the long-term survival of subpopulations (Furlan et al. 2012). Development of the road network not only increases the risk of vehicle-Cheetah collisions, but also has profound negative impacts on dispersal of ungulates, particularly of gazelle populations (Khosravi et al., 2018). Therefore, measures need to be taken urgently to mitigate the impacts of linear infrastructure development and to maintain and restore connectivity (CMS 2015).

#### *4.6.3. Conservation of habitat corridors, marginal suitable habitats and stepping-stones*

Given that majority of global current range (77%) of cheetah is outside protected areas, it is recommended that the conservation of Cheetahs should not be limited to protected areas alone (Durant et al. 2017). Asiatic Cheetahs move across vast distances (Farhadinia et al. 2016b; Khalatbari 2021) and there are several records of cheetah observation outside of protected areas. In Iran, 23–53% of predicted suitable Cheetah habitats are covered by protected areas (Ahmadi et al. 2017; Khalatbari et al. 2018a; Shams-Esfandabad 2021).

Securing and maintaining habitat connectivity between Cheetah populations is of utmost importance for maintaining social functionality and gene flow and avoiding inbreeding within subpopulations. Ahmadi et al. (2017) have modelled habitat suitability of Asiatic Cheetah across Iran and identified likely corridors between main habitats. They overlapped these corridors with the map of protected areas and proposed several "stepping-stones" (light blue spots in Fig. 4.19). These stepping-stones can act as temporary strongholds to help to facilitate movements of Cheetahs between core areas.

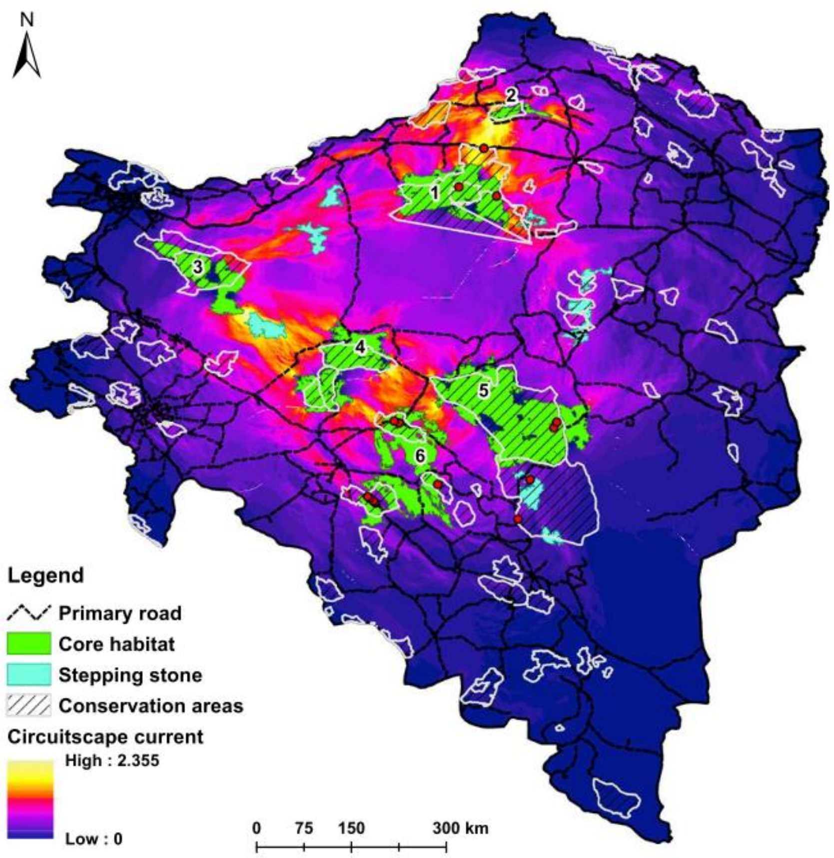


**Fig. 4.19.** Habitat permeability between the six Asiatic Cheetah' core habitats in Iran based on circuit theory. Stepping-stone areas are proposed as temporary strongholds between core areas for moving Cheetahs. Hatched conservation areas (CAs) are those with specific management aimed at conserving Cheetah. Source: Ahmadi et al. 2017.

### *4.6.4. Mine excavation*

Development of mine excavation has been mentioned as one of the main reasons for the declining population of Cheetahs in Southern habitats (Nezami 2018, R. Kargar, pers. comm.). The magnitude and importance of this threat with regard to Cheetah and wild prey population decline and habitat quality decrease in these protected areas were however never systematically assessed. A study by Shams (2017) analysed the habitat suitability of Asiatic Cheetah in Yazd province between 2001 and 2014 and found that in 40% of the suitable Cheetah habitats, the vegetation cover was significantly decreased. Given that there were no significant changes in the temperature and precipitation in the same period, he concluded that human-related variables are the main cause of vegetation cover decline. Moreover, this study found that in the altered suitable habitats of Cheetah in Yazd province, the rate of landscape changes due to mine excavation, roads and human-made structures were 103%, 46% and 28%, respectively (Shams 2017). So far, mine excavation occurred mainly in the Southern cheetah habitats, but permissions for developing mine excavating activities in the Northern habitats including Touran PA are pending (Payamema 2022a).

# 5. Genetic status of the Asiatic Cheetah


**Chapter Summary**

Studies were conducted on the genetic diversity of Asiatic Cheetahs based on nuclear and mitochondrial DNA (mtDNA). The Kerman subpopulation was found to have the highest mtDNA haplotype diversity, followed by the Yazd and Touran populations, while the (now extinct) population from Kavir has the lowest genetic diversity. Several studies have analysed various Cheetah populations across Africa and South-West Asia based on nuclear markers (Table 5.1). These studies confirm the relatively low genetic diversity of Asiatic Cheetahs compared to African populations in Botswana and Tanzania, and other endangered felids (chapter 5). However, it is similar to the genetic diversity observed in the Iberian Lynx *Lynx pardinus* when they were fragmented into two small subpopulations, but higher than the highly inbred Asiatic Lion *P. leo leo* from the Gir Forest (chapter 5). Average pairwise relatedness between Asiatic Cheetahs in Iran was similar for both Northern and Southern subpopulations, with values of >0.25 representing relatedness between half siblings or grandparents and their grandchildren. However, when individuals from the two subpopulations were analysed together, these values were smaller, indicating that they are less related (Table 5.2).

A genome-wide study on the genetic status of Cheetahs found that Asiatic Cheetahs display lower heterozygosity and higher levels of inbreeding than other Cheetah subspecies (Fig. 5.1 and 5.2) and also found reduced variation in the Major Histocompatibility Complex (MHC) in *A. j. venaticus* compared to the subspecies *A. j. jubatus* and *A. j. soemmeringii*, indicating that there might be a reduced immune-response. Individual relatedness analysis confirms a genetic division into Northern and Southern subpopulations. Within these subpopulations, individuals were more related to each other than to individuals from other subpopulations, but traces of past migration and gene flow were observed in four individuals, indicating that there were functional corridors between the subpopulations until recently (Fig. 5.3). All these migration events were estimated to have occurred two generations ago, suggesting that connectivity was higher in previous generations and might have been lost or reduced in recent years. Loss of migration might be a result of population decline and/or expansion of human-made barriers. The Northern subpopulation showed higher values of heterozygosity and allelic richness than the Southern subpopulation.

Another study that included samples from the now extinct Kavir subpopulation revealed former connectivity between Kavir and Yazd, indicating the importance of these subpopulations as steppingstones for gene flow between the north and the south. Therefore, the local extinction of the Kavir population in 2013 may also explain the loss of connectivity between the Southern and Northern subpopulation.

The high levels of inbreeding, fragmentation of populations, the decrease in connectivity over the last two generations and the extinction of the Kavir subpopulations are reasons for great concern. The effective population size was low and estimated as 11 to 17 individuals. This number is far below than what is believed to be needed for the long-term persistence of a (sub)species (chapter 5).

The technical terms of this chapter are explained in a Glossary (Appendix IX).

### 5.1. Mitochondrial DNA

Khederzadeh (2015, summarised in Nezami 2017) conducted a study on genetic diversity, using samples from previously killed individuals across the range of Cheetahs in Iran. In this study it was found that the Kerman population had the highest haplotype diversity, followed by the Yazd and Touran populations and that the population from Kavir had the lowest genetic diversity. Two haplotypes were observed in the population; haplotype 1 was observed in Touran, Kerman and Yazd, and haplotype 2 was observed in Kavir and Yazd. The maximum genetic distance was between the Kerman and Kavir populations and the minimum genetic distance was between the Kavir and Yazd populations.

### 5.2. Nuclear markers

A number of studies have analysed various Cheetah populations across Africa and South-West Asia with varying numbers of samples and microsatellites (Table 5.1). The results vary across studies, with expected heterozygosity He, ranging from 0.412 to 0.766, and observed homozygosity Ho, from 0.438 to 0.609. However, many sample sizes are very small, and the rule of thumb of 25-30 samples x ≥20 microsatellites for a representative population sample (Murphy et al. 2018), and results have to be taken with caution. Large populations in Africa analysed with a sufficient sample size have expected heterozygosity values of nearly 70%, whereas the remaining population in Iran has only a value of 41%. High genetic diversity allows a species/population to respond better by adapting (through natural selection) to changing environmental conditions.

**Table 5.1** Genetic variation across microsatellite loci in different Cheetah populations. N = Number of individuals analysed, Nm= number of microsatellites analysed, Ho = mean observed heterozygosity, He = mean expected heterozygosity. Standard deviation values are where available given in parentheses.

| Region | Population | N | Nm | He | Ho | Reference |
|---|---|---|---|---|---|---|
| All | Total | 30 | 82 | 0.523 (0.640) | 0.443 (0.540) | Driscoll et al. 2002 |
| Africa | East | 10 | | 0.467 (0.570) | 0.433 (0.530) | |
| Namibia | Captive | 10 | | 0.477 (0.580) | 0.457 (0.560) | |
| Namibia | Wild | 10 | | 0.462 (0.560) | 0.438 (0.530) | |
| Namibia | Wild | 98 | 38 | 0.64-0.70 | | Marker et al. 2008b |
| Tanzania | Serengeti | 146 | 13 | 0.480 | 0.510 | Gottelli et al. 2007 |
| All range | Total | 60 | 18 | 0.766 | - | Charruau et al. 2011 |
| Asia | South West | 8 | | 0.397 | - | |
| Africa | North East | 25 | | 0.674 | - | |
| Africa | South | 27 | | 0.698 | - | |
| Botswana | Total | 32 | 14 | 0.620 | 0.581 | Dalton et al. 2013 |
| Botswana | Moremi | 4 | | 0.549 | 0.452 | |
| Botswana | Ghanzi | 14 | | 0.653 | 0.609 | |
| Botswana | Jwaneng | 8 | | 0.579 | 0.649 | |
| Botswana | Sekoma | 3 | | 0.569 | 0.643 | |
| Asia | Iran (2017) | 26 | 21 | 0.412 (0.0330) | 0.504 (0.043) | Khalatbari 2021 |

A fine-scale study, which used road-killed and previously captured specimens and scat samples taken across the current geographical distribution of the Asiatic Cheetah population in Iran (Khalatbari 2021), provided a larger sample size (N = 26) compared to eight used in

Charruau et al. (2011). The study confirmed a relatively low genetic diversity within the subspecies (Table 5.1). Therefore, the genetic diversity of the Asiatic Cheetah is lower than in African populations in Botswana and Tanzania (Dalton et al. 2013; Gottelli et al. 2007, Schmidt-Küntzel et al. 2018). It is also lower than observed in some other endangered felids (e.g., Lion and Tiger; Driscoll et al. 2002; Luo et al. 2004), but it is similar to the genetic diversity observed in the Iberian lynx *Lynx pardinus*, when they were fragmented into two small subpopulations (Casa-Marce et al. 2013), and higher than in the highly inbred Asiatic Lion (*Panthera leo*) from the Gir Forest (Driscoll et al. 2002).

In the Asiatic Cheetah in Iran, genetic diversity estimates show higher values of observed heterozygosity and allelic richness for the Northern compared to the Southern subpopulation, and both subpopulations present higher observed than expected heterozygosity. The average inbreeding coefficient ($F_{IS}$) was -0.22 and -0.14, for the Northern and Southern subpopulations, respectively. Average pairwise relatedness (RL) between individuals was similar for both subpopulations with values of >0.25 representing relatedness between half siblings or grandparents and grandchildren, but smaller when individuals from the two groups were analysed together (Khalatbari 2021; Table 5.2).

**Table 5.2.** Mean genetic diversity values for 21 microsatellite loci of subpopulations of Asiatic Cheetah in Iran. N = Number of individuals analysed, N*a* = mean number of alleles, N*e* = mean number of effective alleles, H*o* = mean observed heterozygosity, He = mean expected heterozygosity, uH*e* = mean unbiased heterozygosity, AR = allelic richness, RL = relatedness (calculated using DyadML65 in Coancestry (Wang 2011)). Standard deviation values are given in parentheses. Source: Khalatbari 2021.

| Genetic units | N | Na | Ne | Ho | He | uHe | AR | RL |
|---|---|---|---|---|---|---|---|---|
| All | 26 | 2.286 (0.138) | 1.888 (0.087) | 0.504 (0.043) | 0.412 (0.033) | 0.430 (0.034) | 2.376 | 0.157 |
| Northern | 11 | 2.333 (0.211) | 1.925 (0.124) | 0.541 (0.064) | 0.327 (0.044) | 0.448 (0.047) | 2.317 | 0.274 |
| Southern | 15 | 2.238 (0.181) | 1.851 (0.126) | 0.468 (0.060) | 0.369 (0.049) | 0.412 (0.051) | 2.177 | 0.258 |

### 5.3. Major Histocompatibility Complex (MHC)

The MHC has an important function in regulating the immune system and is one of the most polymorphic loci known in many species. Reduced variation in the MHC has been associated with high susceptibility to infectious diseases (Schmidt-Küntzel et al. 2018). Prost et al. (2022) sequenced one of the MHC regions (class II DRB exon 2) of 46 individuals, which resulted in a diversity of 13 nucleotide and nine amino acid (AA) haplotypes. They identified nine AA haplotypes, all nine found in *A. j. jubatus*, seven in *A. j. soemmeringii* and five in *A. j. venaticus.* Because of unequal sample sizes, they performed a statistical analysis (extrapolation and rarefaction curve) and found that for *A. j. venaticus* no more than seven haplotypes were to be expected for this subspecies. Whereas for *A. j. jubatus* and *A. j. soemmeringii* substantially more haplotypes could be expected with increasing sample sizes.

### 5.4. Genome-wide analyses

A recent genome-wide study on the genetic status and conservation of Cheetahs has confirmed that the Asian population displays lower heterozygosity in comparison to other Cheetah subspecies, (Fig. 5.1, Prost et al. 2022).

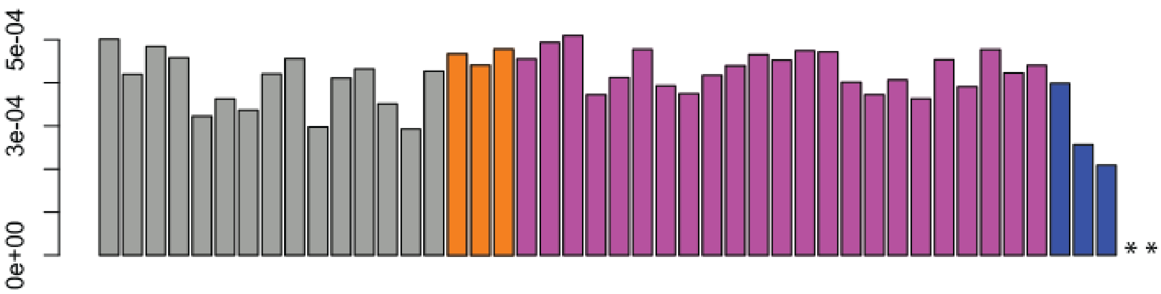


**Fig. 5.1.** Heterozygosity based on genome-wide data indicating low heterozygosity values in two individuals of *A. j. venaticus* (blue bars). ** indicates that individuals of *A. j. hecki* were not used in the heterozygosity analysis. Grey bars *A. j. soemmeringii*, orange bars *A. j. raineyi*, purple bars *A. j. jubatus* Source: Prost et al. (2022). For the distribution of the subspecies see section 2.3, Fig. 2.7.

Using genome-wide analyses, Prost et al. (2022) found that the level of inbreeding in *A. j. venaticus* was higher than in other subspecies of Cheetah (except for *A. j. hecki*) (blue bars in Fig. 5.2). However, this was based on very small sample sizes (N=3 and N=2 respectively).

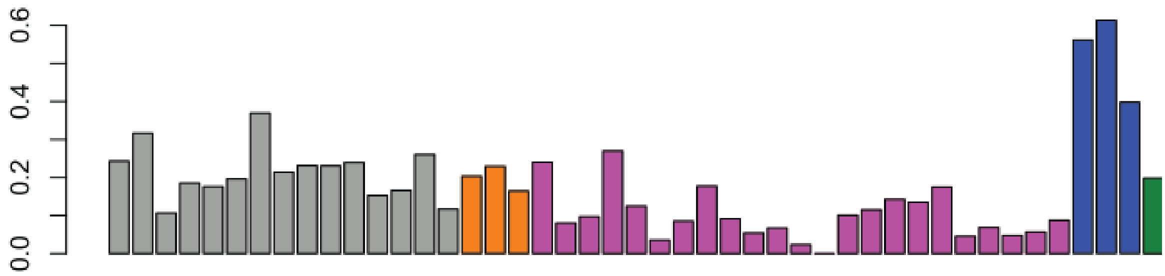


**Fig. 5.2.** Inbreeding coefficient based on 3,743 SNPs indicating high inbreeding in individuals of *A. j. venaticus* (blue) and *A. j. hecki* (green). Grey bars *A. j. soemmeringii*, orange bars *A. j. raineyi*, purple bars *A. j. jubatus*. Source: Prost et al. (2022).

### 5.5. Population structure

The results of individual relatedness maps for Asiatic Cheetah, which estimates the level of relatedness between individuals based on microsatellite data, confirm that the population is genetically divided into two Northern and Southern subpopulations (Khalatbari 2021). This analysis shows that individuals from the same subpopulation are more related to each other than to individuals from the other subpopulation. Traces of migration and gene flow were observed in four individuals (marked with crosses in Fig. 5.3), which shows potential corridors connecting the subpopulations (Fig. 5.3). However, no gene flow has been observed in the last two generations (in all cases, the migration events were estimated to have occurred two generations ago), suggesting that the connectivity between two populations may have been lost. This might be a consequence of population decline, or the expansion of human-made barriers in recent years (e.g., expansion of road network) or a combination of both factors (Khalatbari 2021).

Another study which included more occurrence locations from a broader range (including Kavir and Kerman) found potential connectivity between Kavir and Yazd and also found both haplotypes in the Yazd population (Khederzadeh, 2015). This indicates the potential importance of stepping stones for maintaining gene flow between subpopulations. Therefore, the local extinction of the Kavir population in 2013 may also explain the loss of connectivity between the Southern and Northern subpopulations.

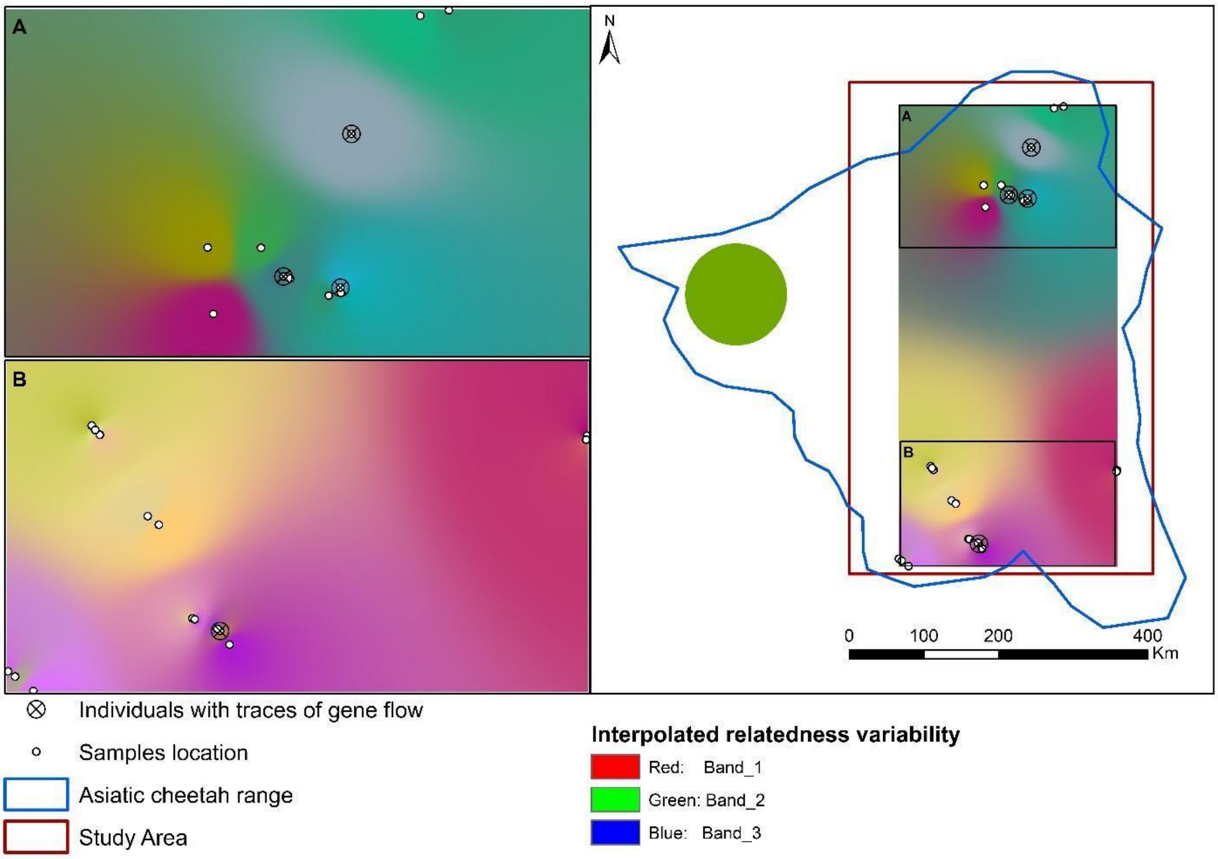


**Fig. 5.3.** Spatial Principal Component Analysis (PCA) map, depicting the variability in interpolated surfaces of individual relatedness of Asiatic Cheetahs, accounted for 86% of relatedness along the first three axes (right). The two figures on the left are close-ups of the Northern (A), including Touran and Miandasht, and Southern (B), including Yazd Pas and Naybandan, subpopulations, which corresponds to the rectangles, A and B, in the study area. The green dot within the species' range polygon shows the location of the recently extinct Kavir subpopulation. Source: Khalatbari et al. (2017), and Khalatbari (2021).

In summary, the genetic diversity of the current population in Iran is low. There are high levels of inbreeding, because the subpopulations are fragmented, owing to decrease in connectivity over the last two generations and the recent extinction of the Kavir subpopulation; all of which are reasons for great concern.

# 6. Plans for the reintroduction of Cheetahs in Asia


**Chapter summary**

In Asia, Cheetah reintroduction has been considered in India and Uzbekistan (chapter 6). In India, the proposal is further advanced and ready to be implemented, while the plans for Uzbekistan are still at an early state of discussion. In both countries, the initial idea was for Asiatic Cheetahs *A. j. venaticus* to be reintroduced. However, this approach was impeded by the dire situation of the last remaining population of the Asiatic Cheetah in Iran and the lack of an ex- situ population.

In India, three landscapes within the historical range of the Cheetah were found to have potential for Cheetah reintroduction in 2010, including Kuno-Palpur Wildlife Sanctuary in Madhya Pradesh, Shahgarh Landscape in Jaisalmar, and Nauradehi Wildlife Sanctuary in Madhya Pradesh. However, reintroduction plans were halted in 2011 and re-started in 2020. Subsequently, six sites were (re)assessed with regard to Cheetah reintroduction, e.g., prey availability, habitat suitability, anthropogenic challenges and required preparatory management actions. The original plan to establish 3–5 Cheetah populations and manage them as a metapopulation was still deemed valid, and all six evaluated sites were considered suitable, although not to the same extent. Among those given priority were Kuno NP-Sheopur Forest Landscape, Gandhi Sagar-Chittorgargh-Bhainsrodgarh WLS with parts of Mukundara TR landscape, and for an initial, fenced population, Nauradehi WLS. Additionally, enclosures, e.g., Mukaundara TR, would be able to host a small breeding group. South Africa and Namibia were considered as potential source countries for Cheetahs to be brought to India.

In Uzbekistan, the Ustyurt Plateau was home to the Asiatic Cheetah up to the 1980s, and the goal is to establish a free-ranging viable Cheetah population within its former natural range and habitats. The plan is to breed and rewild Cheetahs, but first, key prey populations have to be re-established, support of key stakeholders has to be obtained, and the protection of Cheetahs and their prey (including law enforcement) has to be secured (chapter 6). The preliminary phase of the reintroduction plan took place between 1985–2001, during which four Cheetahs from South Africa (*A. j. jubatus*) were held in large enclosures to acclimatise them to lower temperatures and allow them to learn to hunt and kill various prey species. However, the Cheetahs never reproduced, and it is now no longer deemed realistic to implement the next phase due to the low population density of wild prey. However, parts of the programme continue (Fig. 6.1). The legal protection of habitats has improved, restoration efforts for wild ungulate populations have been implemented, an adequate protected area has been gazetted and the programme of Cheetah reintroduction in Uzbekistan is being revised.

In Asia reintroduction of the Cheetah has been considered in two countries so far, namely India and Uzbekistan. The proposal in India is most advanced and the country is moving forward with implementation, while the plans for Uzbekistan are in the early stages of discussion.

In both countries the reintroduction of the Asiatic Cheetah *A. j. venaticus* was part of the original plan, but this approach is impeded due to the dire situation of the last remaining population of the Asiatic Cheetah in Iran and by the absence of a suitable *ex situ* population.

## 6.1. India

The history of the Cheetah in Asia, and specifically in India, has been reviewed in great detail by Divyabhanushinh (2002). This includes a detailed description of the extensive use of hunting Cheetahs, e.g., by the Mughal courts, and the importation of Cheetahs from Africa, in order to satisfy the demand for hunting Cheetahs, because they never bred in captivity. As a likely consequence of this demand for hunting Cheetahs, the species disappeared from the Indian subcontinent in the 1950s, and since then, the question of reintroducing the species has come up several times (Divyabhanushinh 2002). In 1984 the Deputy Minister for the Environment in the Government of India, Mr Digvijay Sinh, asked for the advice of the IUCN SSC Cat Specialist Group and the topic was discussed during a meeting in Kanha in April 1984. The group found that reintroducing endangered felids into their former range would not only be essential for the long-term survival of the respective taxa, but would also stimulate the public interest in the preservation of these species, and facilitate the conservation of their remnant habitats. Therefore, the group recommended that “efforts be made to ascertain the possibilities of the reintroduction of species such as the Asiatic Lion and the Asiatic Cheetah in former habitats from which they have disappeared” (Jackson 1984). As it was already considered difficult to procure Cheetahs from Iran in the 1980s, the question was raised – but not answered – whether Cheetahs from Southern Africa could be introduced to India.

Ranjitsinh and Jhala (2010) presented an in-depth assessment of the potential for reintroducing the Cheetah in India, including a survey of the potential sites and a population viability analysis. Ten sites were assessed in seven landscapes within the historical range of the Cheetah in India, and three were found to have the potential for Cheetah reintroduction:

- Kuno-Palpur Wildlife Sanctuary, Madhya Pradesh: 6,800 km², with a minimum capacity to host 27 Cheetahs and an estimated maximum of over 70 individuals;
- Shahgarh Landscape in Jaisalmer: ~4,000 km², 15–40 Cheetahs;
- Nauradehi Wildlife Sanctuary, Madhya Pradesh: 1,197 km² (in a forested landscape of 5,500 km²), 25–70 Cheetahs.

The main shortcomings of the sites/landscapes that were not considered further were: The total size of the area, the low wild prey population density[4], and potential conflicts with local people. However, the authors concluded, based on a PHVA incorporating environmental, genetic, and demographic stochasticity, that the three selected sites together would have a fair to high probability of population persistence, especially if all three sites were to be managed together as one metapopulation. The authors recommended sourcing animals from Africa, but also suggested a collaboration with the Government of Iran regarding Cheetah conservation.

[4] Many PAs in western and central India harbour population of blackbuck *Antilope cervicapra* and Indian gazelle *Gazella bennettii* (D. Mallon, pers. comm.), which would be suitable prey for Cheetahs.

As a way ahead Ranjitsinh and Jhala (2010) proposed that the Government of India and the concerned State Governments would first have to take a decision in principle, approve the site selection and allocate the necessary resources. After this, detailed preparatory studies and works to implement the reintroduction plan could start. However, the Indian Supreme Court halted the plans for the reintroduction of the Cheetah in 2011, because "Studies show that African Cheetahs and Asian Cheetahs are completely different, both genetically and also in their characteristics." and that “the African Cheetah obviously never existed in India” Phys.org 2012. But in January 2020 the Supreme Court responded positively to a request from the Government and agreed to the experimental introduction of African Cheetahs to suitable habitat in India (Hindustan Times 2020, BBC News 2020).

The assessment study by Ranjitsinh and Jhala (2010) was updated and supplemented by Jhala et al. (2021). They assessed or re-assessed six sites with regard to Cheetah reintroduction, e.g., prey availability, habitat suitability, anthropogenic challenges, as well as the preparatory management actions required. These assessed sites were the following: 1) Mukundara Hills Tiger Reserve, 2) Shergarh Wildlife Sanctuary, in Rajasthan, 3) Gandhi Sagar Wildlife Sanctuary, 4) Kuno NP, 5) Madhav NP, and 6) Nauradehi Wildlife Sanctuary in Madhya Pradesh. The authors concluded that the original plan to establish three to five Cheetah populations and subsequently manage them as a metapopulation was still valid, and that all six sites would be suitable, although not all to the same extent. For free-ranging Cheetah populations, (1) Kuno NP-Sheopur Forest landscape and (2) Gandhi Sagar-Chittorgarh-Bhainsrodgarh WLS with parts of Mukundara TR landscape, and with an initial fenced population (3) Nauradehi WLS, were prioritised. Other enclosures, such as Mukaundara TR, were also identified as being able to immediately host a small captive group of Cheetahs. Jhala et al. (2021) listed the allocation of the selected sites by the Government of Rajasthan and the Government of Madhya Pradesh, and the building of additional fences needed for the experimental introduction as preparatory steps.

A group of Madhya Pradesh government officials visited South Africa and Namibia in February 2022 to explore the availability of Southern African Cheetahs. The plan is to bring at least 16 Cheetahs from Southern Africa to the Kuno Palpur sanctuary in Madhya Pradesh state (BBC 2022). On 17 September 2022, eight cheetahs (five females and three males, aged between two and five-and-a-half,) were translocated from Namibia to India and are now being kept in an enclosure in Kuno sanctuary (status: October 2022) (The Guardian 2022).

### 6.2. Uzbekistan

The Ustyurt Plateau in Western Uzbekistan was probably home to the Asiatic Cheetah until the 1980s. The Cheetah was the largest predator in this open, arid, steppe landscape and is considered a flagship species for the conservation of this ecosystem. Therefore, the aim is to reintroduce this charismatic species (Pereladova & Chelysheva 2013). The long-term goal is to establish a free-ranging viable Cheetah population within its former natural range and habitats in Uzbekistan. The programme required several preparatory steps, including breeding (and training) of Cheetahs, re-establishing the key prey populations, engaging the support of key stakeholders and securing the protection of Cheetahs and their prey, including law enforcement. The proposal identified “preliminary”, “preparatory” and “general” phases, leading to a naturally growing population of wild Cheetahs.

During the preliminary phase in the years 1985–2001 four Cheetahs of the Southern African subspecies *A. j. jubatus* were acquired from Moscow Zoo and were held in a large enclosure

(15,000 $m^2$) at Ecocenter Dzeiran near Bukhara, Uzbekistan, to see if they were able to adapt to the extreme temperature conditions in the Kyzylkum Desert and the Ustyurt Plateau. The animals – as already observed in Moscow Zoo – developed thicker and longer fur during the cold periods. The Cheetahs were offered various local prey as whole carcasses and also hunted and killed Goitered gazelles (*Gazella subgutturosa*) in the enclosure. While the acclimatisation and the trials to hunt and kill were successful, the Cheetahs never reproduced, despite the Ecocenter hosting two females and two males and trying to breed them repeatedly.

The Ecocenter has the facilities to host a group of Cheetahs in several interconnected enclosures. The plan was to breed, train, and finally release Cheetahs from this facility. Founder individuals were requested from the European Association of Zoos and Aquaria Ex situ Programmes (EAZA EEP) population of Northern Cheetahs (*A. j. soemmeringii*), but so far, no animals have been provided.

Recently, the situation changed to such an extent that it now does not seem realistic to implement the next phase of the project through the Ecocenter Dzeiran near Bukhara (O. Pereladova, pers. comm.). A lack of recovery of wild prey in Kyzylkum and Ustyurt means insufficient prey to sustain a population of wild Cheetahs (D. Mallon, pers. comm.). However, some components of the programme have been continued. A new protected area was established in the Ustyurt by decree of the President of Uzbekistan on the 20 March 2019, and gazetted on the 11 November 2020 (O. Pereladova, pers. comm.): “Southern Ustyurt”, 1.4 M ha (Fig. 6.1). Accordingly, the legal protection of the habitats has significantly improved and specific measures to restore the wild ungulate populations (e.g., Goitered gazelle; see Marmazinskaya 2020) are now underway.


**Fig. 6.1**. New protected area on the Ustyurt Plateau of Uzbekistan, gazetted in November 2020. Source (O. Pereladova, pers. comm.).

In recent years the ultimate Cheetah reintroduction objective was discussed in a meeting of a delegation from Uzbekistan with Marco Lambertini, the CEO of WWF International in Gland, Switzerland and in February 2022 an Agreement of Cooperation, regarding environmental protection, was signed between WWF and the State Committee of Ecology and Environmental Protection of the Republic of Uzbekistan (WWF Russia 2021). Accordingly, WWF is planning to revise the “Programme on Cheetah Reintroduction in Uzbekistan” using Cheetahs from the EAZA EEP population of Northern Cheetahs (*A. j. soemmeringii*), taking into consideration upcoming opportunities. This work is included in the WWF Russia Strategy for 2023–2028 and its implementation will start soon (O. Pereladova, pers. comm.).

# 7. Assessment of the demographic and genetic variability of the Asiatic Cheetah

**Chapter summary**

In Iran, while a small breeding population of three females and four males was observed in Touran (Table 4.3), there are no records of breeding in Yazd Province and Naybandan since 2013, and no systematic population monitoring has been conducted over the last seven years. The current population is fewer than 50 individuals and could be as small as 12 (section 4.1), which is considerably smaller than the previously modelled population size. Hence, in its present state and without fast and substantial increase in its population size, the Asiatic Cheetah population is not viable and faces a high risk of extinction within a few generations.

Estimates of effective population sizes show that Asiatic Cheetahs have been in a continuous decline. After a historic decline between 800 and 250 generations ago (circa 4,000-2,500 years ago; Fig. 7.1, chapter 7), the Asiatic Cheetah experienced two severe recent declines, in the 1960s (to assumed 400 individuals) and in the 1980s (to estimated 50¬–100 individuals). Data on population sizes are limited, but several population estimates from 1980 to¬ until 2017 (Table 4.1, section 4.1) suggest about 50–100 adult individuals during the past 25 years, with severe decreases in the past 10 years. Therefore, it is likely that the population is now inbred. A recent study showed that the level of inbreeding in *A. j. venaticus* was higher than in other subspecies of Cheetah. Thus, the population is likely to have an average inbreeding coefficient at the level of half-siblings and to have substantially reduced genetic diversity (chapter 7). As low numbers in the Cheetah population have been sustained over multiple generations, inbreeding has built up and the most recent decline might also have intrinsic reasons. It therefore needs to be considered that an increase in population size might not be sufficient to save the subspecies, if a possible inbreeding depression becomes irreversible.

The Asiatic Cheetah urgently needs a demographic and most likely a genetic rescue strategy. Therefore, a conservation plan to recover the Asiatic Cheetah should include strategies for population management, possibly including options from across the in situ and ex situ spectrum. A range of options should be considered and evaluated, which may include conservation translocation, intensive management of individuals in the wild, and supplementation of the population with unrelated individuals that may be sourced from another subspecies. Yet, given the difficulties and uncertainties of ex situ management, especially in the case of Cheetahs, interventions should be taken with extreme care and should be well planned to avoid further and accelerated loss of individuals and genetic diversity. Interventions aimed at the genetic rescue of Asiatic Cheetah should be conducted simultaneously with actions to mitigate the primary, mostly human-caused, threats in the wild. Genetic rescue without mitigation of the ecological threats would not be sustainable. In turn, in situ rescue – even if it would successfully remove ecological threats – may be too late if the remnant population already faces intrinsic problems due to inbreeding.

In situ conservation, where populations are exposed to natural selection, is often the best way of maintaining functional genetic diversity. In the case of Cheetahs, their promiscuous mating system will allow natural selection to support adaptability and maintain genetic diversity. High genetic diversity helps increasing the entire population's resilience, safeguarding it against diseases and parasites, and maintaining adaptability to future changes, such as climate change. However, the population is now at such a low level that considerations such as natural selection may already be obsolete.

The minimum viable population (MVP) quantifies the minimum size of a population that is viable in the face of fluctuations in demographic parameters, such as survival and reproduction. Fluctuations in demographic parameters can be due to intrinsic causes due to random annual variation in individual birth and survival rates (demographic stochasticity), or external environmental causes, such as disease outbreaks or extreme climatic events (environmental stochasticity) (Gilpin & Soulé 1986; Goodman 1987). The MVP has been defined as the smallest isolated population with a 95% chance of persistence over the next 100 years (Shaffer 1983). Assessing the extinction risk of species is key to species-based threat assessment and is intrinsic to the IUCN Red List assessment process (Mace & Lande 1991, Shaffer 1990). Population Viability Analysis (PVA) is a process of examining the viability of a particular population, taking into account all the various risk factors that may affect the populations. PVA provides a useful tool to predict risks of extinction and can also incorporate genetic factors, including risks from inbreeding and fixation of deleterious alleles. Vortex (Lacy & Pollak 2021) is one of the most widely used PVA modelling tools, and has been used to predict extinction rates for several Cheetah populations and to provide conservation recommendations (Cristescu et al. 2018). However, alternative agent-based models have been developed to explore scenarios not available through Vortex (e.g., Durant 2000). All such models require multiple input parameters, primarily to provide information on the demography of the species (birth and death rates, etc.), but may also include parameters to describe population structure (number and size of subpopulations, migration rates, etc.). The availability of these parameters is a key factor limiting the applicability of the models. In the case of the Asiatic Cheetah information is not available for many of these variables, which would therefore need to be estimated from African populations. However, it may still be possible to draw some general conclusions. For example, simulation models have previously shown how population subdivisions and migration-associated mortality can markedly decrease persistence of Cheetah populations and hasten declines in genetic diversity (Durant 2000). This study indicated that panmictic Cheetah populations, protected from the worst impacts of environmental stochasticity, have the highest chance of long-term persistence (Durant 2000).

The most recent information on the Asiatic Cheetah (see Table 4.3) identified a small breeding population (three females and four males) persisting in Touran, and a small population with no record of breeding in Yazd province and Naybandan (three to four males). Other than these identified individuals, there are occasional Cheetah observations in non-protected areas. No systematic population monitoring has been conducted during the last years, but it is likely that the current population consists of less than 30 individuals (see section 4.1.). The population size of the Asiatic Cheetah is already substantially smaller than previously modelled populations [>50 divided into two subpopulation (Khalatbari et al. 2017); or 300 divided into 15 subpopulations, each containing 20 individuals (Durant 2000a)].

Hence, in its present state and without fast and substantial increase in its population size, the Asiatic Cheetah population is not viable and risks extinction within very few generations. Further PVA analyses are only likely to reinforce this finding.

Estimates of effective population sizes from current to ancestral times were made, using a coalescent approach, implemented in the R package VarEff (Nikolic & Chevalet 2014). This predicts effective population size over time, using microsatellite data, and shows that Asiatic Cheetahs were in continuous population decline, but the rate of decline changed at two points in its history; with an accelerated decline c. 800 generations ago (c. 4,000 years), and a slowing down in this decline 250 generations ago (c. 1,250 years) (marked by arrows in Fig. 7.1; L. Khalatbari, pers. comm.).

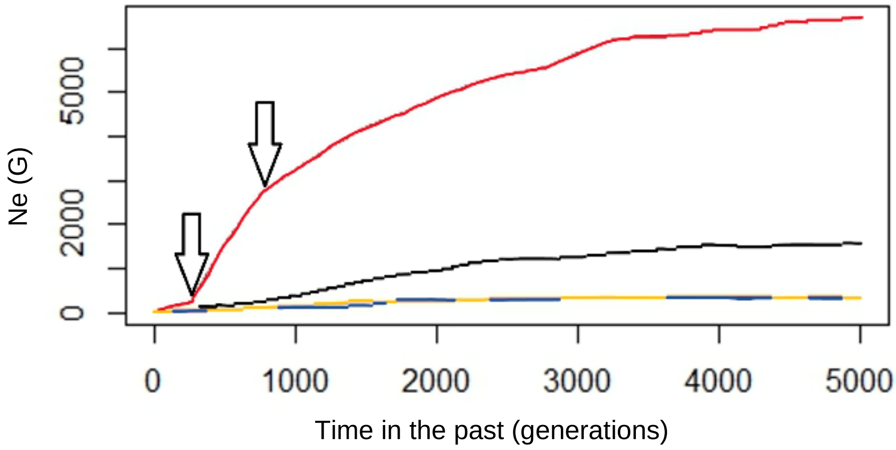


**Fig. 7.1**. Results of VarEff (Variation of effective population size) analysis: The red line presents mean of effective population size, blue line is mode, black is median and yellow is harmonic mean of the effective population size (Ne) over time. Source: L. Khalatbari, pers. comm..

In more recent times there have been two documented severe declines in Asiatic Cheetah. The population was extirpated from most of Asia during the late 20th century and was limited to within the borders of Iran by the 1970s, with the population estimated to consist of 400 individuals (Farhadinia et al. 2017 and references therein: Harrington 1971) (see section 4.1). This restricted population experienced a second severe decline in the 1980s (c. 8 Cheetah generations ago), which reduced it to approximately 50 to 100 individuals in six subpopulations (Asadi 1997). From the 1980s to 2017 different studies have reported different estimations of population size, which are summarised in Table 4.1 (see section 4.1 for more details). However, these estimations are based on extremely weak data, as there were no systematic surveys of Cheetahs at this time.

Additionally, in a recent study by Khalatbari (2021) the effective population size was estimated to be only 11.7 individuals (95% confidence interval: 6.7 to 21.6, using NeEstimator) and 17.2 individuals (95% confidence interval: 9.9 up to 35.6, using COLONY), (Do et al. 2014, Wang 2009). These estimates are substantially below the proposed minimum Ne/N (effective population size/numeric populations size) of 100/1000 required to ensure the long-term persistence of a species (Frankham et al. 2014).

Given the range of expert opinions on population size, it is plausible to consider that the population has ranged between 50–100 adult individuals during the past 25 years and, therefore, it is very likely that the population has lost substantial genetic diversity and become inbred. Prost *et al.* (2022) found that, based on 3,743 SNPs, the level of inbreeding in *A. j. venaticus* was higher than in other subspecies of Cheetah (except for *A. j. hecki*; blue bars in Fig. 5.2), although results for both these subspecies are based on very small sample sizes (N=3 and N=2, respectively), which may not be representative.

Small and isolated populations are more vulnerable to stochastic processes, such as random, demographic, and environmental variation, catastrophes and genetic drift (Shaffer 1981). This in turn can lead to skewed sex ratios, Allee effects, inbreeding, and other characteristics that reduce survival and reproduction, and can lead to further decline and potential extinction of the population. This feedback loop of stochastic effects and continuing decline is known as the “extinction vortex” (Gilpin & Soulé 1986) and contributes to increased risk of extinction for small populations (adapted from Traylor-Holzer et al. 2022).

Kelly (2001) found a high rate of loss of matrilineal lineages in Cheetahs and estimated Ne/N= 0.1 (Kelly 2001). This, combined with a generation time of 4.9 years (Durant et al. 2022a), suggests that genetic diversity in small populations may be lost rapidly (E. Fienieg, pers. comm). However, paternity studies have found high levels of promiscuity in female Cheetahs, which may compensate for losses of diversity through maternal lineage loss in the wild (Gottelli et al. 2007). While it is difficult to give precise figures, the severe population decline of the Asiatic Cheetah over the past century, and its low numbers sustained over multiple generations, could have resulted in an inbreeding coefficient today that is as high as full-siblings. However, recent studies showed that individuals of each subpopulation are related to each other at levels similar to half-siblings or grandparents and grandchildren (Khalatbari 2021).

While populations can survive at small population size and with low levels of genetic variability for quite some time, random chance plays a strong role, and deleterious genes may become fixed in a population. In such situations, inbreeding depression may become irreversible. Given this potential risk to the Asiatic Cheetah, which will be increasing over time as genetic diversity continues to be lost, the population may soon get to the point where it will be impossible to reverse declines without some form of genetic rescue.

According to the recent population estimation by the DoE, 12 adult Cheetahs were identified, in the most optimistic scenario, half of which are females (six or fewer). With each generation the chance of full-sibling mating increases, and this increases the chance of the expression of recessive alleles. Where these alleles are deleterious (and all species carry some deleterious recessive alleles, known as a genetic load), they will reduce the survival or reproductive prospects of individuals. Should such alleles become fixed in the population, then it will be impossible to recover the population. The only hope for the subspecies at this point, will be through a genetic rescue strategy. In Cheetahs the manifestation of deleterious traits caused by excessive levels of homozygosity (inbreeding depression) appear to be limited (Schmidt-Küntzel et al. 2018). This suggests that strong selective pressures may have purged deleterious alleles from the species (Schmidt-Küntzel et al. 2018), as has been observed in other species (Robinson et al. 2018, Grossen et al. 2020). However, there is likely to be a point of no return for Asiatic Cheetahs, as in other species, at which point recovery will become impossible. The best hope for a genetically compromised population is a rapid recovery of the population to return it to a level of well above 100 individuals. If this can be achieved quickly, then it is possible for a population to escape the extinction vortex. However, if rapid recovery is not possible, there is a need to consider alternative approaches to increase genetic diversity and maintain it in the long-term, while continuing to improve conditions to enable the population to become viable in the wild.

Therefore, a conservation plan to recover the Asiatic Cheetah should include strategies for population management, which might include options from across the *in situ* and *ex situ* spectrum. A range of options may be considered, which may include conservation translocation, intensive management of individuals in the wild, and supplementation of the population with unrelated individuals that may be sourced from other subspecies (K. Leus, pers. comm., see chapter 6). Yet, given the difficulties and uncertainties of *ex situ* management, especially in the case of Cheetahs, interventions should be taken with extreme care and should be very well planned to avoid accelerating loss of diversity and individuals (Khalatbari et al. 2021). In addition, any interventions aimed at the genetic rescue of Asiatic Cheetah should be conducted simultaneously with actions to mitigate the primary, mostly human-caused, threats. Otherwise, the same causes will drive the population to the same status as before (K. Leus, pers. comm., Khalatbari et al. 2021).

*In situ* conservation, where populations are exposed to natural selection, is often the best way of maintaining functional genetic diversity (Kaeuffer et al. 2007). In the case of Cheetahs, their promiscuous mating system will allow natural selection to support adaptability and maintain genetic diversity (Pérez-González et al. 2009). High genetic diversity helps increasing the entire population's resilience, safeguarding it against diseases and parasites, and maintaining adaptability to future changes, such as climate change (Spielman et al. 2004).

# 8. Final considerations, possible scenarios and outlook


**Chapter summary**

The Asiatic Cheetah is Critically Endangered and closer to extinction than ever before, despite conservation efforts having been undertaken for more than 20 years. Recovery of the Asiatic Cheetah may still be possible if timely and effective in situ conservation measures are implemented, likely with the support of ex situ breeding (section 8.1 and 8.2).

In situ conservation considerations include actions to effectively manage the PA network, the ranger system, the conditions for rangers and to improve monitoring and patrolling of rangers; limit the conflict between livestock husbandry and wildlife conservation; to reduce Cheetah mortalities due to roadkills; to manage and safeguard water sources; to conserve and monitor wild prey; to conserve habitat corridors, suitable marginal habitats, and habitat stepping stones and to control negative effects of mine excavations (section 8.1.1).

Ex situ breeding seems highly recommendable, but the practical approach depends on the following questions: (1) whether the population in Iran can be maintained with in situ measures alone, (2) whether the Asiatic Cheetah *A. j. venaticus* can be rescued as a standalone subspecies through the capture and breeding of Cheetahs in captivity, and (3) whether at least most of the *A. j. venaticus* genome can be conserved through the reinforcement of the Asiatic Cheetah population with another Cheetah subspecies. Owing to the very low current population numbers, none of these scenarios can guarantee saving Asiatic Cheetahs from extinction and each of them have their own associated risks. Based on the answers to these questions, a number of different scenarios and sub-scenarios are identified, all with associated risks, costs and benefits explained in section 8.2.1. Scenario A consists of in situ measures alone, scenario B of ex situ measures, in which there would either be a pure-bred *A. j. venaticus* ex situ population (B1) or an admixed population, including individuals from other Cheetah subspecies (B2), and scenario C would consist of a combination of in situ and ex situ approaches by maintaining a group of reproducing Cheetahs in Touran, and accelerating (admixed) breeding to provide animals for population reinforcement. Variations and spatially explicit adaptations (e.g., different approaches for the Northern and Southern Cheetah range in central Iran) are also possible.

If genetic rescue through a conservation breeding programme is to be considered, this should be implemented as soon as possible to preserve as much local genetic diversity and local adaptations as possible. The Cheetah's reproductive behaviours will also need to be considered, i.e., many females do not reproduce in captivity while all female Cheetahs reproduce in the wild and female Cheetahs mate promiscuously in the wild. Several scenarios of genetic-rescue modelling are needed to minimise the risk of losing male and female lineages. While a successful ex situ reproduction was achieved in Touran (section 4.5.3), subsequent mortalities in the litter have demonstrated the difficulties of such a programme. If conservation breeding continues, any Iranian Cheetah is of great value for the subspecies' survival and must be handled with utmost expert care. Available information suggests that there are no reproducing females left in the Southern subpopulation and that the functional connectivity between Southern and Northern subpopulations may have been lost. Therefore, the lone males of this region could be integrated into a conservation breeding programme, or females from another subspecies could be released in the south.

The general IUCN Reintroduction Guidelines on mixing subspecies advocate for this to be handled with care and to be case-specific (section 8.2.1). Mixing populations or subspecies is a balance between inbreeding and outbreeding and if *A. j. venaticus* is to be admixed with animals from another subspecies, biological considerations (phylogenetic, ecological and morphological similarities) need to be kept in mind. Most recent research suggests that, based on FST values, *A. j. soemmeringii* is genetically closest to A. j. venaticus, followed by *A. j. jubatus, A. j. raineyi* and *A. j. hecki*. From a practical point of view, both *A. j. jubatus* and *A. j. soemmeringii* would be the most easily available, as there are good established breeding programmes (Appendix X). Phylogenetically and geographically the closest subspecies is *A. j. soemmeringii*, which would likely be fairly easily available from the EAZA Northern Cheetah EEP, and possibly from confiscated animals held in the United Arab Emirates. Availability of suitable and compatible Cheetahs – at an individual level – should be investigated. All the actions for increasing the population size in situ or ex situ should be conducted simultaneously with actions to mitigate the primary, mostly human-caused, threats, otherwise the population will not be able to recover (chapter 8).

So far, Asiatic Cheetah conservation has received about USD 2,400,000 from national and international budgets over the past 20 years. Although the allocated budget and conservation actions were essential for the prevention of the extinction of the Asiatic Cheetah, they were insufficient to halt the decline of both the population and the distribution range. The lack of funding for the Asiatic Cheetah was also related to United Nations UN Security Council sanctions against Iran. The capacity and available funding within Iran seems not to be sufficient to launch a rapid and effective emergency programme for saving the Asiatic Cheetah from extinction. International cooperation in such a priority conservation task is indispensable. Considering exemptions for urgent conservation tasks for such sanctions by the international community, along with measures to protect conservation personnel in range countries, could overcome these obstacles (section 8.3). Implementing the CMS CAMI POW Activities related to fundraising for the Asiatic Cheetah specifically (10.10) and fundraising in general (31.6) are crucial to implement much needed conservation action.

To prevent the impendent extinction, it is needed to learn from the experience of the last two decades, summarized in this report, to make decision on further actions. The main problem in the past was not the lack of understanding or wrong planning, it was the deficient implementation of conservation measures. Significant efforts and sufficient funding were and will be needed to save the Asiatic Cheetah from extinction. The means available in the past were not sufficient, and it seems unlikely that the Iranian conservation institutions will have the capacity and financial resources needed to implement an emergency rescue plan for the Asiatic cheetah now. Hence, international collaboration and support is needed to achieve this goal urgently. However, given the dire situation of Cheetah and its insufficient conservation during the last five years, there is no guaranty that, even if all the means are allocated timely and activities are implemented efficiently, that the remnant population of Cheetah will survive. Nevertheless, a last effort to save the Asiatic cheetah from its final extinction should be undertaken as a common responsibility of the global conservation community.

Despite over 20 years of conservation the Asiatic Cheetah is still critically endangered and moving ever closer to extinction. However, the recovery of the population may still be possible, if immediate action is taken to implement priority conservation interventions. It is recommendable that resolving or mitigating *in situ* threats to Cheetah receives the lion's share of Cheetah conservation funding in Iran, both by trying to save the remaining Cheetahs from extinction, and by preparing the recipient landscape for any re-stocking, reintroduction or introduction efforts resulting from *in situ* conservation attempts.

### 8.1. *In situ* conservation considerations

In 2017, Cheetah experts from the DoE, the CACP and several conservation NGOs met in Teheran to discuss conservation priorities and propose immediate, mid-term and long-term actions (Khalatbari et al. 2017; Table 8.1). A list of experts and their affiliation is presented in the supplementary material of Khalatbari *et al.* 2017. At that time, the situation of the Cheetah was already considered very critical, but not as perilous as today. Nevertheless, most of the conservation needs and proposed actions are still important.

**Table 8.1.** Overview of conservation priorities and actions defined in the 2017 expert workshop

| Conservation priorities | Actions |
|---|---|
| Measures to protect the remaining Cheetahs | Recovery of prey population, specifically gazelles, through prioritising prey management by the DoE and livestock management especially in Touran and Miandasht; |
| | Safeguarding Semnan-Mashhad Road; |
| | Protecting corridor habitats. |
| Improve understanding of the status of and threats to Cheetahs and increase political commitment | Establishing a comprehensive wildlife population monitoring scheme (Cheetah, co-predators, prey); |
| | Assess effective Cheetah population size, population structure, and inbreeding levels through genetic studies |
| | Perform a population viability analysis to understand if the metapopulation is still demographically and genetically viable and is able to recover; |
| | Standardise monitoring protocols to allow comparison of data collected from different sources; |
| | Assess risk of disease transmission from livestock and guarding dogs to wild herbivores and carnivores, respectively, and identify most efficient prevention measures. |
| Mid- to long-term measures that need further data and discussion before implementation | Based on the conclusions of the PVA, consider a conservation breeding programme following a thorough feasibility study; |
| | Develop a livestock-wildlife coexistence strategy; |
| | Recover rangeland and prey populations in more temperate suitable habitat. |

Since this action planning, measures to reduce collisions with vehicles were implemented to a limited extent on the Semnan-Mashhad Road (see 4.5.2); grazing licenses in Touran were bought out from livestock owners through several initiatives, and livestock removed (Fig. 4.10, additional grazing licenses not shown in the figure were purchased by DoE in 2021-2022), ICS, DoE as well as other private donors supported ranger forces work and their equipment in Touran (Payamema 2022b, S. Ostrowski pers. com.), and a captive breeding programme was started in Touran. In other Cheetah protected areas, game guards (rangers) have continued patrols and protection to some extent, despite considerable logistical difficulties owing to the prevailing poor economic condition.

Two studies documented the effective population size, population structure and inbreeding levels (Khalatbari 2021; Prost et al. 2022; chapter 5).

No population viability analysis has been performed, but a brief comparison with population viability models for other Cheetah populations and currently available data for the Iranian population are given in chapter 7 and indicate the perilous predicament of its current situation.

#### *8.1.1. Revisiting conservation priorities and implementation of activities*

As the previous conservation priorities actions have been defined in 2017 and since then, several variables regarding the conservation of Cheetah in Iran have changed, it is needed that Iranian experts, conservationists, managers of protected areas and DoE experts develop an integrated action plan, possibly in consultation with the international conservation community.

In the following sections, recommendations for specific conservation challenges that could be considered in developing this action plan are proposed:

*Protected Areas, PA management and ranger system*

Over the last decades, Iran has made remarkable efforts at expanding and upgrading its network of protected areas in Dasht-e Kavir in order to protect Cheetahs and their prey. Even so protected areas are rarely large enough to secure the totality of range use of large mammals in arid environments (see also 8.1.6), they could provide safe havens at critical moments of their life cycles (e.g., breeding, calving…etc.) and secure, at least theoretically, a certain level of surveillance and protection. Unfortunately, large funding gaps and local policy failures have affected the quality of their management in Iran and hampered their effectiveness.

The status and numbers of ranger forces in Cheetah protected areas is one example of shortcomings. Over the last forty years, and country-wide, an average of 2–3 DoE rangers per year have died while on duty, many of them were killed by poachers (Jowkar et al. 2016 and references therein). In the face of these risks, low wages and poor working conditions reduce their morale and foster corruption (see e.g. the case of capturing of one female Cheetah cub from Miandasht WR described in section 4.5.3). Rangers often have insecure contracts, at times delayed payments, are insufficiently trained and are rarely offered positive career enhancements. The overall budget available to the DoE is far too small to address these problems and has repeatedly been subject to cuts. The effective budget has further been restricted by macro-economic problems of Iran, partly resulting from international sanctions (Jowkar et al. 2016, Khalatbari et al. 2018b). These problems were already identified in the first phase of the CACP (Breitenmoser et al. 2009) and have since not been sufficiently addressed. Eventually, rangers are too few to be optimally used and distributed to maximize protection (Ghoddousi et al. 2016).

There is an urgent need for the country to act to improve the pay and conditions of rangers and improve professionalism across the sector should the survival of wildlife be a genuine objective. Steps that should be considered are:

- Increasing the number of rangers and ensuring they are provided with adequate personal equipment and career enhancement opportunities;
- Providing sufficient vehicles (cars, motorcycles), together with fuel and maintenance, providing well-appointed ranger stations to support regular patrols and to ensure good coverage of PAs;
- Increasing salaries of rangers and their management above the threshold under which misuse of natural resources is a necessity;
- Provide full medical insurance for the rangers and their families;
- Providing legal protection for rangers (e.g., similarly to the civil police force) to ensure they carry out their duties confidently and in greater safety;
- Engaging local DoE offices and rangers with communities (co-management capacity, awareness), improving communication skills, and organising joint events and outreach activities (Jowkar et al. 2016), in order to raise the profile of PAs and rangers in the local communities.
- Providing wildlife monitoring digital tools with automatic geo-referencing, such as SMART for data collection and for optimizing ranger's monitoring efforts.

*Livestock*

Livestock are considered a threat to Cheetahs and prey mainly in the Northern habitats. In general, livestock in prime Northern Cheetah habitats have been considered problematic to wildlife conservation because their numbers largely overshoot carrying capacities of (increasingly drying) rangelands, and guarding dogs (essentially maintained against wolves and jackals) are of proven danger to Cheetahs. However, conflicts between livestock husbandry and wildlife conservation – both Cheetah and its prey – cannot be resolved easily due to the lack of alternative economic options. Local people have traditional grazing rights – often in form of grazing licences owned by families – which they understandably adhere to, and are unwilling to give-up. When assessed from an economic perspective, it appears that traditional livestock husbandry in areas such as Touran, is an increasingly unprofitable occupation, and investigating alternative options, long-term perspectives and wishes of traditional livestock owners is an urgent necessity, as a consequence of climate change, not merely for conservation reasons. Ecotourism has been proposed as a possible alternative livelihood but has so far not substantially contributed to the local economy and it is to be expected that developing and implementing a locally agreed strategy to support a transition from a livestock-based economy to a nature-based economy is unrealistic, and will take too long to prevent the extinction of Cheetah. As an urgency, reducing the direct and indirect impacts of livestock in prime Cheetah habitats through buying out grazing licenses, enforcing effective controls over the number of livestock and shepherd dogs in Touran and Miandasht protected areas should be continued. Concomitantly, offering temporary long-term (25 year) leasing agreements to local livestock owners, particularly in buffer zones and corridors connecting protected areas, should be activated as soon as possible to curb the nefarious trend of people selling their grazing rights to external meat market speculators without local ties. On the longer term, a global reflection on sustainable use of rangeland across Cheetah habitat is to be initiated and effective restoration plans to be implemented as soon as possible to secure remaining wildlife and/or prepare the ground for any successful restocking, reintroduction or introduction attempts of Cheetahs and prey. Such approach, which would concern an area larger than 25 million hectares, and hundreds of rural communities requires a long-duration nation-scale investment.

*Safe road crossings*

Speed limits of 80 km/h between Miamai Karvansara and Abbas Abad Village on the M44 highway (Semnan-Mashhad) need to be enforced, possibly with the help of technical devices. Other adjustments, such as equipping the road with proper light and providing resting areas for drivers to reduce fatigue and remain focused, may also reduce Cheetah-vehicle collision. The underpasses in the fenced areas should be observed by wildlife cameras to evaluate if they are being used by Cheetahs or not. Based on such monitoring, protective measures need to be expanded to all dangerous parts of the road (Fig 4.13 and 4.14, Mohammadi et al. 2018, Khalatbari 2021).

*Water sources management*

Although several observations show that artificial water sources attract several herbivores and even carnivores after being constructed or repaired, the long-term ecological impacts of increasing water sources without proper study on the consequences and possible changes on the herbivore and carnivore community should be considered carefully. Water supplementation should not end up benefitting more livestock than wildlife in protected areas. Water source designs should as far as possible exclude livestock to avoid attracting them to the area, increasing local trampling and overgrazing, and potentially spreading deadly infectious agents to wildlife. It is urgently recommended to develop a concerted and comprehensive water supplementation plan across all Cheetah protected areas and implement it genuinely to optimize the ecological value and cost-effectiveness of this management action.

*Prey conservation*

Given the current status of the current breeding centres for herbivores (section 4.6.2.), significant technical and financing improvements are required should any of these centres aim for restocking wild prey populations for Cheetahs in the future. Globally it has proved far more cost effective and safer to promote the natural increase of free-ranging prey populations rather than investing for decades in captive-propagation operations.

New methods of herbivore population census should be established (section 4.3.3). Thorough population census of herbivores should be carried out in all PAs with modern, more accurate methods. Vaccination of livestock entering the protected areas should become mandatory to prevent wildlife mortality caused by transferring deadly infectious pathogens from livestock. Rangeland management should be considered where it is degraded, in order to reduce negative effects of drought. Measures to mitigate the impacts of linear infrastructure development and to maintain and restore connectivity of herbivores need to be considered (CMS 2015).

*Conservation of habitat corridors, marginal suitable habitats and stepping-stones*

Considering the limited capacity and means of the DoE (see 3.4.2.), the development of Private Reserves (PRs) (see section 4.3.2) for conservation of stepping-stones (Fig.4.19) was considered an alternative solution, which incorporates the private sector and local communities into the conservation of habitats and allows them to benefit from their potential (H. Zohrabi pers. comm.).

Among the five currently established pilot PRs, those located in Kerman and Yazd and based on sustainable hunting approaches, have been particularly successful at increasing wildlife populations within their boundaries, improving habitat conditions, changing the local culture towards conservation, and even improving the economic situation in certain parts (H. Zohrabi pers. comm.). By providing adequate facilities and equipment through the private sector, PRs can help maintaining or increasing wildlife abundance, but also benefit local communities by providing jobs, involving hunters in wildlife management and developing a new culture for wildlife conservation, developing ecotourism.

However, there has been some opposition against hunting-based PRs, primarily reflecting radical views of anti-hunting groups in civil society often relayed in the media (Mizan News 2021b). This has caused problems for the continuation of existing PRs and for the approval of new ones (H. Zohrabi pers. comm.). More efforts should be done to communicate transparently the successes of pilot PR in restoring wildlife and conserving the environment in Iran.

*Mine excavation*

As mine excavation can have long-term negative effect within PAs and on corridor habitats, it is important to understand and reduce these impacts. Given the high contribution of this industry to the economy of local communities and even at national scale, it is unrealistic to avoid mining, but it is possible to minimise the impact on wildlife and nature in general. As this is not fully possible, mine industry should contribute to nature conservation by providing funding for conservation of PAs and PRs as a part of their social responsibility and as compensation. Environmental impact assessments for existing and new mines and mechanisms of contributions/compensation should be defined jointly by the DoE and Ministry of Industry, Mine and Trade (J. Najafi, pers. comm.).

### 8.2. *Ex situ* conservation considerations

Critical questions around the conservation of Asiatic Cheetah are: (1) Can the population in Iran still be maintained with in situ measures alone? (2) If not: Can *A. j. venaticus* be rescued as a stand-alone subspecies through capturing Cheetahs and breeding them in captivity? (3) If not: Can at least most of the *venaticus* genome be conserved through reinforcement of the Asiatic Cheetah population with another Cheetah subspecies? Answers to these questions confer a number of different scenarios and sub-scenarios, which all have their pros and cons that are addressed hereafter. Each of these options bears its risks, which are difficult to evaluate given limited available information and the uncertainty that is inevitably inherent to such activities. Decisions need to be taken, not only in the light of imperfect understanding, but also under increasing time pressure as the Asiatic Cheetah runs out of time.

Captive breeding of Cheetahs poses a particular challenge. While most female Cheetahs reproduce in the wild (Laurenson, Caro & Borner 1992), a large proportion of them do not breed in captivity (86% reported by Wachter et al. 2011). Moreover, female Cheetahs mate promiscuously in the wild, a behaviour that is thought to maximise the genetic diversity of their litters (Gottelli et al. 2007). However, captive female Cheetahs, usually do not have the opportunity to mate with more than one male, and hence will produce litters with lower genetic diversity than found in wild populations. Having several males in captivity and a clever design of the enclosures can potentially solve this problem, but will pose additional pressure on the wild population, if funders should be Asiatic Cheetahs.

Given the complexities around Cheetah reproduction in wild and captive environments, models can help in assessing the potential impacts of different interventions, explore different management scenarios, and provide guidance on the best approach. This could, for example, help identify optimum numbers and characteristics of individuals (e.g., age and sex) for genetic supplementation, plan future release scenarios, and understand the relative importance of different subpopulations and the impact of migration mortalities (Haines et al. 2005, Durant 1998).

### *8.2.1. Possible scenarios for ex-situ and in-situ conservation*

The following options can be derived from the questions asked in previous sections:

***Scenario A*:** Continue and enforce the *in-situ* conservation of Asiatic Cheetah alone.

***Scenario B*:** Save the Asiatic Cheetah through a conservation breeding programme to create an *ex-situ* source population for future reintroduction, either
***Scenario B1:*** as a pure-bred population of *A. j. venaticus,* or
***Scenario B2:*** as an admixed population including individuals from another Cheetah subspecies.

***Scenario C*:** Combine *in-situ* and *ex-situ* approaches by maintaining a group of reproducing Cheetahs in Touran, and accelerate (admixed) breeding to provide animals for reinforcement.

Scenario A is the "classical" conservation approach of the CACP and partners for the past 20 years and has not been able to halt the decline of the free-living population. There is no indication that the conservation strategy *per se* was wrong, but (as summarised in this Report) there is evidence that Cheetah conservation in Iran never had sufficient capacity, resources, and support to be successful. All implemented *in situ* measures would now, with an extremely reduced Cheetah population, have to be successful not only in halting decline, but in rapidly reversing declines of Cheetah and their prey.

Scenario B1 requires the capture of most remaining Asiatic Cheetahs, especially the females, and breed them all in captivity to save the taxon temporarily in a conservation breeding programme. The risk is that not all females might be caught, or capture efforts may lead to injuries or even losses of Cheetahs. Furthermore, the breeding success might be low, and the genetic diversity of the remnant Asiatic Cheetah population might already be too low to allow the creation of a healthy captive group able to serve as source population for reintroduction (see below).

Scenario B2 (see below for further considerations) is likely to provide the fastest approach for creating a captive source population. The obvious disadvantage is that the Asiatic Cheetah *A. j. venaticus* would be admixed with another Cheetah subspecies and hence lose its uniqueness and genetic adaptation to local conditions, although these are currently unknown. On the other hand, if reduced genetic variability and/or inbreeding has already negatively impacted the remaining population, admixture might be the only chance to save at least part of the indigenous gene pool of the Asiatic Cheetah.

Scenario C is at first sight, the most rewarding approach. However, the crucial question is whether the very small population, that would have to be further split into an *in-situ* and an *ex-situ* part, would allow the successful implementation of both approaches. C could be implemented as a combination of A and B2, e.g., pairing (isolated) Asiatic Cheetah males with females from another subspecies. Another challenge of Scenario C would be that it is the most demanding of resources and hence most expensive approach[5] (see below).

Whichever approach is finally implemented, *in-situ* work (section 8.1) must be continued, because conservation breeding should, as soon as feasible, lead to reintroducing Cheetahs into suitable, well-prepared areas in Iran and the long-term recovery of Cheetah and its prey.

Variations and spatially explicit adaptations (e.g., different approaches for the Northern and the Southern Cheetah ranges in central Iran) of the above outlined rough scenarios are also possible and deserve further investigation. Furthermore, assisted reproduction could in theory allow the production of more Asiatic Cheetah offspring than a few captive Cheetahs would naturally allow, and even combine *in-situ* and *ex- situ* reproduction. But the potential benefit of such invasive technique needs to be against the risks (e.g., injuries, stress, social disturbance) any intervention poses to an individual Cheetah.

If genetic rescue by means of a conservation breeding programme is to be considered, then the sooner it is implemented, the greater chance there is of preserving local genetic diversity and local adaptations (E. Fienieg, pers. comm.).

The first successful *ex situ* reproduction was achieved in the Touran facility (see section 4.5.3), but the raise of this litter, along with the prior lack of success in reproduction, also demonstrated the difficulties of such a programme without appropriate experience and resources. If conservation breeding continues, any Iranian Cheetah is of outstanding value for the survival of the Asiatic Cheetah and must be handled with utmost care. Available information suggests that there are no more reproducing females in the Southern part of the range. Without breeding females, and if the functional connectivity between habitats is lost, these lone males cannot contribute to the survival of the subspecies. Hence, they could be integrated into a conservation breeding programme under scenario C, or females of another subspecies could be released in the south to have a first trial at reinforcement with no additional demographic risk for the remnant populations.

*Sourcing Cheetahs for supplementing the current population*

The IUCN Reintroduction Guidelines (IUCN SSC 2013) give rather general advice on mixing sub-species, but recognise that this might be necessary and that it should be handled with care.

Taxon substitution

In some cases, the original species or subspecies may have become extinct both in the wild and in captivity; a similar, related species or subspecies can be substituted as an ecological replacement, provided the substitution is based on objective criteria, such as phylogenetic closeness, similarity in appearance, ecology and behaviour to the extinct form.

**Genetic considerations**

**1.** The founder selection should aim to provide adequate genetic diversity.

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[5] The current breeding programme in Semnan Province, e.g., required a considerable part of the rangers' time, about 20% of total budget for Cheetah conservation in 2021 according to Payamema 2022b.

**2.** Source populations physically closer to, or from habitats that are similar to, the destination may be more genetically suited to destination conditions.

**3.** If founders from widely separate populations or areas are mixed, there may be genetic incompatibilities.

**4.** Conservation introductions may justify more radical sourcing strategies of deliberately mixing multiple founder populations to maximise diversity among individuals and hence increase the likelihood of some translocated individuals or their offspring thriving under novel conditions.

**5.** Genetic considerations in founder selection will be case-specific. If a translocation starts with a wide genetic base, a sufficiently large number of individuals, and subsequent differential performance or mortality is acceptable (and is monitored), then the genetics of the founder selection are unlikely to constrain feasibility of a conservation translocation.

(Citation from Guidelines for Reintroductions and Other Conservation Translocations, IUCN SSC 2013, page 9; further discussion see Annex 5.5 of the Guidelines)

The intention of mixing populations or subspecies is to balance between inbreeding (if the breeding group is too narrow) and outbreeding (if the animals brought in from the outside are too different from each other and/or to the original group). If it is decided to boost *A. j. venaticus* with animals from another subspecies, two questions need to be considered:

1. What is the best alternative from a biological point of view?
2. What animals are in practice available at relatively short notice?

Biological considerations include (1) phylogenetic, (2) ecological, and (3) morphological similarities of a substitute/support group to the original taxon/population.

Phylogenetic delineation of Cheetah subspecies is presented in sections 2.1 and 2.2, morphological and ecological aspects in sections 3.1 and 3.2 and the genetic status of *venaticus* in section 5. Most recent research (Prost et al. 2022; see also discussion) suggests that, based on $F_{ST}$ values, *A. j. soemmeringii* is genetically closest to *A. j. venaticus*, followed by *A. j. jubatus*, *A. j. raineyi* and *A. j. hecki*. From a practical point of view, both *A. j. jubatus* and *A. j. soemmeringii* would be the most easily available, as there are good established breeding programmes (Appendix X). Phylogenetically and geographically the closest subspecies is *A. j. soemmeringii*, which would likely be fairly easily available from the EAZA Northern Cheetah EEP, and possibly from confiscated animals held in the United Arab Emirates. Availability of suitable and compatible Cheetahs – at an individual level – should be investigated.

For the impending reintroduction of Cheetahs in India, the use of Cheetahs from Southern Africa were translocated to India for a first *ex-situ* breeding trial. The plan for the reintroduction of Cheetahs in Uzbekistan considered using animals from the Northern Cheetah EEP. An important question to be discussed at international level is whether for the future recovery of the Cheetah in Asia, one source population (in form of a managed, for the time being captive metapopulation) should be established. We have no information on the original genetic variability of the Asiatic Cheetah, but it is obvious that the ecological differences between historic parts of the range of Cheetah in Asia are as prominent as they are today across the Cheetah range in Africa.

## 8.3. Capacity and Funding

Conservation of the Asiatic Cheetah received about USD 2,400,000 from national and international sources over the last 20 years. Although this is a relatively large budget in comparison to other conservation projects in Iran, it was by far not enough to implement all required conservation activities in a proper way. Although the allocated budget and implemented conservation actions were essential for preventing the extinction of the Asiatic Cheetah, they were not enough to halt the decline of the population and the distribution range. The lack of funding for Asiatic Cheetah conservation was related to the UN sanctions against Iran, which made it not only impossible to receive international support, but also caused cuts in national conservation budgets. Considering exemptions for urgent conservation tasks from such sanctions by the international community, along with measures to protect conservation personnel by range countries, could overcome these obstacles (Khalatbari et al. 2018b).

The CMS CAMI POW listed as one of the activities with high priority:

> *Activity 10.10: Conduct an international Asiatic Cheetah conference in Teheran with all relevant stakeholders to develop a regional programme for the conservation of Cheetah and fundraising.*

The conference was planned for 2018 with regard to CACP III, but the meeting never took place and CACP III was abandoned.

Still, the lack of financial means seems an insurmountable obstacle to implement a Cheetah conservation programme. The CMS CAMI POW lists, under 31. Funding, 12 activities that address the funding of conservation projects for the species listed under CAMI. Several of these activities focus specifically on transboundary conservation projects for migrating species and are therefore not applicable to the remnant Asiatic Cheetah population in Iran, while others are more general and may also be an option to fund Asiatic Cheetah conservation:

> *Activity 31.6: Explore funding options through the Global Environment Fund (GEF), including GEF Small Grants Programme projects for joint proposals between several countries with involvement of GEF-implementing agencies (World Bank, Asiatic Development Bank, UNDP) in the processes of project application.*

## 8.4. Concluding remarks

More than 20 years of conserving Asiatic Cheetahs succeeded to prevent the extinction of the species in the wild – despite all the problems – and remarkably increased the knowledge on the ecology and conservation of the species. However, there was no turn-around in the negative population trend, and the species is closer to extinction than ever before.

To prevent the impendent extinction, it is necessary to learn from the experience and knowledge produced in the last two decades, summarized in this report, to decide on the future actions. The main problem in the past was not the lack of understanding or wrong planning, it was the deficient implementation of conservation measures. Significant efforts and sufficient funding and effort were and will be needed to save the Asiatic Cheetah from extinction. The means available in the past were not sufficient, and it seems unlikely that the Iranian conservation institutions will have the capacity and financial resources needed to implement an emergency rescue plan for the Asiatic cheetah now. Hence, international collaboration and support are needed to achieve this goal urgently. However, given the very dire situation of Cheetah and its insufficient conservation during the last five years, even if all the means are allocated timely and activities are implemented efficiently, there is no guarantee that the remnant population of Asiatic Cheetah will be saved from extinction. The only chance for these efforts to succeed is to try as best as possible to prevent its extinction. Nevertheless, a last effort to save the Asiatic cheetah from its final extinction should be undertaken as a common responsibility of the global conservation community.

**Fig. 8.1.** Female cheetah 'Delbar' and male cheetah 'Kooshki' in Tehran in 2014. Photo: Alireza Shahrdari.

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# Appendix I. CAMI POW species-specific Cheetah measures

**Table Appendix I.1.** CAMI POW species-specific Cheetah measures. See CAMI PoW (2021-2026) for all action points. Cross-cutting issues in the CMS CAMI PoW relevant to Cheetah conservation are included in the following topics: 2. Illegal Hunting, Possession and Trade, 3. Industry and Infrastructure Development / Barriers to Movement, 4. Overgrazing and Livestock Competition, 5. Community Engagement and Sustainable Use. 6. Good Governance of Natural Resource Management, 7. Capacity Development, 8. Scientific Knowledge, 31. Funding, 32. Synergies and Stakeholder Involvement. Other species covered by the CMS CAMI POW, which are relevant as prey for the Cheetah include: 9. ~~Argali (*Ovis ammon*)~~, 13. Chinkara (*Gazella bennettii*), ~~14. Chiru (*Pantholops hodgsonii*)~~, 16. Goitered Gazelle (*Gazella subgutturosa*), 24. Wild sheep (*Ovis vignei*) [crossed out species are potential prey in the extinct range of the Cheetah, but not extant range of *A. j. venaticus*].

| 10. | Asiatic Cheetah (*Acinonyx jubatus*) | Responsible | Priority |
|---|---|---|---|
| 10.1 | Improve protected area management, including through the development of management plans and stronger law enforcement measures. | Department of Environment Iran (DOE), Iranian Cheetah Society (ICS), NGOs | High |
| 10.2 | Complete the fencing of the hot zone of highway 44 along Touran National Park to eliminate vehicle-Cheetah collisions in a way that maintains connectivity and allows Cheetah to safely cross the road e.g. through underpasses or other suitable measures. | DOE, ICS, NGOs | High |
| 10.3 | Implement measures aimed at removing livestock or reducing impact from herding within the Miandasht and Touran reserves. | DOE, ICS, NGOs | High |
| 10.4 | Increase and/or maintain the Cheetah prey base. | DOE | High |
| 10.5 | Review related laws and regulations in support of Cheetah conservation. | DOE | Medium |
| 10.6 | Enhance effectiveness of protected areas through identification and conservation of corridors, such as the corridor between Touran and Miandasht and through a landscape approach (north-east, central-south Iran). | DOE, ICS, NGOs | High |
| 10.7 | Facilitate equipment and technical support to conduct field surveys and conservation activities. | Government agencies, NGOs | High |
| 10.8 | Model potential range in border areas with Afghanistan, Iraq, Pakistan and Turkmenistan. | NGOs and DOE | Medium |
| 10.9 | Continue annual monitoring of presence, numbers, distribution and threats (e.g. camera trapping, telemetry, DNA sampling). | ICS, Scientific institutions, NGOs, Government agencies | High |
| 10.10 | Conduct an international Asiatic Cheetah conference in Teheran with all relevant stakeholders to develop a regional programme for the conservation of Cheetah and fundraising. | Government agencies, ICS, NGOs, IUCN Cat Specialist Group, CMS | High |
| 10.11 | Develop a population management plan, including a plan for captive and semi-captive breeding and a study on population genetics. | Government agencies, ICS, NGOs, Scientific institutions | High |
| 10.12 | Promote capacity-building exchange programs to support game wardens and reserve managers in further developing their skills. | Government agencies, international agencies, NGOs | Medium |
| 10.13 | Involve local communities in conservation and share benefits with them through private reserves, ecotourism in corridors and protected areas. | Government agencies, NGOs | High |

# Appendix II. Body measurements and body masses of Cheetahs from different parts of their range in Africa and Asia.

**Table Appendix II.1.** Body measurements (in centimetres) and body mass (in kilograms) of Cheetahs from different parts of their range in Africa and Asia. M: male, F: female, N: sample size. Bracketed values give the range. [1]The reference includes more body measurement data other than the four variables shown here.[2]The measurement was taken from a subadult Cheetah.

| Locality | Subspecies | Sex | N | head-body-length (HBL; cm) | tail length (TL; cm) | HBL+TL (cm) | Body mass (kg) | Source |
|---|---|---|---|---|---|---|---|---|
| Namibia | *A. j. jubatus* | M | 94 | 125.5 (108–152) | 76.7 (51–78) | 202.2 (167–226) | 45.6 (31–64) | Marker & Dickman 2003[1] |
| Namibia | *A. j. jubatus* | F | 38 | 120.0 (105–135) | 72.0 (57–79) | 192.0 (162–214) | 37.2 (26–51) | Marker & Dickman 2003[1] |
| Southern Africa | *A. j. jubatus* | M | 7 | 122.8 (119–131) | 74.4 (60–84) | 197.2 | 55.0 (50–62) (4♂) | McLaughlin1970 *In* Sunquist & Sunquist 2002 |
| Southern Africa | *A. j. jubatus* | F | 1 | - | - | - | 57.0 | McLaughlin1970 *In* Sunquist & Sunquist 2002 |
| South West Africa (Namibia) | *A. j. jubatus* | M | 7 | - | 71.7 (65–76) | - | 53.9 (39–59) | Smithers 1983 *In* Sunquist & Sunquist 2002 |
| South West Africa (Namibia) | *A. j. jubatus* | F | 6 | - | 66.7 (63–69) | - | 43.0 (36–48) | Smithers 1983 *In* Sunquist & Sunquist 2002 |
| Kalahari Gemsbok NP, South Africa | *A. j. jubatus* | M | 1 | - | - | 206.0 | 53.9 | Labuschagne 1979 *In* Farhadinia et al. 2016a |
| Kalahari Gemsbok NP, South Africa | *A. j. jubatus* | F | 1 | - | - | 190.0 | 43.0 | Labuschagne 1979 *In* Farhadinia et al. 2016a |
| East Africa (Kenya) | *A. j. raineyi* | M | 4 | 132.0 (1♂) | 66.0 (1♂) | 198.0 (1♀) | 61.0 (58–65) | McLaughlin1970 *In* Sunquist & Sunquist 2002 |
| East Africa (Kenya) | *A. j. raineyi* | F | 2 | 118.0 (1♀) | 73.0 (1♀) | 191.0 (1♀) | 52.0 (41–63) | McLaughlin1970 *In* Sunquist & Sunquist 2002 |
| Serengeti | *A. j. raineyi* | M | 24 | 122.5 (113–136) | 68.1 (63–74) | 190.6 | 41.4 (28.5–51; 23♂) | Caro 1994 *In* Sunquist & Sunquist 2002 |

| Locality | Subspecies | Sex | N | head-body-length (HBL; cm) | tail length (TL; cm) | HBL+TL (cm) | Body mass (kg) | Source |
|---|---|---|---|---|---|---|---|---|
| Serengeti | *A. j. raineyi* | F | 19 | 124.5 (113–140; 16♀) | 65.5 (59.5–73) | 190.0 | 35.9 (21–43) | Caro 1994 *In* Sunquist & Sunquist 2002 |
| India | *A. j. venaticus* | ? | ? | 137.0 | 76.0 | 213.0 | - | Divyabhanusinh 1995 |
| India | *A. j. venaticus* | ? | ? | 112.0 | 68.0 | 180.0 | - | Divyabhanusinh 1995 |
| India | *A. j. venaticus* | ? | 1 | 127.0 | 68.0 | 195.0 | - | Divyabhanusinh 1995 |
| India | *A. j. venaticus* | F | 1 | 122.0 | 66.0 | 188.0 | - | Divyabhanusinh 1995 |
| India | *A. j. venaticus* | M | 1 | - | - | 190.0 | - | Divyabhanusinh 1995 |
| India | *A. j. venaticus* | M | 1 | - | - | 188.0 | - | Divyabhanusinh 1995 |
| India | *A. j. venaticus* | F | 1 | - | - | 188.0 | - | Divyabhanusinh 1995 |
| India | *A. j. venaticus* | M | 2 | - | - | 203.0 | - | Divyabhanusinh 1995 |
| India | *A. j. venaticus* | M | 1 | - | - | 195.0 | - | Divyabhanusinh 1995 |
| India | *A. j. venaticus* | M | 1 | - | - | 194.0 | - | Divyabhanusinh 1995 |
| India | *A. j. venaticus* | M | 1 | - | - | 193.0 | - | Divyabhanusinh 1995 |
| Turkmenistan | *A. j. venaticus* | M | 1 | 128.0 | 63.0 | 191.0 | - | Heptner & Sludskii 1972 |
| Turkmenistan | *A. j. venaticus* | F | 1 | 123.0 | 64.0 | 187.0 | - | Heptner & Sludskii 1972 |
| Iraq | *A. j. venaticus* | ? | 1 | - | - | 162.6 | - | Harrison & Bates 1991 |
| Iran | *A. j. venaticus* | M | 1 | 105.5 | 77.0 | 182.5 | 29.0 | L. Hunter et al. 2007 |
| Iran | *A. j. venaticus* | M | 1 | - | - | - | 32.0 | L. Hunter et al. 2007 |
| Iran | *A. j. venaticus* | M | 1 | - | - | 185.4 | 32.0 | Farhadinia et al. 2016a |
| Iran | *A. j. venaticus* | F | 1 | - | - | 176.7 | 31.1 | Farhadinia et al. 2016a |
| Iran | *A. j. venaticus* | F | 1 | 106.0 | 68.0 | 174.0 | 23.0[2] | Yusefi 2004 |
| Iran | *A. j. venaticus* | F | 1 | 104.0 | 64.0 | 168.0 | - | Yusefi 2005 |

# Appendix III. Detailed information on protected areas in the distribution range of the Asiatic Cheetah in Iran.

**Table Appendix III.1.** Detailed information on protected areas in the distribution range of the Asiatic Cheetah in Iran. Year of gazetting, year of upgrading, population of herbivores, livestock (sheep/goat) and dromedary, competitor species in each area and number of rangers. The codes correspond to those in Fig. 4.5. Source: DoE unpublished data.

| Code | Name of area | Year established (category) | Year upgraded (category) | Goitered Gazelle | Chinkara | Wild sheep | Wild goat | Onager | Small livestock | Dromedary camel | Competitor species |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Touran BR | 1972 ( PA) | 2002 (PA, WR, NP) | 424 | 93 | 1,007 | 836 | 137 | | 1,500 | Wolf, Hyaena, Leopard, Jackal |
| 2 | Khosh Yeylagh | 1967 (PA) | 1978 (WR) | | | 1,170 | 305 | | | | |
| 3 | Miandasht | 1975 (PA) | 2013 (WR, NP) | 1,051 | | | | | | 400 | Wolf, Hyaena, Caracal, Feral dogs |
| 4 | Parvand | 2019 (PA) | | 42 | | 414 | 417 | | 10,614 | | |
| 5 | Dasht - Laghari | 2012 (PA) | | 4 | | | | | 937 | | |
| 6 | Darooneh | 2006 (PA) | | | | 20 | 98 | | 41,405 | | |
| 7 | Sirkhoon & Khaf | 2003 (PA) | 2012 (HPA, PA) | 344 | | | | | 7,180 | | |
| 8 | Naybandan | 1995 (PA) | 2001 (WR) | | 158 | 969 | 425 | | 300 | 1,640 | Wolf, Hyaena |
| 9 | Darband-e Ravar | 2010 (WR) | | | 177 | 188 | 156 | | | | Wolf, Fox, Leopard, Caracal |
| 10 | Kamki | 2011 (HPA) | 2019 (WR) | | | 274 | 673 | | 7,851 | | Wolf, Leopard, Hyaena, Feral dog |
| 11 | Bafq | 1996 (PA) | | | | 482 | 719 | | | | |

| Code | Name of area | Year established (category) | Year upgraded (category) | Goitered Gazelle | Chinkara | Wild sheep | Wild goat | Onager | Small livestock | Dromedary camel | Competitor species |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | Ariz | 2009 (HPA) | 2020 (WR) | | | 403 | 440 | | | | Wolf, caracal, leopard, hyaena, feral dog |
| 13 | Dare Anjir | 1999 (PA) | 2002 (WR) | | 36 | 386 | 141 | | | | Wolf, caracal |
| 14 | Kalmand | 1990 (PA) | | 827 | | 336 | 2,143 | | | | |
| 15 | Siah kooh | 2001 (PA) | 2007 (NP) | | 38 | 130 | 80 | | | | |
| 16 | Abbas Abad | 2005 (HPA) | 2009 (WR) | | 32 | 993 | 2,159 | | | | |
| 17 | Kavir | 1964 (PA) | 1976 (NP) | | 503 | 390 | 570 | 11 | | | |
| 18 | Chah-shirin | 2019 (HPA) | | 26 | | 272 | 197 | | | | |

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# Appendix IV. Outcomes and actions of "Conservation and recovery of the Asiatic Cheetah in Iran" plan.

**"Conservation and recovery of the Asiatic Cheetah in Iran" plan**

*Outcome 1*: Cheetah prey populations in Cheetah habitats and neighbouring areas are reinforced.
*Actions*:
- Increase number of rangers in Touran and Miandasht;
- Hire helpers and part-time guards among local communities in neighbouring areas;
- Increase conservation equipment, especially motorcycles and 4WD vehicles in Cheetah habitats;
- Repair, complete and maintain ranger stations;
- Monitor diseases among prey population in Cheetah habitats;
- Monitor, repair and maintain natural springs and water sources in Cheetah habitats, especially in Touran.

*Outcome 2*: Quality and suitability of Cheetah habitats are increased.
*Actions*:
- Acquire grazing rights and remove livestock from the central core area of Touran;
- Safeguard Semnan-Mashhad transit road for crossing Cheetahs;
- Evacuate dromedary camels from central core habitats of Cheetah and manage grazing livestock as per issued grazing licenses;
- Establish private reserves in neighbouring areas of Touran and Miandasht.

*Outcome 3*: Education and research are improved and conflicts reduced.
*Actions*:
- Educate local communities in Cheetah habitats and neighbouring areas;
- Monitor Cheetah presence and range in core habitats;
- Reduce wildlife conflict with local communities in Cheetah habitats through wildlife insurance and management of guarding dogs;
- Build the capacity of intermediate managers, experts, rangers and helpers in Cheetah habitats and neighbouring areas.

*Outcome 4*: A population of captive Cheetahs is created through captive and semi-captive breeding programmes.
*Actions*:
- Captive-breed Cheetahs in Touran facilities;
- Rear cubs in semi-captive conditions;
- Increase the Cheetah population in captivity in terms of breeding sites and base population;
- Collect and preserve sperm from male Cheetahs in Southern habitats and all captive Cheetahs and preserve in standard condition for future use in artificial insemination

# Appendix V. GEF Small Grant Programme projects in Iran in 2003–2009 related to Cheetah conservation.

**Table Appendix V.1.** GEF Small Grant Programme projects in Iran related to Cheetah conservation in 2003–2009.

| No. | Project No. | Project Name | Grantee | Location | Budget (USD) | Year |
|---|---|---|---|---|---|---|
| 1 | IRA-G52-2003-025(IRA98G52) | Partial of Touran-Iran, a world within one boundary, Khartouran, Khoshyelagh, Miankaleh Areas and Golestan National Park | Women's Society Against Environmental Pollution / Nature Institute | Touran | 17,000 | 2003 |
| 2 | IRA/0 IRA/05/09 (57th) | Capacity Building in participatory approaches and techniques for the Cheetah Project Grantees, selected community members, local NGOS and important stakeholders | Iranian Cheetah Society, Eco-researchers, Pooyeh Institute | Touran and Bafq | 15,000 | 2005 |
| 3 | IRA/05/10 (58th) | Khartouran Biosphere Community Empowerment and Awareness Raising for Conservation of Asiatic Cheetah | Eco-Researchers | Touran | 25,000 | 2006 |
| 4 | IRA/05/11 (59th) | Bafq Community Empowerment and Awareness Raising for Conservation of Asiatic Cheetah | Iranian Cheetah Society | Bafq | 25,000 | 2006 |
| 5 | IRA/06/09 (76th) | Developing a pilot on the role of communities in the Preservation of Environment with Reliance on Eco-tourism on the border of Touran National Park | Plan for the Land Society | Touran | 34,000 | 2006 |
| 6 | IRA/SGP/OP4/RAF/07/02 (93) | Empowerment of the Local Community in Naybandan Wildlife Refuge and Tabas City in collaboration with GEF CACP | Mohitban Society | Naybandan | 50,000 | 2007 |
| 7 | IRA/SGP/OP4/RAF/07/05 (96) | Touran Asiatic Cheetah Local Participation and Livelihood Project-Phase 2 | Eco-Researchers | Touran | 25,000 | 2007 |
| 8 | IRA/SGP/OP4/RAF/08/15 (106) | Phase 2 of SGP No. 4 "Bafq Community Empowerment and Awareness Raising for conservation of Asiatic Cheetah" | Iranian Cheetah Society | Bafq | 7,000 | 2008 |
| 9 | IRA/SGP/OP4/RAF/08/16A (107A) | Asiatic Cheetah Fund for local CBOs formed in Naybandan Villages in Tabas | Kanoone Hamandishane Sabz Gostar Tabas | Naybandan | 7,000 | 2009 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 10 | IRA/SGP/OP4/RAF/08/16B (107B) | Asiatic Cheetah Fund for local CBOs formed in Touran villages | Local Cooperatives of Beheshteh Gomshode Kavir, Hafezane Sarza-mine Yuzpalang & Toseyeh va Om-rane Sabz Khartouran | Touran | 3,000 | 2009 |

## Appendix VI. Activities and project conducted by ICS

*Survey for estimating Cheetah population*:

- Between 2012 and 2022 ICS surveyed several Cheetah sites and habitat corridors using camera traps independently or as CACP contractee;

*Public awareness raising, education and training*:

- Between 2013 and 2018 ICS produced education material, teaching sessions and courses for students and teachers in towns in Cheetah areas, organised several festivals and workshops for increasing awareness about Cheetah, wildlife and biodiversity conservation;
- It collaborated with local communities for monitoring the Cheetah population around Dareh Anjir PA;
- Organised workshops for educating rangers in five provinces;
- Collaborated with the DoE for compiling protocols for semi-captive breeding;
- Campaigned for bringing attention to Cheetah conservation;
- Involved in Cheetah Day festivals;
- Produced and disseminated Cheetah info-graphic posters; several leaflets and other educational material;
- Published a news letter called "Cheetah Letter" and internal bulletin about the activities of NGOs.

*Physical protection and support for management*:

- Protected six water sources in Miandasht against dromedary camels; created 12 dykes for collecting and storing floodwater in Miandasht;
- Purchased one wind-pump for a water well in Touran;
- Purchased grazing rights of one pasture in Touran in 2021;
- Hired rangers for maintenance of water sources in Miandasht (six years) and Touran (one year);
- Hired helpers for increasing wildlife protection in Miandasht;
- Collaborated in building a ranger station in Touran;
- Purchased and delivered spare parts for rangers' vehicles and motorcycles and assisted in repairing them in Miandasht and Touran.

# Appendix VII. Activities and project conducted by PWHF

*Monitoring, surveys and research*:

- Camera trapping with DoE in Touran and Kavir for estimating the Cheetah population;
- Engaged with DoE in a herbivore population census in Touran and Kavir;
- Supported technically and financially several MSc and PhD students' works and resulting publications.

*Awareness raising and motivating rangers*:

- Published books on wildlife conservation with emphasis on the Cheetah for educating school students; a coffee-table book on Iranian wildlife; funded or co-funded technical reports and books, such as on rangeland management in Miandasht, or on wildlife diseases in Iran; organised festivals; school events; produced posters, leaflets, awareness films;
- Organised tours for rangers and sponsored outstanding DoE rangers' awards; organised numerous technical workshops for rangers and protected-area managers;
- Organised awareness-raising events, such as celebrity football matches, painting competitions and exhibitions, conferences, short films, movie sessions, etc.

*Policy and fund-raising*:

- Advised mine companies in Yazd province in mitigating their negative impacts on habitats and wildlife;
- Organised meetings, workshops, site visits, mapping and surveys for reducing livestock conflicts with wildlife in Touran and Miandasht;
- Contracted socio-economic studies in villages around Touran BR for identifying target groups, tourist capacity; facilitating tourism and related activities; created a tourist centre in Qale-baha village;
- Developed models of participatory tourist management and conservation in villages around Touran BR in collaboration with CACP and DoE;
- Collaborated with Touran BR management for improving management model;
- Organised several events for fundraising, e.g., of artwork auctions.

*Physical conservation*:

- Revived the Livestock Control Committee (LCC) activities in Touran;
- Funded the construction of a ranger guard station in Kalmand;
- Funded spare parts for ranger motorcycles in several protected areas including Touran BR;
- Supported financially and technically the activation by DoE-CACP of the Livestock Control Committee in Touran BR.

# Appendix VIII. Detailed information on Cheetah prey population

**Table Appendix VIII.1.** Trends of Goitered gazelle and Chinkara populations in Iran in 2014. (Source: M. R. Hemami, pers. comm.).

| | Decreasing | stable/fluctuating | unknown | increasing |
|---|---|---|---|---|
| Goitered gazelle | 59% | 9% | 27% | 5% |
| Chinkara | 53% | 9% | 38 % | 0% |

**Table Appendix VIII.2.** Distribution of two gazelle species in protected areas across Iran. Source: M. R. Hemami, pers. comm.

| | NP | WR | PA | HPA | Unprotected areas | Persian Gulf islands |
|---|---|---|---|---|---|---|
| Goitered gazelle | 39% | 30% | 18% | 3% | 5% | 5% |
| Chinkara | 50% | 19% | 13% | 11% | 5% | 5% |

**Table Appendix VIII.3.** Population size and trend (↓ = decreasing, ↑ = increasing) of herbivores in some PAs in the range of the Cheetah (source: M. R. Hemami, pers. comm.).

| PA | Period | Wild sheep | Wild goat | Chinkara | Goitered Gazelle |
|---|---|---|---|---|---|
| Touran BR | 2015–2020 | 1000 | 645–836 (30%↑) | 100 | 400 |
| Dareh Anjir | 2015–2020 | 512–386 (24%↓) | 354–141 (60%↓) | 49–36 (26%↓) | NA |
| Siah kooh NP | 2017–2018 | 55–227 (312%↑) | 325–80 (75%↓) | 27–59 (118%↑) | NA |
| Kavir NP | 2020 | 390 | 570 | 503 | - |
| Bafq PA | 2020 | 482 | 719 | - | NA |
| Naybandan WR | 2020 | 969 | 425 | 158 | NA |
| Abbasabad WR | 2020 | 993 | 2159 | 32 | - |

**Table Appendix VIII.4.** Information of wild ungulate captive breeding centres in Iran in 2022 (source: DoE unpublished data).

| Species | Province | Area (ha) | Year established | Population size in 2022 |
|---|---|---|---|---|
| Goitered gazelle | South Khorasan* | 45 | 2007 | 18 |
| | Ardabil | 27 | 2008 | 26 |
| | Kordistan | 40 | 2007 | 27 |
| | Razavi Khorasan* | 17 | 2008 | 6 |
| | Khuzistan | 150 | 2009 | **129 |
| Chinkara | South Khorasan* | 100 | 2011 | 18 |
| | Bushehr | 100 | 2009 | 41 |
| Wild sheep | Kurdistan | 40 | 2008 | 90 |
| | North Khorasan* | 50 | 2006 | 10 |

* Located in Cheetah areas; **Arabian sand gazelle (*Gazella marica*) or hybrids.

## Appendix IX. Glossary for genetic terms

**Allele**: Variant of the DNA sequence. In every higher organism, the genetic information is stored in a DNA double helix, each strand of which forms a copy of maternal and paternal genetic material, so that for each DNA segment, there is an allele from the father and one from the mother.

**Effective population size $N_e$**: Based on the effective reproduction of an idealised → population with random distribution of → alleles. The total number of individuals in a population can be misleading, as not all members can reproduce and pass on their alleles to the next generation. $N_e$ is always only a fraction of the total population, often no more than 1/10 of all animals (Frankham 1995).

**Expected heterozygosity $H_e$**: Calculates the expected proportion of heterozygous individuals in a → population under the assumption that mating occurs randomly among all individuals in a population.

**Genetic diversity**: The diversity of all genes within a species or → population, also called genetic variability. High genetic diversity allows a species / population to respond better by adapting (through natural selection) to changing environmental conditions.

**Haplotype:** A haplotype (haploid genotype) is a group of → alleles in an organism that are inherited together from a single parent.

**Heterozygous**: The copies of a section on the genome (→ Allele) of the mother and father are different. The proportion of heterozygous sections of the genome of an individual determines its degree of heterozygosity (→ Expected and → Observed heterozygosity).

**Homozygous**: The copies of a section on the genome of the mother and father are identical.

**Inbreeding**: Mating in partners who are more closely related than in random mating. Leads to an increase in homozygosity in closely related mating pairs because of their similarity. Mating in closely related individuals is naturally avoided in the biology of the species, but inevitably occurs more frequently in smaller than in larger populations, especially after a population experienced a genetic bottleneck.

**Locus (plural loci):** Examined location on the genome.

**Median-joning network:** Statistical analysis to infer phylogenies within species, based on → mitochondrial DNA (mtDNA).

**Microsatellite**: Short, repetitive sections of the genome. The number of repetitions differs between individuals of a species. Microsatellites are therefore suitable for studying the genetic structures of → populations.

**Mitochondria:** Organelles found in large numbers in most cells. They have their own DNA inherited from the mother, the so-called **mitochondrial DNA**, or mtDNA.

**Numerical population size $N_c$:** Number of individuals that occur in an area and are counted there.

**Observed heterozygosity $H_o$**: Proportion of heterozygous individuals within a → population, averaged over the examined → loci.

**Population**: All individuals of a group of animals that live in the same geographical area and can reproduce among themselves.

**Single Nucleotid Polymorphism (SNP):** A genomic variant at a single base position in the nuclear DNA.

## Appendix X. *Ex situ* populations of Cheetah

Several zoos and *ex situ* facilities across Asia, Africa, Europe and North America have captive populations of Cheetahs.

These *ex-situ* populations are being managed by three associations: EAZA European Association of Zoos and Aquaria (Europe), AZA Association of Zoos and Aquariums (U.S.A) and ZAA Zoological Association of America (U.S.A). Within EAZA there are two programmes that are breeding Cheetahs in the scope of EAZA Ex situ Programme (EEP), one for Northern and one for Southern Cheetahs. The EEP was founded in 1985 and issues zoos with mandatory breeding recommendations, in order to maintain genetic diversity as high as possible, avoid inbreeding and develop a European population independent from the wild.

A summary of the global captive population's origins, current numbers and status is presented in Table X.1.

**Table Annex X.1. Summary of the ex-situ population of Cheetahs**

| Association | Programme | Coordinator | No. of Institutions | No. of Countries | Subspecies | Origins | Current population | Latest update | Notes | Reference |
|---|---|---|---|---|---|---|---|---|---|---|
| EAZA | EEP for Southern Cheetah | Lars Versteege | 174 | 21 | *A. j. jubatus* | Namibia, Botswana, South Africa, Zimbabwe and Tanzania | 174(M), 190(F) | December 2019 | | Versteege 2019 |
| EAZA | EEP for Northern Cheetah | Sean McKeown | 22 | 9 | *A. j. soemmeringii* | Somalia, Ethiopia, Sudan and Chad | 59(M), 57(F) | January 2022 | | S. McKeown, pers. comm. |
| AZA | AZA Species Survival Plan - Yellow Program | Adrienne Crosier | 49 | 2 | *A. j. jubatus* | Wild-born from Southern African countries Captive-born from European or South African facilities | 165(M), 165(F) | October 2021 | | Crosier et al. 2021 |
| - | - | CCF | 1 | 1 | *A. j. soemmeringii* | Somalia | 70+ | January 2022 | | S. McKeown, pers. comm. |
| - | - | Sean McKeown | 1 | 1 | *A. j. hecki* | Unknown | 4(M), 1(F) | January 2022 | These Cheetah in Al Wathba, UAE are most likely *A. j. soemmeringii* and not *A. j.* hecki. (S. Mc Keown, pers. comm.) | S. McKeown, pers. comm. |
| ZAA | Cheetah Animal Management Program (AMP) | Jason Ahistus | 19 | 1 | *A. j. jubatus* | South Africa | 52(M), 61(F) | April 2022 | | J. Ahistus, pers. comm. |

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