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A review of ecology and conservation status of Asiatic cheetah in Iran

We reviewed existing knowledge about the Asiatic cheetah *Acinonyx jubatus venaticus*, a critically endangered subspecies which once used to live in west and south Asia, now confined to a small population remaining in Iran. Available literatures, reports and hard facts such as images and films were collected to shed light on biology, status and distribution of the cheetahs in Iran. Unlike previous perceptions about the cheetah characteristics, the Asiatic cheetahs are smaller and lighter than their sub-Saharan African cousins. They mainly live in hilly terrains, foothills and rocky valleys where they have access to existing range of prey in deserts. To cope with environmental variability in drylands, they show high mobility in their movement pattern, patrolling some of the largest ranges ever recorded for the cheetahs. On average, 2.7 (SE = 0.2, ranging 1 to 4) cubs younger than 6 months have been seen in each family, predominantly born in March-April. Since 2001, at least 18 areas in the country are known to have evidence of cheetah presence, mostly (n = 16) officially protected. A joint initiative of national and international organisations has been trying to halt major threats, particularly prey and habitat loss since 2001. However, the subpecies remains critically endangered on the verge of extinction with a population of fewer than 40 individuals, occurring across approximately 242,500 km² (i.e. 23.2% of its historical range in Iran). Decreased breeding, retaliatory killing by herders and occasional mortalities due to poachers or road collisions are the major threats for the small population of Asiatic cheetahs in Iran.

The Asiatic cheetah is a critically endangered large felid now exclusively confined to arid environments of the eastern half of Iran (Farhadinia 2004, Hunter et al. 2007). During the second half of the last century, the predator has been experiencing drastic decline both in number and occupancy across most of its Asian range, from India to the Arabian Peninsula, making it the smallest remnant of any cheetah subspecies in the world (Nowell & Jackson 1996).

Iran's cheetahs were also rapidly disappearing from most of their formerly inhabited regions, leaving no doubt that this enigmatic and rare large carnivore is strongly prone to extinction. As a result, several national and international organisations were convinced to jointly take an action to safeguard the Asiatic cheetahs in Iran (Breitenmoser et al. 2009), yet virtually very little is known about the subspecies morphology, biology and status.

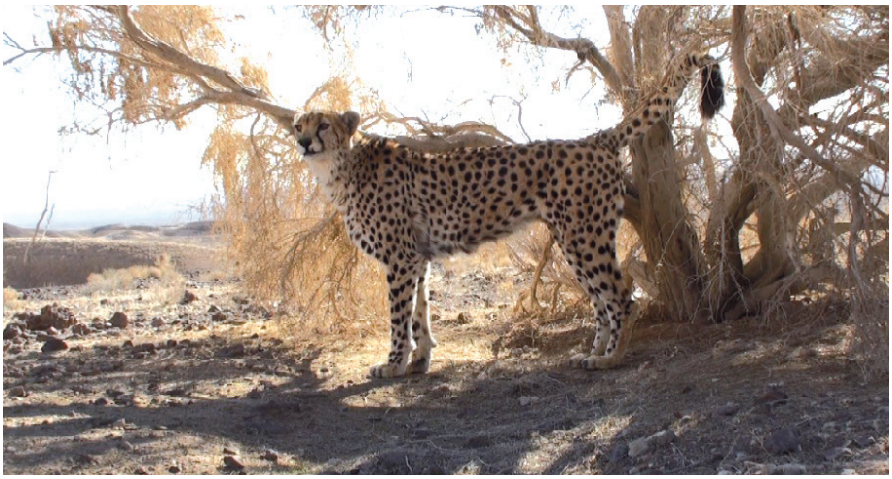

Fig. 1. A solitary male Asiatic cheetah at a scent tree in Kavir National Park, February 2013 (Photo Wildlife Picture Institute).

In this report, we have reviewed available literature to provide a profile on the Asiatic cheetah biology and natural history. Furthermore, we have collated sporadic records of the Asiatic cheetahs to provide general description about them and to update a fairly comprehensive view of the current status of this elusive carnivore in Iran.

Methods

We reviewed all studies conducted on the cheetahs in Iran, including journal papers, university dissertations, research projects, newsletters, and mission reports compiled by different agencies involved in cheetah research and conservation. Also, we obtained hard facts (i.e. image or film) of cheetah families from Provincial Offices of the Iran Department of Environment DoE to analyse cheetah breeding in the country. Finally, we developed a distribution map for the current range of the cheetahs based on occurrence data generously shared by Yazd, Kerman, Esfahan and Semnan Provincial Offices of the DoE as well as by an ongoing monitoring programme led by the Iranian Cheetah Society ICS since 2001 (see Farhadinia et al. (2014) for more details). Reliability of each record individually was assessed by considering whether any hard evidences (e.g. photo, video, or carcass) are present, or only soft evidences are available. We categorised hard evidences as 'C1', and soft evidences as 'C2'.

Taxonomy and general description

The cheetahs are traditionally classified in four African and one Asiatic subspecies, namely as *Acinonyx jubatus jubatus*, *A. j. raineyi*, *A. j. soemmeringii*, *A. j. hecki*, and *A. j. venaticus* (Meester 1971). The latter has been named as the Asiatic subspecies.

The classification and taxonomy of Asiatic cheetah have been extensively debated. Formerly, the Asiatic cheetahs have been identified as *A. j. venaticus* (Griffith 1821) and *A. j. raddei* (Hilzheimer 1913), the latter assigned as Trans-Caspian cheetah inhabiting Central Asia (Heptner & Sludskii 1992, Mallon 2007). Harrison and Bates (1991), Roberts (1997) and Flint (1988) believed the distinction between Asiatic and African cheetah dubious, whereas some authors proposed that this population form a single subspecies, *A. j. venaticus*, with North African cheetahs (Pocock 1941, Ellerman & Morrison-Scott 1966). Recent molecular studies based on a combination of archaeozoological and contemporary samples have revealed that

Acinonyx jubatus venaticus

Names:
یوزپلنگ آسیایی
Yuzpalang-e-Asiayie
Asiatic cheetah

Head and body length:
100-182 cm (males)
160-189 cm (females)
Tail length:
62-77 (males)
59-75 (females)
Weight:
25-38 kg (males)
23-35 kg (females)

Global population:
fewer than 40
Iranian population:
fewer than 40

Distribution in Iran:
Arid areas of eastern half of Iran and probably parts of Iran-Iraq borderland

IUCN Red List:
Critically Endangered (2015)
CITES:
Appendix I

Iran environmental conservation laws & regulations:
Endangered species

Photo ICS/DoE/CACP/Panthera

Asiatic cheetahs (i.e. *A. j. venaticus*) are unambiguously separated from African subspecies some 32,000-67,000 years ago (Charruau et al. 2011).
In general cheetahs are described as a tawny felid with spots and tear marks on their face. However, inter-specific morphological variation across the cheetah global range has been subjected to expert controversy. Heptner and Sludskii (1992) noted that morphological differences between African and Asiatic cheetahs were perceptible but not marked while it was considered that Asiatic cheetahs differ in morphology (Dareshuri 1978) from the African subspecies. Some authors proposed that the main difference between Asiatic and sub-Saharan African cheetahs lies in the type of spotting and probably in the frequency of a big white portion on the tail tip (Divyabanusingh 1995). Groves (cited in Karami 1992) described that the Asiatic cheetah seem to have clearer, darker "shadow spots", more clearly marked faces, more thickly spotted limbs and more marked manes in the adult (cited in Karami 1992).
According to Pocock (1941), possible characteristics to distinguish Asiatic from African cheetahs may include a thinner, less woolly winter coat, the absence of a mane, probably in the summer coat; average smaller size and more inflated tympanic bullae in the Asiatic individuals. In contrast, some authors believed that African cheetahs have denser spotting and larger spots on a brighter or darker ground colour comparing to Asian animals with a very pale background colour, while winter fur is relatively long, soft and dense, and the winter "mane" also long and dense (Heptner & Sludskii 1992). Nevertheless, Salvadori and Florio (1978) considered both of fairly similar size although Asiatic cheetahs are slightly smaller. During the past decades, distinction between African and Asiatic cheetahs was noted as slightly larger body size, darker colouration, and longer fur because of adaptation to a colder climate within the Asiatic subspecies range (i.e. Globers Rule; Dareshuri 1978, Roberts 1997, Karami 1992).
Detailed information about the morphological characteristics of wild cheetahs is available from Africa which shows regionalised variation as well as sexual dimorphism (Marker & Dickman 2003). In Iran, we collected morphological data from 18 cheetahs from the subspecies range in Iran as well as literature (Hunter et al. 2007; Supporting Online Material SOM Table T1). Adult Males weight range from 25 to 38 kg while females vary between 23 and 35 kg, resulting in a smaller body size of Asiatic cheetahs than the Africans (SOM T1).

Habitat and ranging

The Asiatic cheetahs in Iran mainly live in hilly terrains, foothills and rocky valleys within a desert ecosystem (Hunter et al. 2007, Jourabchian & Farhadinia 2008). Cheetahs in central Asia inhabited semi-desert and desert plains and foothills containing a range of vegetation types (Mallon 2007).
Traditionally, the Asiatic cheetah has been believed to concentrate on plains where gazelles as their main prey species occur (Firouz 1974, Heptner & Sludskii 1992, Etemad 1985, Harrison & Bates 1991, Ziaie 2008). Therefore, it was concluded that effective recovery of gazelle population resulted in increasing trend of the cheetah population in 1960s and 1970s (Firouz 1974) and the drastic decline in gazelle numbers in Iran made the cheetahs appear to have switched to mountain ungulates as their prey (Ziaie 2008). In central Iran, the cheetahs are known to select mountainous habitats far from open country (Sarhangzadeh et al. 2015). Similarly, the cheetah's potential habitat in Touran Biodiversity Reserve BR is characterised by high spatial overlap with that of the wild sheep (Nazeri et al. 2015).
Besides prey, cover has also been considered to be a main deriving factor for habitat characterisation of the Asiatic cheetahs. Comparison of several combinations of reserves in Iran clearly showed that the cheetahs persist within a number of areas with low density of gazelles, but with more heterogeneous landscapes, such as hilly mountains and rolling terrains. In contrast, they are rarely or never known from nearby areas where remarkably higher gazelle density occur, but mostly in open flat plains (Farhadinia et al. 2008). As a result, a hypothesis is generated that heterogeneous habitats can provide more prey catchability, a key determinant known for many large cats (e.g. lion *Panthera leo*, Hopcraft et al. 2005; leopard *P. pardus*, Balme et al. 2007). Caro (1994) also noted that the availability of sufficient cover for stalking and resting determined territory selection in Serengeti.
Ranging patterns of the Asiatic cheetahs in Iran is not properly understood, but sparse photographic data show that they have extensive mobility (Farhadinia et al. 2013). More than half of cheetahs detected since 2010 in

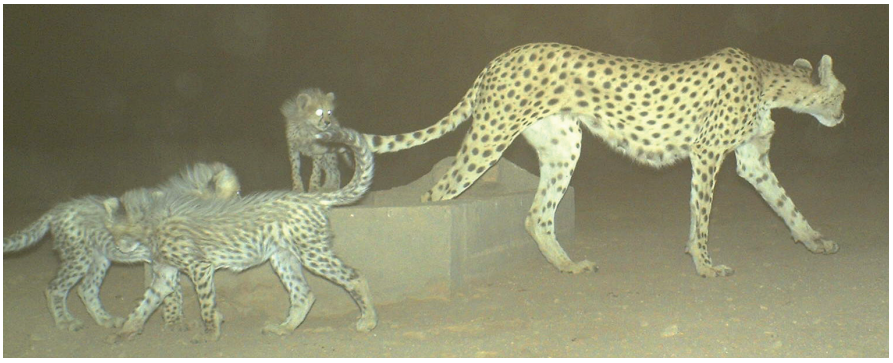

Fig. 2. Asiatic cheetah family in Miandasht Wildlife Refuge, August 2012 (Photo ICS/DoE/CACP/Panthera).

Iran have shown inter-reserve wandering, sometimes up-to 217 km apart (Farhadinia et al. 2016). The mean 100% MCP based on detections by camera traps for 17 adult cheetahs was calculated as 2105.3 ± SE 778.6 km^2 (males: 2474.7 ± 1005.2 km^2; females: 1089.6 ± SE 728.8 km^2, Farhadinia et al. 2016). Furthermore, Hunter (2011) has reported that a coalition of two adult male cheetahs have patrolled an area of than 1700 km^2 in five months in central Iran, one of the largest ever recorded ranges for the cheetahs in the world (Houser et al. 2009).

With the exception of Namibia's semi-arid farmlands where cheetah ranges can measure between 1344 to 2863 km^2 (Wachter et al. 2006 , Marker et al. 2008), most spatial ecology studies in sub-Saharan Africa yielded comparatively smaller cheetah ranges (see Houser et al. 2009 for more details) than recorded here. In contrast, Belbachir et al. (2015) calculated a maximum home range of 1337 km^2 based on 100% MCP estimation of camera trap detections in the arid areas of the Sahara desert.

Cheetahs' home range is generally related to the density of available prey (Hunter et al. 2007) which Iranian drylands host the lowest recorded anywhere in the distribution of the cheetah (Schaller & O'Brien 2001). Such a high mobility may follow a "nomadic" ranging pattern, a non-sedentary behaviour with irregular timing and movement directions and it must be considered when designing monitoring efforts to determine population and occupancy trends for this wide-ranging elusive carnivore (Farhadinia et al. 2016).

Males, whether territorial or not, scent-mark to advertise their presence by spray-marking, scratching, and defecating on prominent features in the landscape (Eaton 1970). In Iran, marking behaviour at signing posts mainly by adult males through directional urination has been photo-trapped in multiple localities, such as Dareh Anjir Wildlife Refuge WR, Touran BR, Bafq Protected Area PA, Ariz No-Hunting Area NHA, Naybandan WR, and Kavir National Park NP (Fig. 1). This behaviour can cause positive bias towards recording more males in the area by camera traps deployed at signing posts (Marker et al. 2008, Marnewick et al. 2008).

Reproduction

Cheetahs show a high rate of reproduction, almost 80% of adults in the wild produce offspring (Laurenson et al. 1992). In contrast, they experience various levels of cub and juvenile mortality across their sub-Saharan African range (Laurenson 1994, Mills & Mills 2014). In Iran, the cheetah cubs are rarely seen in the wild. For example, during 1980s and 1990s, only 15 records of cheetah families are available, with 1 to 3 cubs (Farhadinia 1999).

We were able to develop a photographic database of cheetah families shared by Yazd DoE (6 families), Semnan DoE (6 families) and Iranian Cheetah Society (3 families), summing up a total of 15 families with 39 cubs aging less than six months (Fig. 2; SOM T2). The average number of cubs accompanying their mother was calculated as 2.7 (SE = 0.2, ranging from 1 to 4), somewhat higher than what has already been reported for Asiatic cheetahs as ranging between 2 to 2.5 (Farhadinia 1999). In Africa, average litter size of the cheetahs is 3.6 (Serengeti; Caro 1994) and 3.2 (Namibia; Marker et al. 2003). Our data are based on litter size during their first year of life (usually 3-6 months) whereas African data are based on newly emerged cubs which, progressively in older age classes, litters are less in number (Caro 1994). The cheetahs in northern areas (i.e. Touran BR and Miandasht WR) tend to have larger litter sizes than their southern counterparts such as Bafq PA, Dareh Anjir WR, Naybandan WR and Siahkouh NP (North: 3.0 ± SE 0.2 vs. South: 2.3 ± SE 0.5). Among identified cheetah families, we were able to follow seven cases, unveiling that at least one cub from each family reached the first year, which is higher than in the Serengeti Plains (9.7%; Laurenson 1994) and Kgalagadi Transfrontier Park (45.0%; Mills & Mills 2014). These seven families were accompanied by 17 individuals cubs, mostly survived until their first year of life (88.2%, n = 15, Fig. 3). In Africa, significant difference is seen in post-emergence survival until 14 months, 54.5% in Serengeti (Laurenson 1994) up-to 95.8% in Kgalagadi Transfrontier Park (Mills & Mills 2014). Causes of cub mortality are not known for the Asiatic cheetahs whereas predation by other large carnivores and starvation are two key reasons of mortality for the African cheetah cubs (Laurenson 1994, Mills & Mills 2014).

Asiatic cheetah birth time peaks at March-April, based on aforementioned photographic data of the cheetah families (SOM T2) which is consistent to previous hypothesis (Harrington & Dareshuri 1976, Farhadinia 1999). However, such seasonality may vary in regions with different ecological conditions (Eaton 1970). In northern areas (i.e. Touran BR and Miandasht WR) it occurs mainly in late March/early April whereas it can occur in advance in southern areas (i.e. Bafq PA, Dareh Anjir WR and Siahkouh NP). Surprisingly, 26.7% (n = 4) of births took place in non-peak seasons, around late summer and/or early fall.

Feeding ecology

Cheetahs generally take down medium-sized prey, within a body mass range of 23-56 kg that can be subdued with minimal risk of self-injury (Hayward et al. 2006). In central Asia, the cheetah range overlapped with that of goitered gazelle *Gazella subgutturosa* habitat (Heptner & Sludskii 1992). Furthermore, it has been reported that wild sheep *Ovis orientalis* (Harrington & Dareshuri 1976, Mallon 2007) was part of the cheetah's diet.

In Iran, the cheetahs prey primarily on mountainous ungulates such as wild sheep (mean weight = 34 kg), wild goat *Capra aegagrus* (mean weight = 36 kg) and two species of gazelles (mean weight = ca. 21 kg), namely chinkara *Gazella bennettii* and goitered gazelle.

Wild sheep is the most frequently taken prey for Asiatic cheetahs in most its extant range (Hunter et al. 2007, Jourabchian & Farhadinia 2008, Farhadinia & Hemami 2010). According to sighting reports collected by Jourabchian & Farhadinia (2008), on the basis of 21 cases

of direct observation of Asiatic cheetahs at kills between 1980 and 2007, 50% of sightings were on the wild sheep, followed by wild goat (22%), Persian gazelle (22%) and chinkara (6 %). Scat analysis of more than 400 cheetah faecal samples in Dareh Anjir WR and Naybandan WR also revealed that wild sheep ranked the most frequent prey item (almost 45%), followed by wild goat (almost 26%) and then chinkara (10 to 16%; Zamani 2010). Despite higher percentage of mountainous ungulates in the cheetahs' diet, all feeding ecology investigations are consistent that chinkaras have highest Jacob's selectivity index rather than wild sheep and wild goat (Farhadinia & Hemami 2010, Zamani 2010, Rezaie 2014). In north-eastern Iran, the goitered gazelle is the main available prey for the cheetahs (Farhadinia et al. 2012). Content investigation of five dead Asiatic cheetahs in Touran BR and Kalmand PA revealed hare *Lepus* sp. (n = 2) and goitered gazelle (n = 3) eaten by the predator.

Despite the cheetahs' past co-occurring within onager *Equus hemionus onager* range in Iran (presently they co-occur only in Touran BR), there is no report of cheetah predation on the species, unlike central Asian range where young kulans *E. h. kulan* have been occasionally taken by cheetahs (Mallon 2007).

Cheetahs are also known to kill livestock including young camel, sheep, and goat within the species range (e.g. Dragesco-Joffe 1993, Marker et al. 2003, Selebatso et al. 2008). Cheetahs rarely preyed on domestic animals and were not considered a threat to livestock in central Asia (Mallon 2007). In Iran, the cheetahs are known to occasionally kill livestock in north-eastern country (Farhadinia et al. 2012). Recently, a few young camels have been confirmed to be killed by the cheetahs in a few reserves in Dareh Anjir WR, Ariz NHA and Darband WR (usually two cheetahs seen together). Furthermore, two adult female cheetahs were reported to depredate on domestic sheep and goat at peripheries of Touran BR, one was killed in retaliation by local herders in 2012. Additionally, in Ariz NHA two cheetahs were seen on a domestic goat in late 2000s (H. Hasannezhad, pers. comm.).

Fig. 3. A female cheetah with three full-grown young cheetahs at an artificial waterhole in Touran Biosphere Reserve, August 2009 (Photo SemnanDoE/N. Karami).

Status and distribution

Historically, the cheetah occurred widely through much of non-forested Africa, the Middle East and southern Asia (Caro 1994, Nowell & Jackson 1996). The cheetahs have lost 76% of their African historic range (Ray et al. 2005). In Asia, they formerly ranged across southwest and central Asia to India (Nowell & Jackson 1996, Mallon 2007), but it is now restricted to small populations in Iran (Farhadinia 2004, Durant et al. 2015) with some occasional reports from some neighbouring countries (i.e. Pakistan: Roberts 1997, Husain 2001; Afghanistan: Manati & Nogge 2008; Turkmenistan: Flint 1988). The cheetah is globally considered as vulnerable, but the Asiatic cheetah is categorszed as Critically Endangered on the IUCN Red List (Durant et al. 2015) and is listed on CITES Appendix I (Nowell & Jackson 1996).

Before World War II, the cheetah population was estimated to be around 400 (Harrington 1971), encompassing almost all of the steppes and desert areas of the eastern half of the country and some western terrains near the Iraqi border (63.4% of the country's territory; Farhadinia et al. subm.). Since late 1950s, protection was established for the cheetahs and its habitats to halt poaching of cheetahs and their prey (Firouz 1974). As a result, cheetah sightings increased in different localities, revealing a remarkable resurgence of its population and the efficacy of conservation measures (Firouz 1974, Mowlavi 1985). In the 1970s the range was thought to include arid lands of eastern half of Iran as well as some areas at the borderland with Iraq (Firouz 1974) with a population estimation of 200-300 for the whole country (Firouz cited in Goodwin & Holloway 1974). Joslin (1984) considered this estimation to be too high and came up with approximately 100 cheetahs as a more realistic.

In 1979, the country witnessed a revolution, which interrupted wildlife conservation for a few years. So many areas were occupied by livestock that the cheetah and its prey were heavily poached. The cheetah disappeared from many of its former ranges and was limited to some remote areas with a reliable prey population and relative safety (Asadi 1997, Farhadinia 2004).

In 2000, the Asiatic cheetah was reported from only seven areas, i.e. Kavir NP & PA, Touran BR, Naybandan WR, Bafq PA, Dareh Anjir WR, Ariz NHA and Kamki Bahabad NHA (Ziaie 2008, Jourabchian & Farhadinia 2008). Several crude population estimates have been proposed for that time, all agreeing to fewer than 100 individuals for the entire country (<60; Schaller & O'Brien 2001, Farhadinia 2004, <40; Jourabchian 1999, 50-100; Asadi 1997, 70-100; Ziaie 2008, 60-100; Jowkar et al. 2008). Nevertheless, as a result of the first country-scale assessment based on intensive camera trapping survey across more than half of the known cheetah reserves between 2010 and 2013, it was concluded that Iran lilkey hosts a smaller population that perceived before (Farhadinia et al. 2014).

Since 2001, conservation efforts were boosted in Iran aiming to safeguard the Asiatic cheetah and its biota. As a result, the species has been known to exist within at least 18 areas since 2001 in Iran, 15 C1 localities based on "confirmed" (i.e. image or film) records and 3 C2 areas where "unconfirmed" presence (i.e. tracks verified by us) was reported (Fig. 4). Expansion of the known range of the Asiatic cheetah over the 2000s is likely due to increased survey effort and the increased use of camera-traps rather than actual range recovery or expansion. Nevertheless, fewer than 40 individuals are supposed to persist (ICS unpubl. report) in an area of approximately 242,500 km^2 (Fig. 4), which is equal to 23.2% of its historical occurrence (Farhadinia et al. subm.), spread across seven provinces of Yazd, Semnan, Esfahan, North Khorasan, South Khorasan, Khorasan Razavi and Kerman.

Available information on inter-reserve movement patterns (Farhadinia et al. 2016) as

Fig. 4. Distribution of the Asiatic cheetah in Iran. Red patches denote to C1 reserves, i.e confirmed areas based on hard evidences, such as photos, videos, and dead specimens while blue patches refers to C2 localities which have soft evidences, such as reliable field observations, either verified by us or via a trained person. A few dots show approved cheetah occurrence outside of the current network of the cheetah reserves in Iran. Dark areas and their associated numbers represent cheetah areas as: 1) Kavir, 2) Chah Shirin, 3) Khosh Yeilagh, 4) Touran, 5) Takhti Iran, 6) Miandasht, 7) Dorouneh, 8) Boshrouyeh, 9) Naybandan, 10) Darband, 11) Abbas Abad, 12) Siahkouh, 13) Dareh Anjir, 14) Ariz, 15) Bafq, 16) Kalmand, 17) Kamki Bahabad, 18) Rafsanjan.

well as spatial configuration of the cheetah reserves (Fig. 4) supports three population nuclei in Iran which we use to illuminate the status of the cheetahs at reserve level:

Northern Landscape

Known as the main breeding population nucleus of Asiatic cheetahs in Iran, it is composed of Touran BR (14,000 km^2) and five smaller areas around, namely as Dorouneh PA (667 km^2), Miandasht WR (850 km^2), Khosh Yeilagh WR (1380 km^2), Chah Shirin NHA (680 km^2) and Takhti Iran NHA (350 km^2). Touran BR is one of the largest reserves in the country which has been extensively known as cheetah habitat for decades (Etemad 1985, Hajji 1985, Asadi 1997, Farhadinia 2004, Ziaie 2008) and a recent population survey in the area explored 5 adult cheetahs as minimum number (Ashayeri et al. 2013). In addition to Touran BR, Miandasht WR is also well-known for multiple records of breeding, at least six litters since 2002. In February 2016, an adult male cheetah born in Miandasht WR was killed near Touran BR. Khosh Yeilagh WR, once as a main stronghold for the species in Iran with a population of even 30 (Joslin 1984), was again confirmed to host the cheetahs after filming 2 individuals in 2011. In 2013, an adult female cheetah was also photographed in Dorouneh PA feeding on domestic goat, at border with Touran BR. In north-eastern Iran, Takhti Iran NHA is located not more than 100 km away from Turkmenistan border, but the cheetah presence is known from verified tracks and direct sightings by trained field personnel (Farhadinia et al. 2007). Similarly, Chah Shirin NHA has been known to host cheetahs based on several verified tracks and sightings by local people, and a cheetah has been reportedly killed by herders recently (i.e. 2010s).

Beyond Iran's border in this region, the Asiatic cheetahs ranged from the eastern shore of the Caspian Sea across the Kyzyl Kum and Kara Kum deserts to the middle and lower parts of the Syr Darya and Zeravshan Valleys (Bannikov 1984, Heptner & Sludskii 1992). It is believed that cheetahs probably disappeared from Central Asia by the mid-1980s, though a few individuals may have persisted for a little longer (Flint 1988, Mallon 2007). In the past, they may have wandered from north-east Iran across the border into southern Turkmenistan, but construction of a border fence has made this more difficult (Mallon 2007).

Southern Landscape

The Southern Landscape is composed of 11 areas, including Bafq PA (885 km^2), Dareh Anjir WR (1,753 km^2), Siahkouh NP & PA (2,057 km^2), Kalmand PA (2,290 km^2), Abbas Abad WR (3,050 km^2), Ariz NHA (1,313 km^2), Kamki Bahabad NHA (650 km^2), Rafsanjan County, Boshruyeh County, and the complex of Naybandan WR (15,160 km^2) and Darband WR (14,000 km^2). The first camera trap photograph of a cheetah in Iran was taken in Naybandan WR in October 2001 (Jourabchian & Farhadinia 2008), and this male was found dead by game guards in January 2011, at an estimated age of at least 13 years. Cheetahs have also been reported from Darband WR as confirmed from mortality record of three males in late 2000s, including two adult males that died of poisoning. Dareh Anjir WR is considered the main cheetah reserve in the Southern Landscape because the majority of the cheetah individuals in the landscape have been detected there (Fig. 5). In 2011, an adult cheetah was killed by local shepherds near Boshrouyeh, around 90 km north of Naybandan WR, between Northern and Southern Landscapes.

Kavir Landscape

Not far from the capital of Tehran, Kavir NP has been one of the regularly cited cheetah sites in Iran since 1970s (Bayat 1984, Mowlavi 1985, Hajji 1986, Asadi 1997). However, despite three camera trapping seasons in 2003, 2005 and 2009-2010, resulting in a cumulated effort of ca. 5,300 trap nights, only two different individuals were captured on camera, one adult in 2003 (unknown gender) and one adult male in 2009-2010 (Ghadirian et al. 2010). There are also occasional reports of cheetah presence from southern Kavir NP, but still no evidence is available.

The Asiatic cheetahs are not confined only to aforementioned landscapes and there are sporadic occurrences beyond these regions, predominantly single individuals without evidence of breeding. However, recent field investigations yielded no evidence of cheetah presence in areas within parts of the historical range of the cheetahs in Iran, such as Bidouyeh PA (Allahgholi et al. 2007), Bahram-e-Gour PA (Ghoddousi et al. 2007) and Bajestan (Cheraghi et al. 2007). Addi-

tional surveys are still needed to confirm the species existence in Razavi Khorasan, South Khorasan, Kerman, Hormozgan and Sistan-va-Baluchestan Provinces.

In western Iran, the cheetah was known mostly from eastern Zagros range, but there are a few reports of the species from western hilly and plain areas of Zagros Mountain (Ziaie 2008) with a few sporadic reports from Kermanshah (M. Atarodi, pers. comm.). There is no evidence of the cheetah occurrence in past two decades from the region. On the other side of the border, it has been sighted in Iraq, even from Basra, close to the Iranian territory (Corkill 1929), but it has been considered as extinct in both Iraq and Kuwait (Dickson 1949, Hatt 1959).

Since 2010, evidence of breeding has become rare across majority of the cheetah range in Iran; and only confirmed in the Northern Landscape. Cheetah families have apparently been reported from Ariz NHA and Naybandan WR in 2014 and 2015 by game guards, but without documentation. Additionally, most of recent camera trapping efforts across majority of the cheetah reserves have yielded no (Ghadirian et al. 2010) or very few adult females (Ashayeri et al. 2013, Farhadinia et al. 2014), creating a major challenge for cheetah conservation in Iran.

In captivity

We found reliable reports of at least eleven cheetahs kept within Iranian zoos and facilities since 1950. According to Harrington (1971), a lactating cheetah was captured by a Tehran zoo expedition in Abarguh (Abarkouh) desert, Yazd Province in central Iran. A cheetah cub was also captured in 1969 in Kerman and sent to Tehran zoo which accidentally died. Then in 1970, a young female was found injured in Khosh Yeilagh WR and was sent to Tehran zoo after treatment. Another cheetah has been reported from Tehran zoo in Red List 1974 as an adult male which should be a new individual because of its sex, but there is no data about its origin. Salvadori and Florio (1978) also noted a cheetah in Tehran zoo which we assume that it should be one of the above-mentioned cases. During late 1970s/early 1980s, an adult cheetah was kept by Iran DoE captured from Damghan, as indicated by Etemad (1985).

In August 1980, two cubs from each sex were confiscated from a shepherd in Sabzewar Market, captured in Dorouneh PA (Razavi Khorasan) which were translocated to Mashad Zoo (Karami 1992). The female was alive in August 1984 whereas the male lived until end of 1993 for 13 years (N. Lindsay, pers. comm.). Moreover, following negotiations between Iran and India to exchange Asiatic cheetah and Asiatic lion, a 7 months old female was captured in Touran BR in November 1984 and was sent to Tehran; however, the animal died.

In late August 1994, a female survived from a litter of three cheetahs persecuted by local people in Bafq PA. It lived in Tehran Pardisan Park until Dec 23, 2003 for nine years (Farhadinia 2004).

Recently, two other cheetahs have been captured illegally by local people, both in Touran BR.

In January 2008, a male cub (7-8 months) was recovered by the Iranian DoE after being contacted by a local landowner in Touran BR (Jowkar et al 2008). Also, in April 2011, another female cub estimated to be around 6 months was confiscated by game guards from a shepherd in Touran BR. Both are now kept in Pardisan Park, Tehran for breeding purposes by the Conservation of Asiatic Cheetah Project CACP.

Formerly, several plans have also been proposed by Iranian senior experts in mid-1990s, such as Kaboudan Island (Lake Urmia, plan drafted by H. Ziaie), Kolah Ghazi (plan written by M. T. Moeinian/Esfahan DoE), Touran, and Bamou NPs (managed to be built by B. Dareshuri) with the aim of establishing breeding centres. However, the first two cases were abandoned in the planning phase and the latter two resulted in construction of large enclosures, but no cheetah was released within these sites.

Main threats

Presently, two types of threats affect the cheetah survival in Iran. Direct threats are underlying factors directly targeting the cheetahs which can result in individual casualties. In contrast, indirect threats affect the species through suppressing habitat suitability or prey abundance. Nevertheless, we acknowledge that while both kinds of threats are likely interrelated, direct threats can be to some extent the result of indirect ones.

Direct threats

We were able to obtain 47 records of cheetah mortality between 2001 and 2016, 70.2% (n = 33) confirmed based on available evidences such as photo or carcass whereas the rest (n = 14) have been approved by trained game guards or local experts, but no evidence exist. Only seven individuals (14.9%) were considered to be due to natural causes in contrast to majority of casualties mediated by human.

Most of the cheetah range does not host high density of livestock, except Touran BR and Miandasht WR which have large numbers of domestic sheep and goat and are permitted to graze in parts of the areas during winter. Generally shepherds tend to have more positive attitude toward the cheetahs comparing with other larger predators (Hamidi & Nezami 2009), probably due to their low density, shy behaviour as well as people's comparatively less loss to the cheetahs comparing to other larger predators.

Nevertheless, as cheetahs recover, conflict with livestock could emerge as a threat over time and that livestock management

Fig. 5. A coalition of two cheetah brothers which have been detected in five different reserves between 2009 and 2016 in central Iran (Photo ICS/DoE/CACP/Panthera).

and herder education should be considered. Thus, between 2002 and 2016, at least 21 cheetahs are known to be killed by herders in different reserves, 66.7% (n = 14) are approved based on hard fact such as carcass or photo, just a few have received penalty. As a result, local herders are currently the single most remarkable cause of human-induced mortalities of cheetahs in Iran, typically in companion with herd dogs. At least 13 cheetahs were known to be killed only in Touran BR, equal to 61.9% of country's herders-caused mortalities of the cheetahs.

Almost equally important, growing network of roads is an emerging major problem for the cheetahs in the country. Between 2004 and 2016, road collisions have been accounted for 14 cheetahs casualties (29.8% of total cheetah mortalities) in different parts of Iran, including 8 (6 males vs. 2 females) in Yazd Province. one in Darband WR (1 male) and 5 in Touran BR (4 females vs. 1 male), which are unlikely to be afforded by the current small number of the cheetahs in Iran. With respect to our updated knowledge about high mobility of the cheetahs across different reserves (Farhadinia et al. 2013, 2016) and growing network of roads in different parts of the country, particular attention is essential to deal with this challenge.

We are suspicious that available evidences of cheetah poaching (n = 5) is thoroughly representative of the actual level of the threat. Few of poaching cases are trapping and poisoning, not specifically targeting the cheetahs. Purposeful shooting to the cheetahs is apparently uncommon in Iran, simply because the cheetah encounter is quite accidental in the wild. There are occasional rumors of cheetah shooting in remote areas which expectedly are not associated with evidences such as photo or confiscated carcass due to high legal penalty. Nevertheless, even unverified reports can be an alarming indicator that poaching still can be a major concern for the tiny number of the cheetahs in Iran. Also, there is no evidence available of cheetah trade from Iran.

Indirect threats

Presently, it is suspected that the disappearance of prey is the key indirect threat to the cheetah survival in Iran within most areas (Farhadinia 2004, Hunter et al. 2007, Ziaie 2008). The cheetahs exist in arid environments with extremely low density of wild ungulates which are susceptible to poaching. It has been proposed that the cheetahs can live based on small mammals, particularly hares (Karami 1992, Ziaie 2008), but hares may be too small to sustain cheetahs (especially females with cubs; Hunter et al. 2007) and recent faecal analysis have shown a minor contribution of smaller mammals, including the hare, to the cheetah diet (Zamani 2010, Farhadinia et al. 2012, Rezaie 2014). Therefore, depletion of medium-sized ungulates as main prey can lead to livestock predation (Farhadinia et al. 2012), bringing the cheetahs into more encounter with communities.

Equally important, habitat loss is an essential cause to endanger survival of both the cheetahs as well as their prey which can be due to overgrazing, development plans (e.g. road construction and mining activities) and drought (Karami 1992, Asadi 1997, Farhadinia 2004, Hunter et al. 2007). The latter is believed by many game guards to have adversely affected population growth of ungulates in recent years, but there is no empirical data to support it.

Moreover, domestic camels roam throughout the desert areas of the country. The camels compete with wildlife over scarce water sources and the local people who traverse the deserts in search of their camels tend to poach wildlife.

Most of the cheetah range in Iran hosts various reservoirs of minerals meaning high demands from relevant governmental and non-governmental agencies, particularly in Abbas Abad WR, Naybandan WR, Darband WR and most of Yazd Province's reserves. Fortunately, most of the cheetah range is officially under protection by the DoE which may stop many requests.

Protection measures

Since 1959, the Asiatic cheetah has been officially protected in Iran. However, it has never been subject to any specific conservation initiative in the country. In September 2001, a partnership between Iran DoE, and Global Environment Facilities GEF United Nations Development Programme UNDP was established to form the Conservation of Asiatic Cheetah Project in which various international and national NGOs have been involved. The goal of this project was formulated as "securing the conservation of the Asiatic cheetah in the I. R. of Iran and the related complex of rare and endangered wild species and their natural habitats with the support and collaboration of local communities".

Currently, some 125 game guards, mostly from communities around the cheetah reserves are hired to afford anti-poaching efforts within the confirmed cheetah range in Iran. Currently, 16 out of 18 confirmed cheetah reserves in Iran (Fig. 4) are officially protected by the Iran DoE, with basic law-enforcement infra-structures. Additionally, recent establishiment of several conservancies, managed by communities around the cheetah reserves in central country has resulted in an reported increase of prey number. Also, strong deterrents have been approved by the government regarding the killing of cheetahs, including jail time and high fines (currently 1 billion IRR equal to US$ 28,570) which is the highest fine on a violator compared to any other wildlife species in Iran. Public awareness campaigns, including Asiatic Cheetah National Day on 31 August have been established both nationally and locally in communities inside and around the cheetah habitats to increase people's knowledge about the cheetah and its ecosystem and dispel misconceptions and myths. In 2014, the Iranian national football team announced that their official kits are imprinted with pictures of the Asiatic cheetah in order to bring attention to conservation efforts. Also, a comprehensive insurance programme has been launched by the CACP to compnesate people who suffered from cheetah depredation.

The Asiatic cheetah has provided the Iranian community as a milestone to enter modern wildlife conservation. Based on the CACP terminal evaluation for its first phase, "The conservation of the Asiatic cheetah has definitely created more national and international awareness than any other wildlife conservation project in the region. In Iran, it has generated wide interest among young researchers for cat, carnivore and wildlife conservation and research in general, and it has the potential to help spread this interest across the national borders to the whole region" (Breitenmoser et al. 2009). Nevertheless, the subspecies' small and fragile population is unlikely to be independent from protection measures for decades to come.

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Supporting Online Material SOM Table T1 and T2 are available at www..catsg.org.

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