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Cats in Iran










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Original contributions and short notes about wild cats are welcome **Send contributions and observations to ch.breitenmoser@kora.ch.**

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Cover Photo: From top left to bottom right:
Caspian tiger (K. Rudloff)
Asiatic lion (P. Meier)
Asiatic cheetah (ICS/DoE/CACP/Panthera)
caracal (M. Eslami Dehkordi)
Eurasian lynx (F. Heidari)
Pallas's cat (F. Esfandiari)
Persian leopard (S. B. Mousavi)
Asiatic wildcat (S. B. Mousavi)
sand cat (M. R. Besmeli)
jungle cat (B. Farahanchi)

URS BREITENMOSER[1]

Introduction

Iran has a remarkable diversity of cats. Until recently, ten cats from the cuddly sand cat to the mighty tiger roamed the country (Table 1). The two largest species, the Caspian tiger and the Asiatic lion, have disappeared a bit more than half a century ago, but eight species are still extant. Iran embraces habitats from subtropical to temperate climatic zones, from the seashore to the alpine level, and is well-known for its high biological diversity, which includes among others almost 200 mammal species. The high diversity is however not only a consequence of the country's climatic features. Iran is also a crossroads between the continents, between Central Asia and Africa, the Indian subcontinent and Europe. Clearly, the region has been a passage way for species migration throughout the Holocene and the Pleistocene, and more than that, it has been a refuge for many species during the big climatic changes of the past aeons.

Iran is still a refuge for some threatened cats. Best known, Iran hosts the only remnant population of the Asiatic cheetah, the largest share of the regional leopard subspecies, typically called the Persian leopard, and most likely the core populations of many other cat species in south-west Asia – although we often do not know exactly.

The notorious lack of reliable and up-to-date information on distribution, abundance, and trend of the cat populations is a considerable hindrance to defining and implementing sensible and well-targeted conservation measures. Data needed to assess the conservation status of a species are often not primarily a question of sophisticated research, but rather of consistent and careful compilation of information that is "somewhere" available, and of subsequent monitoring. Cat News Special Issue N° 10 intends to set a baseline for the continuous observation and assessment of the situation of Iran's cat populations. The 33 authors of the articles compiled in this issue have reviewed the existing publications and have compiled available data on all ten cat species. This amazing work has been favoured by two circumstances: First, Iran has a high standard of education and research with a considerable number of universities, working groups, but also non-governmental organisations, which are involved in science-based conservation projects. Second, the Department of Environment DoE maintains in all provinces (Fig. 1) regional offices, and ranger stations in many of the protected areas. The DoE structure provides a perfect network for the systematic compilation of monitoring data for the conservation of wild cats and wildlife in general. And the cooperation between conservation organisations, scientists and DoE personnel – as demonstrated by the list of authors of this issue – offers the chance to assure that information is not only collected, but also analysed and interpreted in a consistent way.

Table 1. Cat species occurring in Iran and IUCN Red List categories of the respective species.

Scientific name	English name	Iranian name	IUCN Red List status
Panthera tigris virgata	Caspian tiger	ببر	Extinct
Panthera leo persica	lion, Asiatic lion, Persian lion	شیر ایرانی ,شیر آسیایی,شیر	Endangered
Acinonyx jubatus venaticus	Asiatic cheetah	یوزپلنگ آسیایی	Critically Endangered
Caracal caracal	caracal	سنگوله‌گوش ,یوزخفو ,یوزو(ک) ,کاراکال	Least Concern
Lynx lynx	Eurasian lynx	کلش ,پلنگ مول ,ورشک ,وشق ,لینکس ,سیاهگوش	Least Concern
Otocolobus manul	Pallas's cat, manul	گربه پالاس	Near Threatened
Panthera pardus saxicolor	Persian leopard	پلنگ	Endangered
Felis chaus	jungle cat	گربه جنگلی	Least Concern
Felis margarita	sand cat, sand dune cat	گربه شنی	Least Concern
Felis silvestris	wildcat, wild cat	گربه وحشی	Least Concern

The capacity and the organisational framework for the sensible surveillance of the conservation status of the Iranian cat populations exist, and "Cats in Iran" gives the starting point. The species articles also reveal gaps of knowledge to be closed and unanswered question to be addressed. Yet, the lack of information is no excuse for not engaging with conservation. In the year 2012, the Department of Environment, in cooperation with the Karaj University of Environment and the IUCN/SSC Cat Specialist Group, has developed and published "Conservation of Cats in Iran – a roadmap to a comprehensive approach for the conservation of the indigenous cat species of the I. R. Iran". The *Roadmap* was developed in a workshop bringing together people interested in cat conservation from the DoE headquarter and provincial offices, from universities and NGOs. This was the so far largest gathering for discussing cat conservation in Iran and has laid the fundament for further cooperation. The *Roadmap* provides the conceptual framework for further activities. Together with the now published status reviews in this Special Issue, it will provide guidance for advancing the conservation for each of the extant cat species in the country, e.g. in form of species-specific action plans.

The DoE's protected areas network provides a spatial concept for the conservation of the cats. The DoE manages close to 300 protected areas and national monuments of various size and protection status. For many cat species, these protected areas can, if well-preserved, host important source populations and are designated reference areas for the monitoring. The significance of the protected areas for conserving viable populations is however not yet understood and will need to be studied further. Larger cats like cheetahs and leopards with huge individual home ranges likely roam also outside a protected area and need hence to be protected also in the matrix, and even for smaller cats, isolated populations within protected areas might be too small to be demographically or genetically viable in the long run without being connected to neighbouring populations. Consequently, for a sound conservation of the cats, the multi-use landscape outside protected areas needs to be considered, too. This however requires a different approach, as it implies integrating wildlife conservation into human activities with a number of different land uses.

To engage with local people, communities, and stakeholders, it will be important to inform a broader audience than the conservationists about the state of the cats. This Special Issue about the Cats in Iran is also meant to inform a broader audience and to support awareness raising for these fascinating cats, but also the threats to their survival and the need for their protection and conservation.

Fig. 1. Provinces of Iran.

KAVEH FAIZOLAHI[1]

Tiger in Iran - historical distribution, extinction causes and feasibility of reintroduction

A historical range for the extirpated Caspian tiger *Panthera tigris virgata* in Iran, and close to Iran border in adjacent countries, is constructed based on records extracted from scientific literature as well as from travel journals from 17th century to first half of the 20th century. The records were classified into three categories of reliability, depending on the accuracy of identification and the precision of locality. The historical range is potentially open to re-introduction, and as new molecular research established, Amur tiger could be used as a stock to repopulate tiger in its former range from Central Asia to the Caucasus. However, Caspian tiger habitats in Iran have changed dramatically in the last century, and the main causes of its extinction are now at least as effective as before. If any potentially suitable habitat appears in feasibility studies, a long phase of preparation, beneficial to all wildlife, is needed before reintroducing tiger to land it disappeared from more than half a century ago.

The Caspian or Hyrcanian tiger *Panthera tigris virgata* is a usual member of many lists comprised of the most recent mammalian extinctions, including species and subspecies such as Tasmanian wolf *Thylacinus cynocephalus*, aurochs *Bos primigenius*, quagga *Equus quagga quagga*, Atlas bear *Ursus arctos crowtheri*, etc. The Caspian tiger once roamed across a wide range in northern Asia and was finally wiped out from northern Iran nearly half a century ago.

This is a literature review with the aim of determining the distribution and causes for the decline and disappearance of the Caspian tiger. I then looked at new molecular data which prove that the *virgata* (Caspian) and *altaica* (Amur) subspecies are taxonomically synonymous. Using these findings, I discuss the feasibility of tiger reintroduction within its former Iranian range using Amur tigers, *Panthera tigris altaica*.

Taxonomy

Traditionally there have been eight recognised subspecies of *P. tigris* (Mazák 1981), of which three are now considered extinct (Nowell & Jackson 1996, Jackson & Nowell 2008) and a new subspecies, *P. t. jacksoni*, was recently described from Malaysia (Luo et al. 2004). The Iranian population of tiger belonged to the extinct subspecies *P. t. virgata* (Illiger, 1815). Its type locality is Mazandaran, northern Iran (delimited by Harper 1940). No holotype specimen of *P. t. virgata* exists. Other common names for this subspecies include Hyrcanian tiger, Turan tiger, Persian tiger, Central Asian tiger, Turkestan tiger, Transoxiana tiger, Occidental tiger and Mazandaran tiger.

On one hand, some authors believe that the usual taxonomic lumping of all middle Asian tigers under the *P. t. virgata* subspecies may mask a great differentiation in co-adapted gene complexes between regional populations (Hemmer 1987); on the other hand, new molecular results show that recognizing *P. t. virgata* at a subspecific level may be not justified. It has however been demonstrated that intraspecific variation of tiger is largely clinal and conforms more or less with ecogeographic rules such as Bergmann's (Kitchener 1999). By applying ancient DNA techniques to museum specimens, Driscoll et al. (2009) showed that the Amur and Caspian tigers are sister taxa to the Indochinese tiger, *P. t. corbetti*, being separated from that subspecies by only six and five mitochondrial steps respectively. Caspian tiger haplotype differs only by a single step from Amur tiger and the Caspian tiger was genetically more diverse than the almost identical Amur tiger. All Amur tigers share a haplotype that is derived from that of the main Caspian haplotype (Driscoll et al. 2009).

It is suggested that *P. t. virgata* (Illiger, 1815) and *P. t. altaica* Temminck, 1844 should taxonomically be considered as a single subspecies, as they comply with the three criteria of subspecific taxonomic designation: 1) a distinct and united geographic distribution throughout a continuous range, 2) a unique natural history, and 3) largely concordant phylogenetic characters (O'Brien & Mayr 1991, Driscoll et al. 2009). The Caspian tiger and Amur tiger may have a recent common ancestry and may thus be considered as synonymous under the prior *P. t. virgata* trinomial. There is even a suggestion to consider all continental tigers as one subspecies (Wilting et al. 2015), mainly with the intention to facilitate tiger conservation management.

As Hemmer (1987) put it: "Tigers have phylogenetically developed population differences, but man has developed the concept of subspecific taxonomy. Thus, conservation strategies must not rely primarily on such man-made concepts, but on nature's existing population".

Table 1. Size and cranial characters of Caspian tigers (Ognev 1962. Mazák 1981, Heptner & Sludskii 1992).

	Males		Females
Total length	270-295 cm		240-260 cm
Tail length		90-110 cm	
Weight	170-240 kg		85-135 kg
Skull length	316-369 mm		268-305 mm
Condylobasal length	259-308 mm		225-263 mm
Zygomatic width	219-254 mm		183-203 mm

Phylogeography

The Caspian tiger's uncertain biogeographical origin and phylogenetic placement in the tiger family tree has puzzled naturalists for over a century (Macdonald et al. 2010). Heptner & Sludskii (1992) proposed that tigers colonized this area from north-west India and Hemmer (1987) like Mazák (1981) suggested a route from north-east Asia via central Asia. Driscoll et al. (2009) deduced that tiger expanded in northern Asia through the Silk Road (Gansu corridor) from eastern China, between the Himalayan Plateau and the Mongolian Gobi desert, first towards west into Central Asia up to Anatolia, and then eastwards into the Russian Far East. Tiger expansion into Central Asia is very recent (Holocene) and Caspian tiger geographical variation dates back to less than 10,000 years ago.

Caspian tiger may have been the most isolated of all mainland tiger subspecies during the stadials of the Pleistocene, "(they) were doubtless excluded from India by the Hindu Koosh and the desert areas of Persia and Baluchistan" (Pocock 1929). Vereshchagin (1967)

considers it a postglacial immigrant due to lack of fossil remains in the Caucasus. Indeed, the nearly continuous range of the tiger in northern Asia (except a gap around 100° E) is clearly evident in older maps (Mazák 1965). "There is evidence that the tigers of the Perso-Turkestan district are, or were, continuous in their distribution with those of Mongolia" (Pocock 1929). Ellerman & Morrison-Scott (1951), report a historical distribution in the Ob basin and the Altai Mountains. The historical distribution of Amur and Caspian tigers extended from Anatolia to the Russian Far East and this range became discontinuous within the last 200 years, probably due to anthropogenic factors (Driscoll et al. 2009).

Morphology

The maximum known weight of Caspian tigers exceeds 240 kg but evidently could be greater (Heptner & Sludskii 1992). There is not much consensus on size of the Caspian tiger. According to different authors, it was the second or the third largest tiger of all. Lydekker (1901, 1907) described it as "a small and somewhat rough-haired variety" based on a mounted specimen in the British Museum. Pocock (1929) stated that "there is little, if any, difference in size between this tiger and the Indian subspecies". This is in concordance with Mázak (1981) while Joslin (1988) considered it of intermediate size.

Body size in tigers is probably influenced by phenotypic responses to the environment (Kitchener 1999). The great size variation may be a case of ecological variation resulting from temporary climatic conditions (Mayr & Ashlock 1991), indicating a highly plastic phenotype. Sexual size dimorphism in tigers increases with latitude (Kitchener 1999) and was striking in Caspian tiger, where males were almost two times heavier than females (Mázak 1981; Table 1).

Sagittal and temporal crests, especially in large males are very strong and prominent (Mazak 1981). The occiput is very broad (Pocock 1929), as in Amur tigers, "which may indicate a close relationship between these populations" (Kitchener 1999).

Though the Caspian tiger was in average smaller than the Amur tiger, the largest individual, killed on the Sumbar in Kopet-Dag on 10 January, 1954 (stuffed skin in Ashkhabad Museum), with a greatest skull length of 385 mm (Heptner & Sludskii 1992), exceeds slightly even the maximum value known for the Amur subspecies (skull length 383 mm; Mazak 1981; Table 1).

Coat pattern

Caspian tiger expected near the paler ground colour and fewer stripes ends of the range in a clinal variation that seems to be a rule for more northern tiger populations. However the stripes in Caspian tiger were more numerous and closer set (Pocock 1929). The ground colour was somewhat richer, darker red, with a tendency to turn brown in some specimens (Pocock 1929). The ground colour of tigers' pelages is usually understood as a reflection of habitat and/or humidity (Gloger's rule), so the dark, more striped pelage of the Caspian tiger is not unexpected in the dense humid jungles of south Caspian. Nevertheless, Heptner & Sludskii (1992) showed that Caspian tiger displayed a wide variety of striping patterns and ground colour variations.

Both Satunin (1914) and Pocock (1929) showed that the stripes in some Caspian tigers were not black as in the Bengal tiger (Harper 1940). Pocock (1929), however, points to a great variation in British Museum specimens, with two of four Caspian tiger pelts having quite black stripes just as in the Indian tigers. The other two are partly and wholly brown.

There are two Caspian tiger skins with dubious origin (most probably from Golestan area) in Iran Biodiversity Museum (Fig. 1) and Darabad Museum of Nature and Wildlife (Fig. 1), both in Tehran. They seem to conform to other descriptions of Caspian tiger pelage, as their ground colour is not so pale, with a red ochre hue.

Seasonal coat colour and length dimorphism was prominent: the winter coat was considerably lighter and paler in colour and denser and longer, than the summer coat with a less distinct pattern. Hair was markedly longer on the head insofar as the ears projected only insignificantly (Heptner & Sludski, 1992). The fur even in summer were thick (8 to 13 mm on the back and 20 to 30 mm on the abdomen), but tended to grow much longer in the winter (30 mm and more on the back) especially on the nape (up to 20 to 50, and even 90 mm long) that look like a mane, on the cheeks, on the sides of the face, and along the belly (Pocock 1929, Ognev 1962, Heptner & Sludski 1992, Mazák 1981).

Habitat

Primary habitat of the Caspian tiger in Iran included riparian and lowland forests, reed-covered coastal plains, and wetlands. Secondary habitat was alpine forests on the northern slopes of the Alborz Mountains made up of dense vegetation consisting of beech, oak, hornbeam, tamarisk, pomegranate, boxwood, and ash trees (Blanford 1876, Zarudny 1891, Vuosalo 1976, Joslin

Fig. 1. Left: the tiger hide in Biodiversity Museum of Iran, Tehran, and right the tiger hide in Darabad Museum of Nature and Wildlife, Tehran, both most probably from Golestan area (Photos F. Heidari).

1986). Its presence has been confirmed up to 1,800 m in northern Iran (Blanford 1876). It was also reported to have traversed vast expanses of desert while traveling from northern Iran to the eastern shores of the Caspian Sea (Heptner & Sludskii 1992).

Ecology and behaviour

There is little information on the natural history of Caspian tigers in Iran. In the Ili River Valley in Kazakhstan, tiger territories measured 20 by 50 km^2, while a male and two females were thought to have occupied an area measuring only 42 km^2. Their territories partially overlapped (Joslin 1988).

Tiger mortalities due to wild boar anti-predatory defence have been recorded in the Trans-Caucasus and Iran (Brandt 1856). Brown bears also may cause injuries and even death to tigers. Cubs were killed by male tigers, brown bears, and other predators. Evidence shows that tigers in the Trans-Caucasus had suffered injuries from porcupine. Wolf and leopard competed against tigers for prey and habitat (Heptner & Sludskii 1992).

An altitudinal migration was observed as tigers climbed into the mountains during spring and summer, following grazing ungulates, and descended to lower altitudes in autumn, wintering in the plains (Kock 1990, Heptner & Sludskii 1992). Chodźko (1850, cited in Sahami 2006) observed the same pattern of seasonal migration in Guilan Province, northern Iran. Due to following migrating ungulates the Caspian tiger was known as "road" or "travelling leopard" in Central Asia (Extinction Website 2010).

Prey

While the tiger's main prey was the wild boar *Sus scrofa*, roe deer *Capreolus capreolus*, Caspian red deer *Cervus elaphus maral*, Urial *Ovis vignei arkal*, golden jackal *Canis aureus*, jungle cat *Felis chaus*, various domestic animals, including horse, ass, water buffalo, camel and dog (Vuosalo 1976, Heptner & Sludskii 1992) were also preyed upon. Cattle were attacked only in winter according to Vereshchagin (1967). In north-east Iran, tigers also preyed on goitered gazelle *Gazella subgutturosa* (Brandt 1856) and in Alborz on wild goat *Capra aegagrus* (Kotschy 1845). There is no record of Caspian tiger preying on locally extinct ungulate fauna such as Caucasian elk *Alces alces caucasicus*, Caucasian wisent *Bison boasus caucasicus*, aurochs *Bos primigenius*, or tarpan *Equus ferus* within its Iranian range, though their coexistence in Iran-Caucasus border in older times seems plausible.

Panthera tigris virgata

Names:
ببر Babr
Caspian tiger

Head and body length:
240-295 cm
Tail length:
90-110
Weight:
85-240 kg

Iranian population:
0

Distribution in Iran:
Nowhere

IUCN Red List:
Extinct (2008)
Excludes *P. t. altaica*
Amur Tiger: Endangered (2010)

CITES:
Appendix I

DoE List:
Protected (since 1957), extinct, based on hunting and fishing law

Photo K. Rudloff

Demography

The Iranian tiger populations of south-west (Talysh Mts) and south-east Caspian region were supposed to act as source to sink respectively in south Caucasus (Transcaucasia) and Turkmenia Kopet-Dagh (southern Transcaspica; Heptner & Sludskii 1992). It was reported to reproduce once every two or three years, bearing two to four cubs per litter. No particular breeding season has been documented (Joslin 1986).

In Trans-Caucasus, two litters with two cubs each have been recorded (Heptner & Sludskii 1992). A Caspian tiger reportedly bred and produced young twice in the Moscow Zoo over a two-year period (Joslin 1988). There is an image of a tigress with her two unborn cubs hunted by royalties in north-eastern Iran around the 1920s.

Distribution

The Caspian tiger occupied the most western area of the species' range. The distribution extended westwards to the south of the Caucasus and eastwards across central Asia from the Caspian, through northern Persia (Mount Elburz), northern Afghanistan, the Aral Sea, and the Pamirs, River Ili, Lake Balkhash, Tarim and Lake Lop-nor. The range extended as far east and north as the Altai and the southern Ob basin (Kirk 1969), reaching Europe through the Ukraine, in reed beds along the Terek and Kuban rivers, and in the Don River mouth.

Historical distribution of tiger in Iran

For a better apprehension of tiger historical range in Iran, scientific literature as well as travel journals from 17th century to first half of the 20th century have been searched for reports on tiger occurrence in Iran and records close to Iran border in adjacent countries (Supporting Online Material SOM Table T1 & T2). It should be noted that older provincial divisions of Iran in the period that contains most of the tiger records were different from now (for example Guilan and Mazandaran applied to much larger areas, and Golestan was not considered a separate province). Hence the vague older references to these names may not refer to their modern borders.

The tiger occurred in the northern Iran in forests and reed beds surrounding most rivers and wetlands, from Tejen in Sarakhs along the border with Turkmenistan through the south Caspian lowlands all the way along the border with Azerbaijan and Armenia to Arax near Ararat. This almost 2000 km strip includes parts of 8 provinces: West Azerbaijan, East Azerbaijan, Ardabil, Guilan,

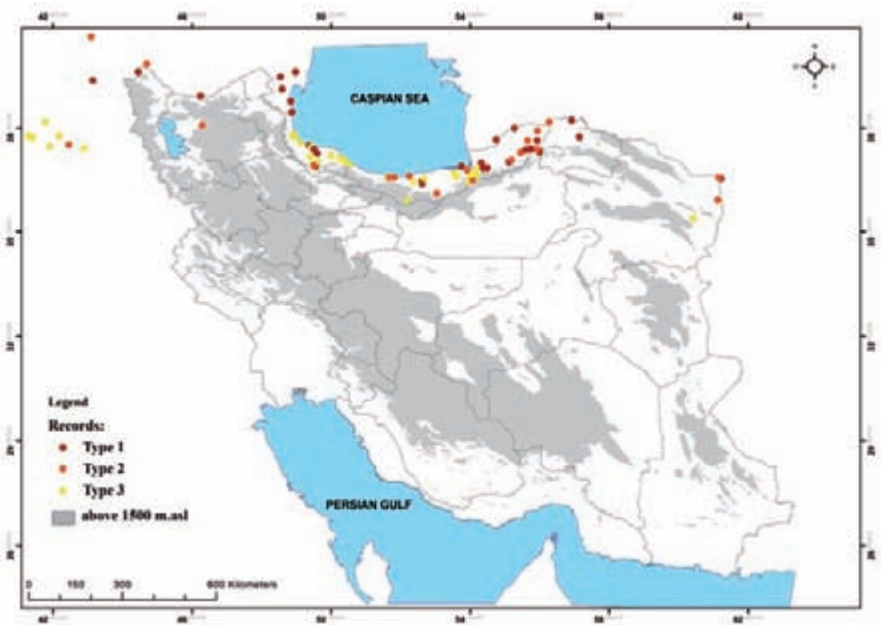

Fig. 2. Distribution range map of the tiger, based on historical records in Iran and close to the Iranian border in adjacent countries. For definitions of record types see the text below "Historical distribution of tiger in Iran" (map produced by N. Ahmadi).

Mazandaran, Golestan, North Khorasan and Razavi Khorasan (Fig. 2, SOM T1 & T2). The specified records of known locality, were assigned to 3 categories based on their reliability, a concise version of Boshoff & Kerley (2010) method: 1) accurate identification and precise locality (sighting or specimen); 2) accurate identification or precise locality, but not both; and 3) questionable identification in imprecise locality.

Tiger in Persian arts and folklore

Objects in form of tigers or with tiger designs can be found dating back as far as 3400-3000 BP (Negahban 1996; Figs. 3-5). Moreover, the tiger appears in some ancient Persian miniatures and in tribal carpet designs (Vuosalo 1976, Tanavoli 1985). There are many references to tiger and its skin in Persian poetry of the 10th and 11th century, such as Shahnameh (977-1010) by Ferdowsi, Garshaspnameh (ca. 1066) by Asadi Tusi and Diwans of Farrukhi Sistani, Manuchehri Damghani, and Qatran Tabrizi among others. Tiger has been mentioned in some Persian bestiaries of the 12th to 14th centuries, such as Ajayebnameh by Hamadani (1166), Farrokhnameh (Fig. 6) by Yazdi (1184), Ajayeb Almakhluqat (Fig. 7) by Qazvini (1280), and Manafe'e Hayavan (Fig. 8) by Maraghi (1299).

Conservation status

The Caspian tiger is extinct in Iran (Harrington & Darreshuri 1977, Joslin 1986, Ziaie 1996, Jackson & Nowell 2008, Karami et al. 2008) with no conclusive records in more than 50 years, although dubious reports still surface.

In captivity

There are no Caspian tigers in captivity today (Kirk 1969, Nowell & Jackson 1996). A small tame tigress, named Theresa, which had been presented to the Soviet ambassador in Iran, lived from 1924 to 1942 in Moscow Zoological Garden (Heptner & Sludskii 1992). The only other tiger in European zoos which was certainly originated from Persia, was the young female tiger of Hagenbeck Zoo in Hamburg, Germany, that lived there from 1955 to 1960. This tigress, named Soraya (a female Persian name which means Pleiades, and the name of the queen of Iran, 1951-1960), probably was the last Caspian tiger in captivity (Fig. 9 & SOM Figure F1).

Causes of extinction

Sometime before 1911, Col. Kennion came across only two tigers in Golestan Province and wrote in his memoirs "considering the abundance of game and the fewness of the tigers' foes, it is quite a problem why the latter are not more numerous in these parts" (Kennion 1911, p. 246) and Pocock (1929, p. 522) stated that "there is reason to fear that the race is on the wane."

In the 1930's, around 80 to 100 tigers were presumed to still survive within its Iranian range but subsequently these numbers declined (Schaller 1967, Heptner & Sludskii 1992). Tigers became "quite rare" in the forests on the southern coasts of the Caspian Sea. By the middle of the last century, almost tiger's entire preferred habitat had been reclaimed for cultivation, with the result that the survivors retreated to the mountain forests, where the last recorded Caspian tiger was shot in 1959. Intense felling of forests appears to have caused the animal to disappear altogether from Iran (Misonne 1959, Lay 1967).

The extirpation of Caspian Tigers in northern Iran was caused by the loss of critical resources including habitat, water and prey. Habitat was lost through the burning of riparian vegetation, draining of wetlands and the conversion of forests into cultivation. Use of DDT in 1940s and 1950s cleared the reed-covered wetlands of malaria mosquito, as one of the most prohibiting factors for people invading tiger habitat. Tigers were forced to retreat to the margins of their natural habitat in the forested mountains. Here they competed for resources with the largest leopard subspecies - the Persian leopard *Panthera pardus saxicolor* - but were not able to survive and became extinct by the 1960's.

Between 1973 and 1976 extensive efforts were made by the biologists of the Iranian Department of the Environment DoE to search for tigers in the forests of the Alborz Mountains, but no trace or evidence was found (Joslin 1986 & 1988, Firouz 2005).

Tigers have proven to be an adaptable species and live in a variety of habitats and climates across the world. Tigers have a relatively high reproductive rate with short inter birth intervals. They are quick to fall back into oestrus in the event of the loss of a litter. They prey on a variety of species from small to large mammals and tigers can adapt their hunting technique based on the type of prey and habitat. However, some characteristics of the species in western Asia made it more susceptible to human development in the regions as well as to wildlife trade.

Distribution pattern

One of the most important factors concerning the decline and extinction of the Caspian tiger was its natural restricted distribution. The various historical records show that the distribution of the Caspian tiger was ramified and associated with watercourses, river basins and lake edges, embedded in a large expanse of desert environment, rendering the species vulnerable (Heptner & Sludskii 1992, Sunquist et al. 1999).

On the southern side of the Caspian Sea, tigers occurred in the forested areas of

northern Iran, where they were associated with riverine habitats, important areas for the species and its prey. With the increasing human population and the advent of development, rivers were used as modes of transport for colonisation. The persecution of tiger and its prey increased with increasing movement and activity of humans in the area (Sunquist et al. 1999).

Prey

The emergence of tiger as a large-bodied, forest-edge predator followed the radiation of the cervids. Cervids are vital to the tiger's survival in the wild. Tigers living in regions where high rainfall results in a naturally low cervid and other terrestrial mammal diversity are especially vulnerable (Sunquist et al. 1999). This was the case with the late Caspian tiger. The Caspian tiger's former distribution in Iran overlaps with distribution of cervids such as Maral red deer and roe deer.

Red deer and wild boar formed the tiger's prey base, with red deer being the principal item in the diet, but as deer numbers declined, tigers had increasingly to rely on wild boar, which were in those days abundant on the coastal plains. Wild boars are a resilient species and can sustain high rates of culling with the ability to recover populations over relatively short periods of time. However, their numbers were affected by hunting, disease, natural disasters and in the Caspian region, suid diseases, floods and fires have contributed to a high loss of individuals (Novikov 1962, Heptner & Sludskii 1992, Sunquist et al. 1999). The tiger's disappearance from the Caspian region was therefore related to the decline in wild boar on which it increasingly and solely relied.

Hunting and persecution

Not many tigers were killed in Iran, unlike the systematic tiger eradication which took place in Russian territory, when "large parties of sportsman and military squads actively hunted wild boar and tigers with reckless abandon" (Heptner & Sludskii 1992, Sunquist et al. 1999). Nonetheless, the conflict was inevitable nearing the end, as more tigers attacked livestock when their natural prey became scarce. Chodźko (1850, cited in Sahâmi 2006) reported that every year a lot of them were killed in Guilan and Mazandaran and mentioned a tiger that was shot by artillery guild in Sarakhs at 1833. As he observed "Guilan highlanders are generally dexterous shooters. When an ox was killed by a tiger, they never moved the corpse, but lay in ambush on a tall tree waiting for the tiger to come back. The tiger seldom dies with the first shoot, so it would be chased into the jungle by hunters and their hounds" (Sahâmi 2006, translated into English by the author).

The tiger's decline has been attributed to its over-hunting in the Caucasus (Vereshchagin 1967), Afghanistan (Habibi 2004) and also Iran (Misonne 1968). It seems that there was not a high demand for tiger fur in northern Iran as according to Nikitin (1941) "the animal's fur is inexpensive in Guilan and we purchased many kinds of them" (translation by the author). Nevertheless, there is another report of shops selling tiger and panther skins in the larger towns, such as Qom and Kermanshah (Bird 1891).

Direct persecution also played a critical role in elimination of the tiger from northern Iran. Cubs were caught to be exhibited in menageries (Novikov 1962). Blanford (1876) saw specimens in Tehran zoo and reported that "cubs are often captured in Mazandaran and brought to Tehran." There is a similar report from Mount Ararat that "young are caught in traps by the people round the mountain, to be exhibited in shows of wild beasts throughout Persia" (Blyth 1845).

Agriculture

Cotton, rice and other crops grew well in the rich silt along the rivers, thus the Caspian lowland dense forests and marshes were cleared for agricultural use (Sunquist et al. 1999). Cultivation of the reed beds led to disappearance of wild boars that supported the tigers. Indeed the last tigers were recorded in the remaining fragment of reed stands in the southeast Caspian region. Deforestation sped up as the human population increased and more pastures were needed for livestock. Local inhabitants carried out uncontrolled burning of thickets along the banks of the rivers to provide new growth of grass for their livestock (Habibi 2004). Apparently intense felling of forests and extensive habitat destruction has caused the animal to disappear altogether from Iran (Misonne 1959, Lay 1967).

Human-tiger conflict

The Caspian tiger is often an emblem of bloodthirsty cruelty in classical literature (e.g. Shakespeare in Macbeth); however, it seems that there was not an intense human-tiger conflict in the area.

Persian tigers were not man-eaters (Vuosalo 1976, McDougal 1978). "Man-eaters appear to have been almost non-existent among the Caspian race of the tiger, at least in Iran" (McDougal 1978). Mazandaran peasants told Vambery (1865) that they very rarely attack human beings. Kennion (1911), interviewing

Fig. 3. One of a pair of golden hollow tiger heads found in excavations of the ancient site of Marlik, near Rudbar in Guilan Province, 3400-3000 BP (Negahban 1996).

Fig. 4. A silver dish depicting a tigress against a tree, 4th century. Silver, 22.8 cm in diameter. The Hermitage Museum, Saint Petersburg (S-41).

Fig. 5. An oval silver bowl with running tigresses on each side, 6th-7th century, Sasanian period. Silver, niello inlay. The Metropolitan Museum of Art, New York, Met-05679.

Fig. 6. Tiger illustration in an old Persian bestiary, Farrokhnameh (1184).

Fig. 7. Painting of a maned tiger in an old Persian bestiary, Ajayeb Almakhluqat (= Marvels of Creation; 1280).

Fig. 8. Tiger, according to an old Persian bestiary, Manafe'e Hayavan (= Benefits of Animals; 1299). It could be read as "…if oppose a man, even though it is hungry, does not charge. When bleeds, it irritates and gets furious, and all the beasts would be wary of it. While it falls ill, looks after a dog, and rejuvenates after devouring it."

local hunters, concluded that "man-eating tigers, meaning tigers that regularly preyed on man in preference to game, were unknown in Mazandaran" (historical delimitation, including Golestan Province). The local hunters recalled only two men killed by tigers, both of them by beasts they had wounded. The same also affirmed specifically for Guilan tiger that "never attack a man unless it is wounded" (Chodźko 1850). Yet, there is a famous anecdote of an attack in 19th century in Guilan, in which a curious tiger, caused no casualties (Serena 1883).

A reputed depredation on livestock was never a problem as "abundance of wild boars and mountain sheep leaves no excuse for attacking livestock" (Chodźko 1850). However during the final phase of their existence, it became a source of conflict and led to direct persecution through all kinds of trapping and poisoning. Tigers searched for cattle in lowland villages in winter and visited mountain pens from May to October (Chodźko 1850).

There are no references of the use of tiger parts in traditional medicine of Iran. "The animal had not been surrounded by legends of therapeutic powers, as is the case in China" (Vuosalo 1976).

Conservation measurements

Tiger is protected in Iran under national legislations since 1957 (Firouz 2005) and was officially declared as extinct in 1967. Once the tiger's decline had become well recognized, laws were enacted both in Iran and the USSR giving it total protection. However, it was too late to save it in the wild (Joslin 1988).

As the indigenous local tiger population in Iran is extirpated, there remains only one conservation measure possible within Iranian borders, which is reintroduction, with the lowest score in effectiveness (Chundawat et al. 2008).

Feasibility of reintroduction

Habitat preference is likely to correlate strongly with taxonomy, and a good taxonomy should be informed by evolutionary relationships. The molecular differences between the extinct Caspian tiger and the extant Amur tiger are minimal, suggesting that they belong to the same subspecies (Driscoll et al. 2009). Indeed, the amount of genetic variation in Caspian/Amur tigers over their entire distribution, from the Caucasus to the Russian Far East, is less than the amount of variation within a single population of Bengal or Sumatran tigers (C. Driscoll, pers. comm.). This has practical implication for conservation, because a taxonomic assessment is a prerequisite to any re-introduction program.

According to re-introduction guidelines (IUCN/SSC 2013), "(individuals to be reintroduced) should preferably be of the same subspecies or race as those which were extirpated" and "the source population should ideally be closely related genetically to the original native stock and show similar ecological characteristics (morphology, physiology, behaviour, habitat preference) to the original sub-population", although it advises a cautious approach for populations that have long been extinct.

As Driscoll et al. (2009, 2012) suggest "one potential implication of the recent molecular study is that former Caspian tiger habitat in Central Asia is open to reintroductions from Amur stock." Based on their results, Macdonald et al. (2010) consider Caspian tiger a Management Unit MU separate from the Amur population that together would form an Evolutionarily Significant Unit ESU. Macdonald et al. (2010) musing about where Caspian tigers might be reintroduced in Iran, mention the Golestan National Park, Atrak valleys, and Miankaleh protected area. However, since its extinction, the original natural habitats of tiger in Iran have changed considerably. Golestan NP, which consists mainly of secondary tiger habitat and probably never contained a large population of tigers, could thus be excluded from the list. Two other potential areas have lost the larger part of their original vegetation and now are very poor in prey base. It is not known if the carrying capacity of the remaining habitat is sufficient to support a self-sustaining population of tiger in the long run. The habitat loss as the main cause of the extinction of local population is currently at a maximum.

Any tiger conservation program should ensure a healthy stable population of cervids, bovids and suids. No information is available for maral deer and wild boar populations in northern Iran. Populations of Maral deer in Golestan National Park may not surpass 500 and probably no more than 60 in any specific locality in Iran (Kiabi et al. 2004) which is insufficient to sustain a healthy tiger population. No maral population lives in Miankaleh or Atrak valleys at present.

The effects of a re-introduced species on an ecosystem, including competitors and prey species need to be understood (IUCN 1998). Using captive-bred individuals does not increase the probability of success. Re-

introducing a species merely because of the availability of captive stock is a decision not recommended by the IUCN (1998). Nonetheless, the tiger is a resilient species and where conditions are favourable (sufficient cover and prey), its populations can grow rapidly (Sunquist et al. 1999). So if a reintroduction program for tigers is to be performed in any potentially suitable habitat in Iran, a long phase of preparation is to be expected. Prey base should be strengthened and vegetation should be improved.

Currently, there is no tiger reintroduction project in Iran, and no comprehensive feasibility study has been conducted on the potential of tiger habitats in Iran. Actually, two captive-bred Amur tigers (one male and one female) have been imported from Russia in an effort to start such a program, which was suspended after the male individual succumbed to a disease recognised as glanders in Eram Zoo, Tehran. There is no political will in Iran to proceed further, at the present time.

Fig. 9. Soraya lived in Hagenbeck Zoo from 1955 to 1960 (Photo K. Rudolff).

Conclusion

A disagreement on priorities for tiger conservation surfaced in 2011 when in a letter to Science, Driscoll et al. (2011) supported the restoration of populations in selected habitat within the historic range of the extinct Caspian tigers as a new boold infusion to the species. Their proposition includes reintroducing zoo-bred Amur tigers with known ancestry, to potentially suitable habitats assessed by Jungius (2010) in Central Asia among others. But then a counterpoint by Rabinowitz et al. (2011) underlined the efficiency of 'traditional' approaches when properly implemented. "If we are considering reconstructive surgery for the tiger, then let's stop the bleeding first" they concluded (Rabinowitz et al. 2011).

The situation in Iran is strangely similar to this debate: many species of large mammals are on the IUCN Red list of threatened species - Asiatic Cheetah, Persian Leopard, Asian Wild Ass, and Mesopotamian Fallow Deer - and the Iranian ungulate fauna have been decimated during the last three decades. This is why many Iranian experts have their reservations and express serious concern regarding reintroduction programs. The problem, in their view, is expending limited money and resources for a species which is globally important but not a priority in Iran.

However, "the reintroduction of tigers - a flagship species, could be a catalyst in motivating the restoration of habitat which is beneficial to all wildlife, not just the tigers" (C. Driscoll, pers. comm). So perhaps we are not confined to choose between having what we lost and losing what we still have. The common denominator is a secure, well-protected land and the goal is not just to have tigers, but to restore complete, working natural ecosystems. No doubt that not all reintroductions succeed, but many of them do and having tigers represented in the natural fauna in specific areas is not a fantasy at all.

In conclusion, the famous quote by William Beebe seems true more than ever: "when the last individual of a race of living beings breathes no more, another heaven and another earth must pass before such a one can be again." However, a conservationist should keep in mind that "restoration is not about the nostalgic re-creation of a lost past, but about building a sustainable future" (Macdonald 2010).

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Supporting Online Material SOM Figure F1, Table T1 and T2 are available at www.catsg.org

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The lair of the lion in Iran

It is more than a half-century since Iran lost its Asiatic lion. Lions were widespread in south Iran, specifically on the slopes of the Zagros and forest regions around Shiraz. They were slightly smaller than their African ancestor, with an obvious running belly fold, shorter mane, and thus visible ears. Current climate and other physical conditions in Iran seem to be in favour of the lions return. However, prey population and potential anthropogenic conflicts are major obstacles in re-introduction plans.

Everlasting beast

Although extinct in Iran's wilderness, lions are still alive in literature and fine arts. The lion has been Iran's national emblem for many years. An illustration of the lion with a sward in hand and the sun in his back was stamped on the Iran's flag for decades. This charismatic species has been known as a symbol of glory, grandeur and power since Mithraism era (Khosravifard 2010). Initiation into Mithraism consisted of taking seven steps or climbing a ladder. The lion (or leo) was the fourth step that asked for physical strength (Hami 1976). This perception of the lion has been frequently portrayed in paintings, sculptures and poets of Iranian artists (Afshari 2005, Ghasemloo 2005, Zekrgu 2006). The archaic Pazyryk carpet has a design motif of the Asia-tic lion (Parham 1992, Tanavoli 2008). Hunting lions is a common pattern in Persepolis reliefs. The most renowned of these reliefs is the combat of the lion and a bull (Fig. 1). The lion as a sign of heroic triumph and illumination is fighting with a bull, which was known as a symbol of darkness and ignorance (Boyce 1996). The cultural significance of the male lion is still reflected in the sculptures of stone lions on the top of the graves of the dead men who are recognised as courageous and valiant in the Zagros (Fig. 1).

Here, we briefly report a summary of an extensive literature review we have done on lions in Iran during modern times. The main sources of information about Asiatic lion in Iran are the hunting diaries and the travel logbooks, which their contents were often aimed to serve certain purposes, and hence exaggerating or neglecting the truth on behaviour and figure of the lion. Nevertheless, these evidences are certain proofs of the existence of lions in the reported localities.

We used these historical evidences and observation records to model the habitat favourability of lions in Iran. To model the historical distribution of the lion we employed MaxEnt version 3.3.1 (Phillips et al. 2006). MaxEnt has generated higher predictive accuracy than many other methods (Elith et al. 2006), and has outperformed others where sampling was poor (Costa et al. 2010), or data were collected with sampling bias (Phillips et al. 2009, Rebelo & Jones 2010). For more information about MaxEnt and its statistical explanation, see Elith et al. (2011).

Ecology and behaviour

Since 56 years ago, when the last lion has been seen in Iran (Schnitzler 2011), sadly no roar was heard even in captivity and no relics was left in national museums. Our understandings of their habitats and behaviour are limited to historical observation records or indirectly through similar studies on the only free ranging population of this species in the Gir Forest National Park of India. Lions in Asia are slightly smaller than their African ancestor (Nowell & Jackson 1996). They have an obvious running belly fold, and their mane does not extend to the forehead so the ears are always visible (Pocock 1930, Firouz 2005; Fig. 2 & 3). Since lions were divided into two Asiatic and African groups only around 100,000 years ago, they are still morphologically quite similar (O'Brien et al. 1987) and have just developed some minor traits due to their distinct habitats. The Asiatic lion has bifurcated infraorbital foramen which is different in the African specimens (O'Brien et al. 1987). The Asiatic lions are social predators. Social predation provides the possibility to kill creatures larger than those that a single lion could overpower alone. However, unlike the African lions, their diet consist mainly of livestock (Pocock 1939, Joslin 1973) and small wild ungulates, with a preference for Persian fallow deer *Dama dama mesopotamica*, wild boar *Sus scrofa*, and chital *Axis axis* (Meena 2009). This diet preference might be the reason that the pride size in Asiatic lion is relatively smaller; 2 to 5 females and male coalitions. Their home range is estimated around 110 km² for males (Nowell & Jackson 1996) and around 50 km² for females (Jhala et al. 2009). The coalition of males defends the territory of the pride.

Fig. 1. Left: The lion and bull in combat at ancient Persepolis (Photo Courtesy: Abbas Jafari). Right: The stone lion on the top of the grave of a recognised courageous and valiant man (Photo Courtesy: Abbas Jafari).

Habitat and distribution

Historical distribution of the Asiatic lion was vast and ranged from Greece and Syria in the west through Azerbaijan, Iraq, Iran, Afghanistan, Pakistan, and up to India in the east (Jhala et al. 2009). The Asiatic lion once had an extensive distribution in Iran as well, ranging from the border of Iraq through the Khuzestan plain to the province of Fars.

Schnitzler (2011) has reviewed literature on the historical evidences and collected a complete list of historical observations of the Asiatic lion. There are few other observation records that we added to the list (Table 1). Zell-e Soltan (1850-1917) the Qajar prince, who is famous for his extraordinary hunting records, has mentioned Dasht-e Arjan and Kamfirouz in the Fars Province as a main roaming area of the lion: "lions are also to be found here. Wild sheep, ibex, partridge, snow partridge, and bear are so abundant

that shooting them is of no importance…", he wrote after a hunting trip near Ardekan Mountain (Zell-e Soltan 1989). His statement is concurring with Hasan Ibn Hasan Fasaei's descriptions of the Fars Province between 1883 and 1894 (Fasaei 1993). He has mentioned the city of Nobandegan as a well-known area of the lions in the Fars Province. These location names had also been mentioned in Mostofi's historical book (Mostofi 1983).

All available observation records of the Asiatic lion in Iran were located below 2000 m. The highest locations were reported from the surroundings of the Dasht-e Arjan (~1950 m) and the Kotal-e-Pirezan (~1700 m), and the lowest locations from the Khuzestan Plain (~50 m). The eastern part of the lion's habitat in the country is confined to the southern and western slopes of the Zagros vegetated with steppe flora such as *Artemisia* sp. and *Astragalus* sp., and pistachio-almond woodlands where parallel ridges enclosing broad valleys. Mean annual rainfall in this part is higher at about 450 mm. Deep snow and freezing is also not unusual. Towards south-west the characteristics of the lion's habitat gradually change and the *Amygdalus scoparia*, *Acer cinerascens*, and further south Ziziphus spina-christi, *Prosopis spigera* are dominant with sparse *Prosopis spigera* and Acacia thorn savannah in coastal area, until it reaches the Mesopotamian marches with halophile vegetation. This part of the habitat receives about 100 mm annual rainfall, while in summertime temperature routinely exceeds 50°C and the climate is occasionally very humid. The described habitat is not bounded to the Khuzestan and the Fars Provinces where all historical observations occurred. It continues with slight differences towards east into Hormozgan Province and a bit towards north where the Zagros Mountains meet the central plateau in the Kerman Province, and ultimately ends to the Hamoun Lakes at the border with Pakistan. This habitat distribution is in accordance with the distribution model of the lion in Iran (Fig. 4).

The habitat favourability model (Real 2006) for Asiatic lion in Iran was trained based on all historical observations (n = 20) over topographical (i.e. elevation, slope, and aspect), biological (i.e. Enhanced Vegetation Index), and bioclimatic variables. Elevation above sea level and mean diurnal temperature had the highest contribution, followed by maximum temperature of the warmest month and enhanced vegetation index. Khuzestan Province and the west of Bushehr, Fars, and Kuhkiloye-Buyerahmad Provinces were ranked as the most favourable habitats. The rest of Bushehr and Fars Provinces from east, and Lorestan Province and part of Ilam Province from north formed a buffer with moderate favourability. Other provinces were ranked as unfavourable, except some fragmented areas in Hormuzgan, Yazd, Kerman and Sistan-Baluchestan Provinces that were ranked as moderate favourable. Our modelling attempt also revealed a favourable habitat in the Sistan-Baluchestan Province, near the city of Iranshahr. This might be due to the effect of prevalence, bias in species occurrence data, or selection of the predictors and should be studied more carefully. There are many other biologic and anthropo-

Panthera leo persica

Names:
Shir شیر
lion
Shir - e- Asiaei شیر آسیایی
Asiatic lion
Shir - e - Irani شیر ایرانی
Persian lion

Head and body length:
170-250 cm (male)
140-170 cm (female)
Tail length:
60-90 cm
Weight:
160-190 kg (male)
120 kg (female)

Global Population:
Exists as a single isolated population in India, numbering approximately 350 animals. Total number of mature animals is 175.
Iranian Population:
0

Distribution in Iran:
Nowhere
Habitat area:
From dense reed-bed, dense savannah type bush and riparian forests of Khuzestan to the oak forests and pistachio-al-mond forest of the Zagros Mountains.

IUCN Red List:
Endangered (2008)
CITES:
Appendix I

Country Red List:
Extinct

Photo P. Meier

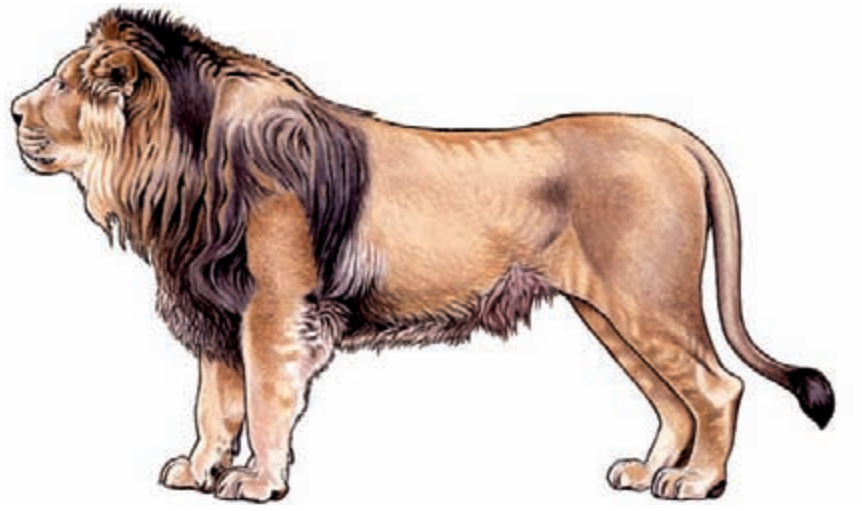

Fig. 2. Sketch of Asiatic Lion (courtesy of the Rotterdam Zoo).

Table 1. Data from the literature indicating the presence of lions in Iran during modern times. Adopted after Schnitzler (2011).

Locality	Date	Reference	SDM *	Remarks
Dasht-e Arjan (Fars)	1320s	Mostofi 1983	+	
Kamfirouz (Fars)	1320s	Mostofi 1983	+	
Ramhormoz (Khuzestan)	1841	Kinnear 1920	+	
Kuh-e Asemari (Khuzestan)	1841	Kinnear 1920	+	
Shushtar (Khuzestan)	1841	Joslin 1986	+	
Susa (Khuzestan)	1850	Kinnear 1920	+	
Kotal-e Pirzan (Fars)	1867	Etemaad 1985	+	
Shiraz (Fars)	1870	Guggisberg 1963	+	
Karun river (Khuzestan)	1875	Etemaad 1985		*Vague location*
Dasht-e Arjan (Fars)	1876	Etemaad 1985	+	
Nowbandegan (Fars)	1883	Fasaei 1993	+	
Dasht-e Arjan (Fars)	Late 1800	Zell-e Soltan 1989	+	
Kamfirouz (Fars)	Late 1800	Zell-e Soltan 1989	+	
Susa (Khuzestan)	1897	Guggisberg 1963	+	*Currently Shush*
Kazerun (Fars)	1900	Etemaad 1985	+	
Ahwaz road (Khuzestan)	1908	Schnitzler 2011		Vague location
Sannyat (Fars)	1916	Schnitzler 2011		Unidentified location
Posht-e Kuh (Fars)	1917	Schnitzler 2011		Unidentified location
Khark valley (Khuzestan)	1918-19	Schnitzler 2011		Probably Misspelled
Karun river (Khuzestan)	1940s	Firouz 2012		Vague location
South of Shiraz (Fars)	1923	Guggisberg 1963	+	
South of Persia	1928	Schnitzler 2011		Vague location
Dezful (Khuzestan)	1929	Guggisberg 1963	+	
Dezful (Khuzestan)	1932	Etemaad 1985	+	
Northwest Dezful	1942	Etemaad 1985	+	
Northwest Dezful	1943	Etemaad 1985	+	
Dez valley	1957	de Planhol 2004	+	

* SDM = Species distribution models. Data points that were used to train the SDM.

genic parameters that should be considered in the habitat modelling of the lion in Iran, specifically for conservation purposes such as species reintroduction. However, in the case of the Asiatic lion in Iran where species occurrences are few and subject to uncertainty, the use of knowledgeable experts and deductive approaches wold be practical (Niamir 2011).

Lions don't come easy

Like other large carnivores on top of the trophic chain, lions should have had occurred in low densities and large ranges, with large tracts of territory for maintaining viable populations. Taking into account the arid and mountainous environment, and the lower prey density, a lion in Iran would need more space than the average home range size given by Nowell & Jackson (1996). Such a large home range increases the competition over limited natural resources, thus the human-lion conflicts. Moreover, low density populations of such "conflict species" will have a high extinction risk since they are already living at the ecological/demographic lower limit and even a low or moderate additional anthropogenic mortality can push such a population over the edge.

In 1973, for the first time there was an agreement to exchange 15 lions from India with 7 cheetahs *Acinonyx jubatus venaticus* from Iran. Although preliminary studies, site selection, and even some site preparation activities had been conducted by the Department of the Environment DoE of Iran, the project was not executed (Khosravifard 2010, Firouz 2012). According to the site selection stu-dies, an area of 1,910 km² within the Arjan National Park (currently Arjan Protected Area) was nominated for the reintroduction purposes. As discussed above the allocated area won't be extensive enough to host 15 individuals. The state of the environment has changed since 1973, and any new reintroduction projects would definitely need an intensive assessment of the availability of suitable habitat and the potential extension of a viable population as key components of reintroduction planning. Restoration of the original habitat and amelioration of causes of extinction must be explored and considered as essential conditions for these projects (Sarrazin & Barbault 1996).

Fig. 3. Male Asiatic Lion and Asiatic lion cub in the Gir Forest National Park, India (Photos P. Meier).

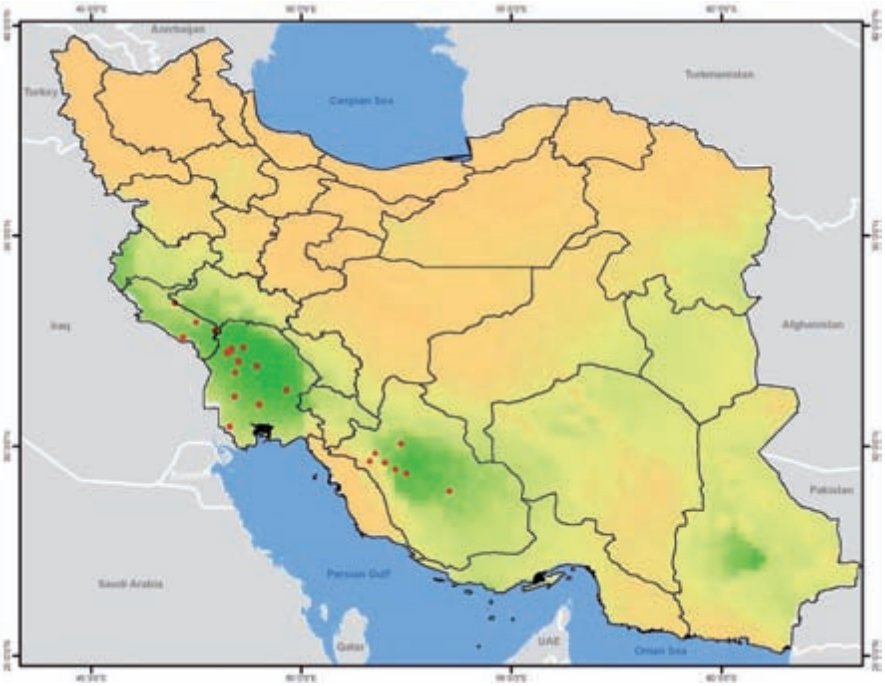

Fig. 4. Habitat favourability prediction of Asiatic lion in Iran, based on historic records (red dots, corresponds to Table 1). Green shade = favourable habitat.

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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 program 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 categorized 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 (Marnewick et al. 2008, Marker 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 (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 *Ovis orientalis* (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 popualtion 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. How-ever, 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 program 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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The caracal in Iran - current state of knowledge and priorities for conservation

Little information is present regarding biology and ecology of the caracal *Caracal caracal* in Iran. The majority of the available information comes from cheetah reserves in the central provinces, where about a decade of monitoring initiatives and extensive camera trapping surveys have been conducted. The caracal occurs in a wide variety of habitats across Iran, and presence records are currently lacking only from the Caspian Sea region, hyper-arid central deserts, and the Iranian Caucasus. The Iranian caracal's diet purportedly includes a great variety of prey of different sizes from small rodents and birds to medium-sized ungulates. Occasional predation on domestic small stock is likely to bring the caracal into conflict with local pastoralists. In spite of being highly adaptable and widely distributed, the caracal is in need for conservation attention. The main conservation priorities for the caracal in Iran are scientific research and mitigating negative interactions between caracals and traditional pastoralists. The caracal has been the subject of little empirical research in Iran, and elsewhere outside southern Africa. Here, we provide a thorough summary of what is known to date about the caracal in Iran, enriched with reliable field observations, unpublished reports, and anecdotal accounts. By summarizing the current state of knowledge about the biology and ecology of Iranian caracals, we provide suggestions for future research, as well as priority conservation actions.

We performed a comprehensive review of existing literature referencing aspects of caracal ecology and natural history, including peer-reviewed papers and grey literature, as well as an extensive attempt to collect unpublished reports and field observations by interrogating with Iranian biologists, and trained rangers, taxidermists, and hunters. Finally, we briefly reviewed a large dataset of camera-trap surveys aimed at the Asiatic cheetah *Acinonyx jubatus venaticus* between 2002 and 2013. Following Moqanaki et al. (2010), we assessed reliability of each record individually by considering whether any hard evidences (e.g. photo, video, carcass, museum specimen of known origin, genetic sample) are present, or only soft evidences are available. We considered all such records before 2000 as 'historical', and classified hard evidences as 'C1', and soft evidences as 'C2'. The remaining ambiguous records were not considered in this study.

Description

The caracal is a medium-sized cat of Africa and Asia, almost twice the size of a domestic cat. However, with a slender body build and long legs, caracals appear much larger superficially resembling a small puma *Puma concolor*. The tail is proportionally short and reaches up to one-third of the body length. Males are larger and heavier than females. Adults in Iran weigh between 7.3 to 25 kg (Table 1). Though seasonal variation may exist, the Middle Eastern caracals are paler and relatively smaller than African caracals (Harrison & Bates 1991). The coat ground colour is uniform, varies from light sandy to reddish-brown, and whitish on the underparts. Apart from scattered lighter-coloured spots on the belly and undersides of the animal's chest and legs, no distinct marking pattern is present. Facial marking of dark lines and white patches occur inside the nose and eyes' edges. The most unambiguous characteristics are the well-developed, silvery black-backed ears, accompanied by long black tufted hairs (Fig. 1).

Taxonomy

The caracal was first classified by Schreber (1776) as a species of the genus *Lynx*, however, later assigned to the *Felis* group. More recent incorporation of morphological and molecular studies has proposed a new lineage, *Caracal*, with two genera, *Caracal* and *Leptailurus*. Hence, three species of *Caracal*, caracal *C. caracal*, African golden cat *C. aurata*, and serval *Leptailurus serval* are grouped together (Johnson et al. 2006, Werdelin et al. 2010).

Fig. 1. A caracal in the vicinity of Nadushan, Yazd Province, in May 2009. Accused of killing domestic fowl, this caracal was chased by local villagers into a water canal to get drowned, but was eventually rescued by the local wildlife authority (Photo H. Moghimi).

There is a necessity to accurately define the subspecies classification so that the caracal's conservation status can be determined. Although their geographical distribution is not well defined, the IUCN/SSC Cat Specialist Group recognizes eight subspecies (Nowell & Jackson 1996): (1) *C. c. caracal* in South Africa; (2) *C. c. limpopoensis* in the Northern province of Limpopo in South Africa to Zimba-bwe; (3) *C. c. damarensis* in Namibia; (4) *C. c. nubicus* in the Nubian Desert westward to Cameroon; (5) *C. c. poecilictis* from Nigeria and the grasslands of southeastern Gabon (where previously it was suggested for later dismissed *lucani*); (6) *C. c. algirus* in North Africa; (7) *C. c. schmitzi* from the Sinai Peninsula through West Asia to India; (8) *C. c. michaelis* in the Caspian region of Turkmenistan eastward to the Amu Darya (River). The Iranian subspecies is considered to be *schmitzi*, although *michaelis* might occur in the north-east of the country as well (Karami et al. 2008, Hassan-Beigi et al. 2014).

Habitat

Despite being highly adaptable, caracals apparently prefer drier open terrains with sufficient shelter and vegetation cover and avoid true deserts and dense tropical rain forests (Heptner & Sludskii 1972, Weisbein

Table 1. Measurement and weights of caracals from Iran (n = 21). Sex: F = female, M = male, ? = sex unknown. W = weight, HB = head-body length; T = tail length; SH = shoulder height.

Location, Province	Sex	W (kg)	HB (cm)	T (cm)	SH (cm)
Chahar-Khaneh, Esfahan	F	N/A	73	27	45
Shiraz-Kouh, Esfahan	M	13.0	78	27	46
Kouh-e Parviz, Esfahan	F	N/A	70	24	44
Anarak, Esfahan	F	8.4	69	21	43
Abbas Abad, Esfahan	M	N/A	81	28	47
Zavar, Esfahan	M	4.0	39	16	27
Hormod PA, Fars	?	N/A	82	24	N/A
Moshajjareh, Esfahan	M	11.0	76	26	45
Chupanan, Esfahan	F	9.2	77	23	43
Kouh-e Zard, Esfahan	M	8.8	69	N/A	43
Shahrud, Semnan	?	12.0	105	27	37
Southeast Semnan, Semnan	?	10.3	109	N/A	N/A
Vicinity of Naein city, Esfahan	?	13.0	N/A	N/A	N/A
Abbas Abad WR, Esfahan	M	13.6	80	26	44
Parvand PA, Razavi Khorasan	M	10.5	91.5	32.5	N/A
Jen-e Naein, Esfahan	F	N/A	66	21	39
Ashtian, Esfahan	M	12.0	82	28	47
Abbas Abad WR, Esfahan	F	7.3	75	23	42
Tang-e Haft, Lorestan	M	25.0 *	N/A	N/A	N/A
Abbas Abad WR, Esfahan	M	9.8	67	26	42
Abbas Abad WR, Esfahan	F	5.9	56	22	37

* We could neither verify nor reject this measurement. As long as no additional evidence is available, we suggest to cite this specimen with caution.

& Mendelssohn 1990, Avenant & Nel 1998, Adibi et al. 2014, Singh et al. 2014). Caracals in Iran live in a wide variety of habitats: from the temperate Kopet Dag plains in the north-eastern-most corner to the semi-arid mountainous woodlands of Central Zagros in the west, and from southern Alborz forest steppes through the central extreme dry lands to the semi-desert coasts of the Persian Gulf (see Distribution; Fig. 2). Camera-trapping surveys in Iran have captured the animal at stations mostly characterized by dry riverbeds and well-vegetated foothill trails (Fig. 3).

Distribution

Geographical distribution of the caracal expands over 20 million km^2 across, at least, 40 African and 19 Asian countries (Nowell & Jackson 1996, Avgan et al. 2016). But the knowledge on its current status is outdated, in particular for the North African and Asian populations. A present-day assessment of the caracal population trend is lacking. The caracal is rare in North Africa and throughout a large proportion of its entire Asian range it is believed to be threatened to some extent (Sunquist & Sunquist 2002). Despite a lack of empirical data, the species is thought to be in decline in Iran (Ziaie 2008).

In Iran, the distribution of the caracal has been poorly documented. It seems that the species has a broad distribution (Fig. 2). Lay (1967) reviewed previous accounts from Persia and together with his findings provided only four records from Khuzestan, Kerman, and Tehran Provinces. Etemad (1985) noted 10 new reports, together with the first evidence from the Zagros region. No additional sites beyond these records were presented by later authors (Harrison & Bates 1991, Ziaie 1996). In the IUCN Action Plan for Wild Cats, Nowell & Jackson (1996) shaded almost the whole country as the potential species range. The authors reported occurrence of the caracal within five Iranian protected areas, including Kiamaky Wildlife Refuge WR, East Azarbayjan Province. Although their source is not presented, to date, this is the only indication of the species' occurrence in the Iranian Caucasus (north-western Iran). Accordingly, recent global efforts have also included this region within the caracal geographical distribution (Sunquist & Sunquist 2002, Breitenmoser-Würsten et al. 2008).

Literature on the current distribution of the caracal in Iran is still limited in Etemad's (1985) work (Firouz 2005, Karami et al. 2008, Ziaie 2008). However, due to recent cheetah surveys using remotely triggered camera traps, a wealth of up-to-date and reliable records are available (see Supporting Online Material SOM T1). Previously, the most representative information on current distribution of caracals in the country had been proposed by Ghoddousi et al. (2009), which is a modified version of the Etemad's map updated by more recent observations. No further information on the origin of the data is presented. Mousavi (2010) also endeavoured to map the range of the caracal in Iran. However, the author ignored the previous literature and exclusively shaded the eastern and central part of Iran.

The majority of the C1 records are restricted to the central provinces of Iran (Fig. 2) where, more than a decade of field surveys for cheetahs has been undertaken (Jourabchian & Farhadinia 2008). The caracal marginally occurs in western Iran as well. In the south in Sistan-va-Baluchestan, Hormozagan and Bushehr Provinces, the caracal has rarely been recorded. To our knowledge, no reliable records exist from the Iranian Caspian region either. Overall, the Global Mammal Assessment distribution (data in Breitenmoser-Würsten et al. 2008) provides a good representation of the caracal distribution in Iran. However, the caracal's occurrence in the Iranian Caucasus must be evaluated, and it is likely that the caracal's distribution is more extended in southern Iran.

North-eastern Iran (North, Razavi, and South Khorasan Provinces)

Prior to 2000, the only official evidence of caracal occurrence on the Khorasan region was a single dubious report by Etemad (1985) from the Kopet Dag along the Turkmenistan border (Fig. 2). The cat has been recently photo-captured in Miandasht WR (Farhadinia et al. 2007, H. Absalan, unpubl. data) and Behkadeh Razavi No-Hunting Area (Farhadinia et al. 2009), North Khorasan Province. In Razavi Khorasan Province, C1 records are from Bardeskan, Parvand Protected Area PA, and Shir-Ahmad WR where the animal has regularly been reported. Recent human-induced mortality records from Ark & Korang PA (Hassan-Beigi et al. 2013) confirm the presence of caracal in South Khorasan Province as well, excluding the newly annexed Tabas County.

Central and South-Central Iran (Qom, Markazi, Tehran, Semnan, Esfahan, Yazd, Fars, and Kerman Provinces)

A majority of both historical and recent C1 and C2 records are from the drier provinces of Iran in the central plains (Fig. 2), including by-catch camera-trap photos during cheetah surveys (SOM T1). This species has been recorded from various sites in Fars and Kerman Provinces, and more frequently in Semnan, Esfahan, and Yazd Provinces. Only scattered records are available from Tehran, Qom and Markazi Provinces (Fig. 2). During camera-trapping surveys (SOM T1) some authors reported a higher capture success for the caracal compared to other sympatric felids, thus hypothesized a higher relative abundance for this lesser cat in central Iran (e.g. Farhadinia et al. 2007, Farhadinia et al. 2008, Ghoddousi et al. 2009). On the other hand, some failed to or rarely photo-captured the species in its potential habitat (SOM T1). Taking into account the opportunistic methodology that most of the previous surveys have followed, these encounter rates are unlikely to represent true indices of abundance.

Western Iran (Zagros region toward Khuzestan Province)

Records in this region are rare and sporadic. Hamedan Museum of Natural History possesses an adult specimen allegedly collected from vicinity of Hamedan city in 1974-5. In mid-1980s, a sub-adult individual was found in Sefid-Kouh, Lorestan Province (Etemad 1985). In 2010, the species was photo-trapped at c. 2300 within a highland oak forest in Ilam Province. Besides more consequent records from Ilam, new hard evidence is documented from Lorestan, Kohgiluyeh-va-Buyer Ahmad, and Khuzestan Provinces (Fig. 2). This species' occurrence in Chahar Mahal-va-Bakhtiari and Kermanshah Provinces is still uncertain.

Southern Iran (Bushehr, Hormozgan, and Sistan-va-Baluchestan Provinces)

Alongside the Persian Gulf coast, caracal occurrence has seldom been reported (Fig. 2). To our knowledge, previously the only verifiable caracal record from this region was a carcass of an individual discovered in Mond PA, Bushehr Province in 1999. This specimen is purportedly in possession of Natural History and Technology Museum of Shiraz University. In September 2013, a carcass of a female caracal killed by local herders was discovered in Jam County, Bushehr Province.

Caracal caracal

Names:
کاراکال kârâkâl
یوزو(ک) yuzu(k)
یوزخفو yuz xafu
منگوله‌گوش manguleh gush
caracal

Head and body length:
61-108 cm
Tail length:
18-34 cm
Weight:
6.2-20 kg

Global Population:
Unknown
Iranian Population:
Unknown

Distribution in Iran:
Everywhere but north (Caspian Sea region), northwest (Iranian Caucasus), and extreme central deserts of Iran

IUCN Red List:
Least Concern (2016)
CITES:
Appendix I (Asian population) and II

Country Red List:
N/A
Iran environmental conservation laws & regulations:
Category II (Near Threatened and Protected)

Photo M. Eslami Dehkordi

One sub-adult individual accompanying the female was subsequently captured and released in the area later on.

Ecology and behaviour

Caracals are considered to be solitary predators, although reports of adults roaming together exist (e.g. Grobler 1981), also from Iran (Farhadinia et al. 2007, Mousavi 2010, Hamidi et al. 2011; Fig. 4). However, there is insufficient information whether female caracals with their sub-adult offspring(s) have been distinguished in the reported observations. The activity period is nocturnal-crepuscular, albeit in less disturbed habitats caracals appear to be active during the daytime (Avenant & Nel 1998, Ílemin & Gürkan 2010, Singh et al. 2014). New camera-trap data from central Iran also did not detect significant differences in diurnal and nocturnal activity periods of caracals (Farhadinia et al. 2012, Akbari et al. 2016). Nonetheless, the daily activity of caracals is correlated with ambient temperature rather than the photoperiod; the warmer the temperature in summer, the more active the caracals will be during the night (Avenant & Nel 1998).

Males occupy notably larger home ranges that often overlap with one to several females. Home range size varies significantly across their geographic range, averaging from 26.9 km^2 in sub-humid habitats (Avenant & Nel 1998) to 316.4 km^2 in arid landscapes (Marker & Dickman 2005), and is probably correlated with food availability and habitat type. Seasonal variation in size of home range may exist in an order of magnitude (Bothma & Le Riche 1994, van Heezik & Seddon 1998).

Little information is available regarding reproduction and development of free-living caracals. Earlier captive studies noted that reproduction is weakly seasonal and mating takes place year-round (review in Sunquist & Sunquist 2002). In South Africa, births peak in October-February, with average litter size of 2.2 (Bernard & Stuart 1987). Farhadinia et al. (2007) speculated that births occurred in April on a semi-arid site in Naein, Esfahan Province. All confirmed field observations from Iran (n = 10) have recorded two kittens except one litter with 3 kittens that has been observed in Bahram'gur PA, Fars Province (Farhadinia et al. 2007).

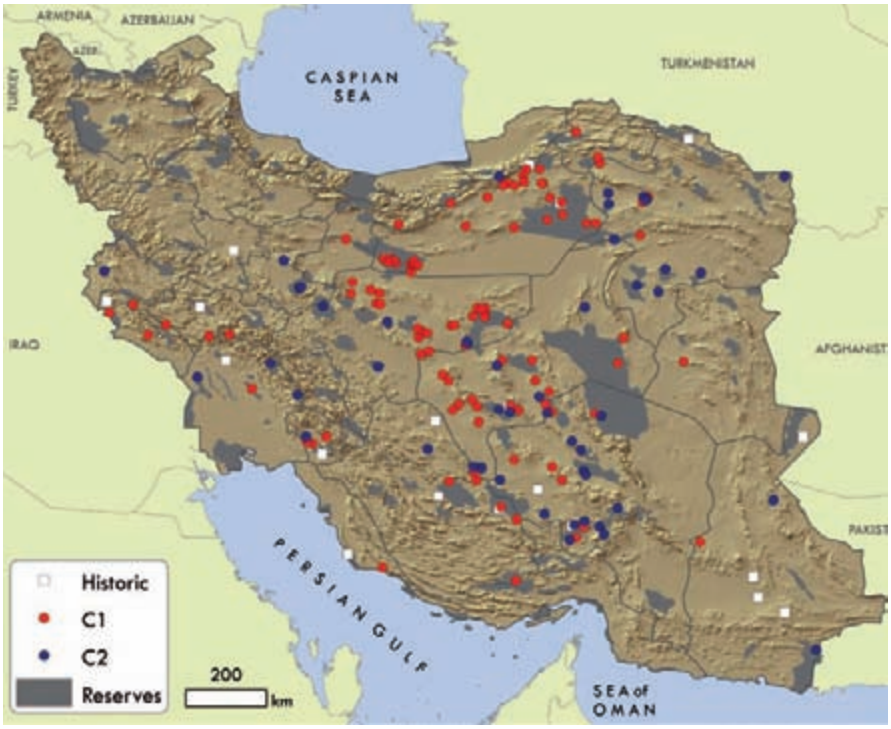

Fig. 2. Former and current distribution information for the caracal in Iran (1975-2016). Historical records (white squares): confirmed presence records before 2000, including data in existing literature; 'C1' (red dots): hard evidences, such as photos, videos, dead specimens, genetically-identified samples; 'C2' (blue dots): soft evidences, such as reliable field observations, either verified by the authors or via a trained person. 'Reserves' includes National Parks, Wildlife Refuges, and Protected Areas.

Prey

The caracal's diet includes insects and small birds to medium-sized (<40 kg) ungulates (Avenant & Nel 2002). Caracals predate domestic animals and occasionally feed on carrion. Although the majority of a caracal's diet compromises <5 kg prey, the preferred prey are believed to be gazelle-sized ungulates (review in Sunquist & Sunquist 2002). The bulk of the diet across the poorly-studied Asian distribution is made up of lagomorphs and small rodents (Heptner & Sludskii 1972, Weisbein & Mendelssohn 1990, Mukherjee et al. 2004, Singh et al. 2014).

In Iran, caracals have anecdotally preyed upon a variety of species including gray francolin *Francolinus pondicerianus* in Khabr National Park NP (A. Sharafi, pers. comm.), an unidentified rodent in Darband-e Ravar WR, Kerman Province (ICS, unpubl. data), hedgehog *Paraechinus* spp. in Dareh Anjir WR and Rueppell's fox *Vulpes rueppellii* in Siah-Kouh NP, Yazd Province (A. Jafarpour pers. comm.). Addi-tionally, Farhadinia et al. (2007) and Ghoddousi et al. (2009) found remains of cape hare *Lepus capensis*, Libyan jird *Meriones libycus*, and various unidentified rodents in caracal scats collected in Abbas Abad WR, Esfahan Province, and Bahram'gur PA, Fars Province, respectively. In other instances, camera trap pictures of caracals on hare hunt have been taken in Touran NP, Semnan Province, and Abbas Abad WR, Esfahan Province (CACP, unpubl. data). In February 2013, a caracal was photographed in Khaeez PA, Kohgiluyeh-va-Buyer Ahmad Province, killing supposedly a mongoose *Herpestes* spp. (Fig. 5). Predation on gazelles *Gazella* spp. is also documented in Iran. The secretive cat has several times invaded the chinkara's *G. bennetti* enclosure at Shir-Ahmad WR, Razavi Khorasan Province, and held responsible for a few cases of killing them (A. Khani, pers. comm.). Additionally, in October 2011, three caracals were observed on a goitered gazelle *G. subgutturosa* carcass in Kalmand-Bahadoran PA, Yazd Province. The hind limbs had been consumed (A. Zare', pers. comm.). A caracal scavenging ungulate carcasses left by the cheetah and an unidentified predator have been photo-captured in Kavir NP, Semnan Province (CACP, unpubl. data). In Iran, and elsewhere, caracal predation on domestic livestock brings caracals into conflict with humans; the result is killing of caracals in retaliation (Farhadinia et al. 2007, Tourani 2010, Hassan-Beigi et al. 2013; see Fig. 1).

In captivity

Single individuals of unknown origins were kept at private zoos in Mashhad (Vakil Abad Zoo) and Shiraz prior to 2010. In October 2010 the latter, a three-years-old male caracal presumably wild-caught in Fars Province, was released in Bahram'gur PA in order to study the rehabilitation consequences (Hamidi et al. 2011). This caracal stayed near the release site for around 2 months, but then 10 days later it was found in poor conditions approximately 95 km away in Shahr-e Babak, Kerman Province, accompanying another adult caracal (Hamidi et al. 2011). The animal was recaptured and because of health concerns, translocated to Tehran and is now kept at Tehran Eram Zoo (Memarian et al. 2011). Presently, an adult caracal of unknown sex and origin is in possession of Isar Zoo, Alborz Province.

Main threats

Habitat loss and fragmentation are the main threats to the Asian caracals (Nowell & Jackson 1996). In Iran, conflict with humans has negatively affected the caracal populations in human-dominated areas, as Ziaie (2008) believes that the retaliatory killing and loss of prey are the principle causes of the species' decline in Iran.

Caracals suffer from traditional pastoralist systems in Iran. Interviewing villagers in the centre of the country has revealed that its persecution is relatively common (Farhadinia et al. 2007, Ghoddousi et al. 2009, Tourani 2010, Hassan-Beigi et al. 2013). We were able to collect 52 mortality records from the mid-1980s to December 2015, in which for 31 of these a clear cause could be obtained (59.6%). Accordingly, 45.2% were killed in vehicle collisions (n = 14), and 35.5% due to poaching activities or retaliatory killing (n = 11), and 19.3% (n = 6) had been chased and killed by herding dogs.

Protection measures

The IUCN Red List of Threatened Species considered the caracal's status as 'Least Concern'. In Asia, the animal is included in CITES Appendix II. The Iran Hunting and Fishing Law of 1967 (last revision 2015) classified the caracal in Category II, defined as a fully protected, near-threatened species. In addition, poaching will result in a fine of 100,000,000 Iran Rials (USD 1 ≈ IRR 35,000).

The paucity of information on the lesser cats of Iran, including caracals, has been an obstacle for their conservation. Many

knowledge gaps remain about the status of the caracal in Iran. No research has been specifically carried out on the species and our state of knowledge is restricted to by-catch data from larger felid surveys, particularly cheetahs. Likewise, even globally, few in-situ studies have been undertaken on caracals (Brodie 2009). Extensive camera-trapping fieldwork would provide valuable information on caracals (and other sympatric species) in sites where its occurrence is uncertain, particularly in western and southern-most Iran. In the meantime, relevant ecological information for its conservation, such as habitat use and activity patterns could be obtained from such studies. The question of the subspecies status and genetic diversity remains another important, unsolved issue in conservation planning for caracals in the country.

A considerable number of protected areas have been established in the caracal's range in Iran (Fig. 2), but the lack of interest and coordination among local authorities would block any future management practices. Thus, more involvement of the local reserve staff in sharing their information should be centrally implemented. Yet, caracals are not confined to the protected areas in Iran and better management of the nomadic pastoralists and anthropogenic activities within the species' habitats is needed. Although caracals are highly adaptable and widely distributed, more attention is urgently needed by both national authorities and conservationists in order to thoroughly assess its conservation needs in Iran.

Fig. 3. A camera-trap photo of a caracal from Miandasht Wildlife Refuge, North Khorasan Province, in October 2014 (Photo ICS/DoE/CACP).

Fig. 4. A pair of caracals photographed in Darband-e Ravar Wildlife Refuge, Kerman Province, in February 2014 (Photo ICS/DoE/CACP/Panthera).

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Fig. 5. A caracal photographed in Khaeez Protected Area, Kohgiluyeh-va-Buyer Ahmad Province, in February 2013, preying on a mongoose (Photo H. Dideban/Kohgiluyeh-va-Buyer Ahmad Department of Envoironment).

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Supporting Online Material SOM Table T1 is available at www..catsg.org

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The largest lesser cat in Iran - current status of the Eurasian lynx

The study reviews the status of the Eurasian lynx *Lynx lynx* in Iran with regard to its geographic range, prey species, reproductive biology, human-lynx conflicts, causes of mortality, and conservation measures, based on information from May 2011 to 2016. Based on a thorough literature review, personal interviews, and national questionnaire surveys, we conclude that the lynx is widely, but patchy distributed in North, North-West and West Iran. Iranian lynx feed on a variety of prey, including hare *Lepus* spp., wild sheep *Ovis orientalis*, wild goat *Capra aegagrus* and rarely livestock. Although lynx-human conflicts were considered negligible, poaching accounted for 29.2% of the known lynx mortality, followed by herdsmen and shepherd dogs, road accidents and other factors. Habitat degradation, traditional livestock husbandry, and prey depletion were recognised as the most significant threats to lynx in Iran. Conservation measures recommended are (1) evaluation of the conservation status of protected areas with lynx occurrence, (2) survey of lynx population status, research and conservation planning and (3) public awareness and engagement of local people.

As one of the most widespread felid species (Sunquist & Sunquist 2002), the Eurasian lynx ranges from the Atlantic coast in Western Europe to the Pacific coast in the Russian Far East (Nowell & Jackson 1996, Breitenmoser et al. 2015). In Central and Western Europe, where the lynx has been the subject of several reintroduction efforts (review in von Arx et al. 2009) and the populations have recovered and expanded (Breitenmoser et al. 2015), continuous monitoring programmes have been established (Molinari-Jobin et al. 2012). Thus, our knowledge on lynx biology and ecology has greatly improved. However, very little is known on natural history and status of this species in eastern parts of its distribution, particularly from south-western Asia (Nowell & Jackson 1996).

Knowledge of the lynx in Iran is quite scant and some confirmation of its occurrence go back to the late 1960s (see Moqanaki et al. 2010 for a review). To date, no more than a handful studies on the Iranian lynx have been carried out, with only one in situ study (i.e. Moqanaki et al. 2015). Previous literature (i.e. Etemad 1985, Ziaie 1996, Firouz 1999) exclusively addressed the limited data on distribution of the lynx in the country, often with very few updates in the later publications (e.g. Firouz 2005, Karami et al. 2008, Ziaie 2008). So far, the Iranian Caucasus (Azarbayjan region) was considered the only hotspot of this species in the country (Karami et al. 2008, Ziaie 2008). However, recent efforts have shown a wider distribution in the Alborz and Zagros mountain chains (see Moqanaki et al. 2010). In this paper, scattered information generated in recent years is compiled to provide a critical review of the current state of knowledge on different aspects, such as biology, ecology, and legal status of the Eurasian lynx as well as important protected areas for the species' conservation in Iran.

Methods

This study is based on review of confirmed literature records, personal interviews with experienced people, and national questionnaire surveys of provincial offices of Iran Department of Environment DoE (details in Moqanaki et al. 2010). Furthermore, a new questionnaire to DoE provincial offices was sent to obtain recent lynx observations and mortality records from May 2011 to end of September 2016. Thus, our updated database comprised various aspects of lynx biology, diet, mortality, and lynx-human conflict from 1965-2016. We classified records prior to 2000 as "historic occurrence". The remaining were categorised following our previous report (i.e. Moqanaki et al. 2010): C1: "confirmed" occurrences or "hard facts", C2: "probable" and C3: "unconfirmed" records.

Description

The Eurasian lynx is the largest member of the genus *Lynx*. In spite of being considered as a lesser felid, the lynx appears powerfully built with its strong and long legs. It has ears with 4-7 cm long, black hair tufts, a well-developed facial mane hanging down from its lower cheeks, and a short black-tipped tail about one-sixth of the head-body length (Nowell & Jackson 1996). The winter fur colour is variable from grey to yellowish or brown to greyish but the under parts of body are whitish (Sunquist & Sunquist 2002). Three main coat patterns for lynx are reported: predominantly

Fig. 1. A free-ranging human-habituated lynx photographed in Sarab, East Azarbayjan Province in 2003 (Photo F. Heidari).

Fig. 2. Distribution of historic (<2000) and present (≥2000) observations of the Eurasian Lynx in Iran. White square: historic occurrence; red dot: C1; blue dot: C2; yellow dot: C3.

spotted, predominantly striped and unpatterned (Nowell & Jackson 1996). However, Thueler (2002) reported a fourth pattern with rosettes for the Alpine population. Based on 46 individuals verified in this study, "flecks" or "clear spots" were the predominant coat pattern in Iran (Fig. 1). Morphological measurements and weights for a total of 18 dead adult lynx have been collected (Table 1).

Taxonomy

The species has never been subject to taxonomic and phylogenetic investigations in Iran or its range in south-west Asia. However, it has been assumed that the subspecies in Iran is *L. l. dinniki* (Karami et al. 2008) which reportedly inhabits the Caucasus Ecoregion, Turkey, Iran, and northern Iraq (Breitenmoser et al. 2015).

Distribution

A comprehensive country-wide assessment of the lynx distribution in Iran was published by Moqanaki et al. (2010), with C1 records confirming lynx presence in 14 out of 30 Iranian provinces. The authors identified priority areas for future surveys to verify the presence of lynx. In this study we present new occurrence data from 2011-2015 (Fig. 2; Supporting Online Material SOM Table T1). Out of the current 31 Iranian provinces, we obtained C1 records in 17 provinces (SOM T1). The provinces with the highest number of C1 records are: East Azarbayjan (n = 11), Mazandaran (n = 10), Qazvin (n = 8), and Semnan (n = 6). In Bushehr and Hormozgan Provinces along the Persian Gulf in the south, together with Khuzestan Province in the south-west and Qom in north-central Iran (Fig. 2), neither historic nor any contemporary records of the lynx presence (C1, C2, or C3) is available (SOM T1). Overall, our updated data confirms Moqanaki et al. (2010)'s conclusion about the association of the lynx distribution with Alborz (in the north) and Zagros (north-west to south-west) mountain chains in Iran, and at least occasional occurrence of the lynx in the adjacent north-eastern and south-central provinces (Fig. 2; SOM T1). Yet, we failed to fill the knowledge gaps in parts of the lynx' possible range, i.e. the presence of the species across the eastern part of Iran towards the south coast is still dubious.

Habitat

The lynx in Europe and Siberia is known as a forest-dwelling species, and its habitat is closely connected with abundance of small ungulates (Breitenmoser et al. 2015). In contrast lynx have been observed in thinly wooded areas in central Asia, also in thick scrub woodland and barren, rocky areas in the Himalayas (Nowell & Jackson 1996). Eurasian lynx were recorded on elevation of 4,500 m in Ladakh; one female lynx with kittens was seen at 5,500 m (Sunquist & Sunquist 2002). Lynx habitat in Iran is primarily characterised by mountainous forests and scrubland (Firouz 1999, Ziaie 2008), e.g. the Hyrcanian forests along the Caspian Sea coast and the fragments of Zagros oak forests stretching from the north-west towards south-west. However, the Iranian lynx persist throughout the semi-arid highland steppes in the southern slope of Alborz Mountains as far as east in north-eastern Iran. The lynx in the Iranian Caucasus has been reported mainly from the highland rocky areas (Fig. 3); although this may be partly a result of higher detection probabilities in more barren landscapes. Iranian lynx have been reported from a wide range of altitudes, varying from 1,200 m to 2,300 m above sea level.

Camera trapping efforts within the confirmed range of the lynx in a number of Iranian protected areas, i.e. Anguran Wildlife Refuge (WR, Zanjan Province), Kiamaky WR (East Azarbayjan Province), Golestan National Park (NP, Golestan Province), Tandoureh NP (Razavi Khorasan Province), and Dena NP (Kohgiluyeh-va-Buyer Ahmad Province) indicates presence of co-predators such as Persian leopard *Panthera pardus saxicolor*, brown bear *Ursus arctos*, wolf *Canis lupus*, golden jackal *C. aureus,* common fox *Vulpes vulpes*, striped hyaena *Hyaena hyaena*, and wildcat *Felis silvestris* (Hamidi et al. 2014, Moqanaki et al. 2015, M. R. Masoud, unpubl. data, Mohitban Society, unpubl. data, M. S. Farhadinia, unpubl. data).

Reproductive biology

Breeding season in Eurasian lynx in Europe lasts from February to mid-April and gesta-

Table 1. Morphological measurements and weights (mean values and range) of 18 dead adult Eurasian lynx individuals from 2008-2016. m = males, f = females, ? = unknown.

Sex	Sample size	Head-body length (cm)	Tail length (cm)	Sex	Sample size	Weight (kg)
f	9	88.1 (78-98)	15.2 (13-19)	f	6	14 (12.5-15)
m	8	90.8 (78-102)	16.8 (14-21)	m	6	15 (10.3-28)
?	1	88	17			

tion lasts around 67-74 days. They usually give birth in late May to litters of 1-4 kittens, but usually 2-3 kittens are born (review in Sunquist & Sunquist 2002). Our scattered records from Iran (n = 7) indicate litter size from 1-3 dependent cubs, mean = 1.7 (± 0.76 SD), mainly seen in April-June.

Feeding ecology

Eurasian lynx are predators that have specialised on small and medium-sized ungulates in many parts of their ranges (e.g. Okarma et al. 1997, Odden et al. 2006, Breitenmoser et al. 2015). The main prey species of the lynx in Europe include roe deer *Capreolus capreolus*, chamois *Rupicapra rupicapra*, occasionally red deer *Cervus elaphus* or wild boar *Sus scrofa* (e.g. Odden et al. 2006, Schmidt 2008). Where ungulates are scarce, they forage for birds, hares and rodents (Breitenmoser et al. 2015). An exceptionally high density of the lynx in the absence of ungulate prey has been reported from south-western Turkey (Avgan et al. 2014).

The stomach contents of six adult lynx in this study contained murid rodents (n = 4), hare *Lepus* spp. (n = 4), Afghan pika *Ochtonoa rufescens* (n = 1), chukar partridge *Alectoris chukar* (n = 3), snake (n = 1, possibly *Gloydius intermedius*), and wild goat kid *Capra aegagrus* (n = 1). Additionally, based on 17 opportunistic sightings mainly by protected areas' rangers, the species predates on a variety of prey, such as Persian ibex *Capra aegagrus* (n = 6, in Arasbaran, Central Alborz and Parvar PAs), wild sheep *Ovis orientalis* (n = 1, Anguran WR), domestic sheep (n = 4), and hare *Lepus* spp. (n = 5). All wild ungulates killed by the lynx were reportedly females. Furthermore common fox was seen to be chased by lynx; as observed in previous studies on the lynx diet (e.g. Odden et al. 2006).

Mortality causes and human-lynx conflict

We collated 72 cases of lynx mortality from 1965-2016, and causes of mortality were identified for 51 (70.8%) dead lynx. Within our database of Iranian lynx mortality the most important reasons of lynx fatality were poaching (29.2%), herding dogs (26.4%; Fig. 4), followed by road accidents (8.3%) and other factors such as diseases (6.9%). All road-killed specimens were reported after 2008 (e.g. Fig. 5), most probably because of development road network in the country in recent years also boost for carnivore interest and research among Iranian biologists and fairly better communication between provincial and local DoE offices, together with our previous effort of collecting such data (i.e. Moqanaki et al. 2010). Only one unconfirmed report involved an interspecific fight; in Kiamaky WR, a dead lynx was detected killed by an unknown larger carnivore, presumably a leopard (M. R. Masoud, unpubl. data).

Even though lynx-human conflicts as a result of predation on livestock and game are relatively widespread in Europe (e.g. Andren et al. 2006) we have no verifiable data on such conflicts in Iran. Therefore, we assume that such interactions are currently negligible. DoE conducted a questionnaire survey concerning wildlife-human conflict in 2010, but did not receive any reports from DoE provincial offices related to lynx-livestock predation in 2001-2010 (Abdollahi et al. 2012). Based on a recent semi-structured questionnaire surveys in Anguran WR, Zanjan Province, no evidence of lynx-human conflict was discovered (Moqanaki et al. 2015). But occasional cases regarding livestock predation by the lynx are reported; e.g. nomadic pastoralists in Chal Ghafa area, Esfahan Province, reported the lynx as an occasional predator of their domestic sheep, and confirmed the retaliatory killing of at least 2 individuals in 2001-2003 (E. M. Moqanaki, unpubl. data). Herding dogs seem to be an important cause of human-induced mortality to lynx. However, there is presently insufficient information in our database indicating that whether lynx do approach livestock herds or it is the presence of freely-grazing domestic herds in many lynx habitats that increases the chance of lethal lynx-herding dog encounters.

Main threats

Habitat loss and fragmentation are the primary threats to lynx (Fig. 6), followed by depletion of the potential prey base (e.g. roe deer, wild goat and wild sheep). Habitat deterioration occurs through deforestation in the northern and north-western range of the species in Iran, due to the development of croplands and residential areas. Moreover, there is growing network of roads in the country, which affects negatively the species and its habitat. Hyrcanian forests, distributed as narrow belts in the northern parts of the country, together with the remnant temperate broadleaf and mixed forests in the Iranian

Lynx lynx

Names:

سیاهگوش	Siah-goush
لینکس	Lynx
وشق	Vashagh
ورشک	Varshak
پلنگ مول	Palang-mul
کلش	Kalash

Eurasian lynx

Head and body length:
80-130 cm
Tail length:
11-24cm
Weight:
18-38 kg
(Ziaie 2008)

Global Population:
unknown
Iranian Population:
unknown

Distribution in Iran
North, North-West and West of Iran

IUCN Red List:
Least Concern (2015)
CITES:
Appendix II

Country Red List:
Proposed as Vulnerable (Moqanaki et al. 2010)
Iran environmental conservation laws & regulations:
Protected species

Photo F. Heidari

Fig. 3. Eurasian lynx habitat in Arasbaran Biosphere Reserve in East Azarbayjan Province, Caucasus Ecoregion, in June 2011 (Photo M. Mousavi).

Fig. 4. A young Eurasian lynx in Avaj No-Hunting Area, Qazvin Province, in January 2012. The young animal was chased and treed by herding dogs, but later released (Photo M. Karami).

Caucasus are considered as crucial habitats for the species (Moqanaki et al. 2010). However, these landscapes are threatened due to clear-cutting and intensive logging (Saghebtalebi et al. 2013). Furthermore, traditional livestock husbandry system increasing risk of lynx-herding dog encounters is considered to be another threat to lynx in the country.

Current and future protection measures

The present study expanded our knowledge about the lynx occurrence to several localities, formerly unknown to biologists. These areas are mostly No-Hunting Areas NHA, such as Do & Seh Hezar (Mazandaran Province), Avaj, Tarom-e-Sofla (Qazvin Province), Kharaqan (Markazi Province), and Karafs NHAs (Hamadan Province), in which improving their protection level for safeguarding the lynx and its prey can be a priority for Iran DoE. Obviously, controlling activities adversely affecting habitat use of the lynx and its prey must be continuously respected.

The lynx is listed as a "protected" species in Iran and fine for compensation of a lynx specimen is IRR 100,000,000 (USD 1 ≈ IRR 35,000). As an elusive predator with extremely low detectably, the lynx is still virtually unknown across most of its range in Iran. Consequently, the species might be considered safe from disappearance, even within its key areas while it is not (e.g. Moqanaki et al. 2015). As a priority, population size and trend of the Iranian lynx is yet to be understood, preferably at some key (or reference) areas. All previous extensive and intensive camera trapping efforts within several Iranian protected areas containing confirmed presence records of the lynx have been unsuccessful in capturing any photographs of the species (e.g. Hamidi et al. 2014, Moqanaki et al. 2015, Mohitban Society, unpubl. data, M. S. Farhadinia, unpubl. data), except for one photograph obtained in Kiamaky WR in January 2009 (M. R. Masoud, unpubl. data). Therefore, optimizing sampling protocols is still a major challenge for Iranian biologists. Application of GPS telemetry must be approached in order to obtain some basic information on the ecology and land tenure system of the lynx in Iran.

Moqanaki et al. (2010) suggested classifying the Eurasian lynx as a regionally vulnerable species in Iran; we agree that this category would raise both public and governmental concerns about the conservation of this species in the country. Any plan to conserve the species in Iran must incorporate law enforcement measures, but with active involvement of suitable research and monitoring agenda.

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Fig. 5. Female Eurasian lynx killed in road accident in Bayjan area, Mazandaran Province, in September 2008 (Photo Mazandaran Department of Environment).

Fig. 6. Male and female Eurasian lynx found electrocuted by sagging power lines in Sayin Darreh, Abyek, Qazvin Province, in March 2016 (Photo Qazvin Department of Environment).

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Supporting Online Material SOM Table T1 is available at www.catsg.org

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Baseline information and status assessment of the Pallas's cat in Iran

Iran is most likely the western boundary of the Pallas's cat's, or manul *Otocolobus manul* global distribution range. The Pallas's cat is amongst the least-studied felids in Iran and basic questions about its status and natural history have yet to be answered. Our review of the available information suggests significant increases in the range of the species previously known from Iran. North-eastern Iran remains a hotspot of Pallas's cat occurrence in the country, but there are a growing number of recent confirmed records from southern slopes of Alborz Mountains, as well as the south-central provinces. Human disturbances such as mining activities and traditional pastoralism, particularly during summer when alpine and sub-alpine rangelands are occupied by flocks of livestock, might have adverse impact on the Pallas's cat. The lack of scientific understanding of the Pallas's cat in Iran restricts our ability to conserve the species.

The Pallas's cat is a short-legged small cat, approximately the same size as a domestic cat, with a broad distribution through semi-arid and arid steppes of Russia and China to the Caspian Sea region in western Asia. Being considered as one of the least-studied carnivores of Iran, very little verifiable information is present about the natural history and aspects of ecology of the Pallas's cat in the country. The need to identify the current distribution and status of the Pallas's cat is urgent in order to direct future research to understand the species' conservation needs. In this study, we present a review of the current state of the species' biology and geographical distribution range in Iran as recorded in the last 25 years, as comprehensive as possible, and discuss potential threats in the Iranian range of the Pallas's cat.

Methods

Our study approach was similar to the one described in details in Moqanaki et al. (2010). In brief, we undertook a synthesis of the Pallas's cat in Iran using published reports, unpublished accounts, museum specimens, and extensive interviews and interrogations with trained Iranian biologists, provincial wildlife authorities, taxidermist, and hunters. We updated this information during two participatory workshops facilitated by Iran Department of Environment DoE, University of the Environment, and IUCN/SSC Cat Specialist Group, in Karaj, Alborz Province (27-29 November 2011) and Sari, Mazandaran Province (12-14 May 2012). Following our earlier work, we filtered and refined the unpublished data based on their reliability and categorized them into three groups of: 'historical': confirmed records of presence obtained before 2000; 'C1': confirmed records with physical evidences (e.g. photos, videos, carcasses, museum specimens with identified origins); 'C2': reliable field observations verified by either us or a trained person. Unlike Moqanaki et al. (2010), we did not find the 'C3' category applicable to our Pallas's cat records, because we felt that the remaining unconfirmed records are too ambiguous given our criteria.

Fig. 1. A Pallas's cat phototrapped in Salouk National Park, North Khorasan Province, in fall 2015 (Photo M. S. Farhadinia/WildCRU/ICS/Panthera).

Description and taxonomy

Adult manuls, the species' other popular name, weigh 2.5-5.3 kg and the average body length is approximately 55 cm (Sunquist & Sunquist 2002, S. Ross, unpubl. data). The Pallas's cat has a heavy fur coat of silvery to rufous-grey and faint stripes on the body (Fig. 1). Short-rounded ears and large eyes are set on a flattened broad face. Distinctive dark stripes adorn the face and cheeks and the head is decorated with small spots. A spectacle-like pattern circles the eyes. The tail is bushy and banded with narrow stripes, with a dark tip at the end. The coat coloration may appear darker in spring-summer (Nowell & Jackson 1996, Sunquist & Sunquist 2002).

We obtained 16 measurements from the Iranian Pallas's cats (Supporting Online Material SOM T1). On average, Iranian specimens weigh 2.4 ± SE 0.1 kg (male: 2.5 ± SE 0.2 (n = 8) vs. female: 2.3 ± SE 0.1 (n = 6)). Furthermore, head and body length reaches 55.5 ± SE 1.1 cm with a mean tail length of 25.5 ± SE 0.4 cm for Iranian Pallas's cats.

The taxonomic status of the Pallas's cat was unclear until very recently. At first, on the basis of the coat appearance, Peter Simon Pallas postulated that the manul is a likely ancestor of Persian domestic cat breeds (Nowell & Jackson 1996). Later authors classified the species as *Lynx*, *Felis*, and subsequently in its own genus. Today, *Otocolobus* is believed to be a monotypic genus. Novel molecular studies have suggested a very close phylogenetic relationship with the *Prionailurus* lineage (Johnson et al. 2006). Three subspecies are proposed to date: *O. m. manul* (Pallas 1776) in Russia, Mongolia and northern China; *O. m. nigripectus* (Hodgson 1842) on the Tibetan Plateau and probably Kashmir; and *O. m. ferrugineus* (Ognev 1928) from Central Asia to Iran. While the eastern subspecies is the typical greyish morph, the western population shows a variably rufescent coat colour (Nowell & Jackson 1996; see Figs. 1-3).

Otocolobus manul

Names:
گربه پالاس Gorbe-ye-Palas
Pallas's cat (manul)

Head and body length:
48-60 cm
Tail length:
23-29 cm
Weight:
1.5-3.7 kg

Global Population:
Unknown
Iranian Population:
Unknown

Distribution in Iran:
Mainly north-east and north outside the Caspian region with scattered records for the rest of the country

IUCN Red List:
Near Threatened (2016)
CITES:
Appendix II

Country Red List:
N/A
Iran environmental conservation laws & regulations:
Category II (Near Threatened and protected)

Photo F. Esfandiari

Distribution

Iran is likely the western boundary of the global distribution range of the Pallas's cat. The species is amongst the least studied felids in Iran and basic questions about its status and natural history have yet to be answered. In this study we gathered 84 new occurrence records of the Pallas's cat in Iran (C1 and C2; see Contemporary records), of which 72.6% (n = 61) were hard evidence (C1) and the remaining reliable sightings verified in this study (C2). Our data significantly increases the range of the species previously known from Iran (Fig. 4). North-eastern Iran is a hotspot of Pallas's cat occurrence in the country. More recent records also originated from the south-central provinces (Fig. 4). The Pallas's cat has not been reported in south-eastern Iran, though there are old anecdotal reports from neighbouring Pakistani Baluchistan (Pocock 1939, Roberts 1997). Therefore, our data indicate that as well as containing its western global range boundary, the Pallas's cat reaches also its southernmost known limit in Iran (30° N).

Historical records (up to 2000)

The manul presence in Iran was confirmed from an undated specimen reportedly obtained in "Meched" (Mashhad), Razavi Khorasan, by Sir P. R. Sykes (now in possession of the Natural History Museum of London; A. C. Kitchener, pers. comm.). Together with other specimens found from neighbouring countries, this specimen was a basis for Pocock (1939) to conclude that the Pallas's cat range in Iran is "northern Persian". No reports of the Pallas's cat were made over the three decades following this record (Lay 1967). Nonetheless, Misonne (1959) speculated about the species presence in north-west and north-east Iran based on the manul occurrence in Ararat, the Caucasus, and Turkmenistan in the vicinity of the Iranian border, respectively. Lay (1967) purchased a skin of unknown origin from a Tehran fur dealer (now in possession of Field Museum of Natural History, Chicago). Jamsheed (1976) and Firouz (1999) presented photos of different individuals both from Khosh Yeilagh Wildlife Refuge WR, Semnan Province. Etemad (1985) provided undated records from north-eastern Iran, including Sarakhs, in the vicinity of the Tajan River, the Iranian area bordering the Kopet Dagh Mountains, and adjacent to Nakhchivan and Aras River in northwest Iran (Fig. 4). There have also been unconfirmed reports of the felid from Mouteh WR in central Iran in the Wild Cat Action Plan (M. T. Moeinian pers. comm. cited in Nowell & Jackson 1996).

Contemporary records: north-eastern Iran (Razavi, North, and South Khorasan Provinces)

North-eastern provinces hold the majority of recent confirmed records of the Pallas's cat presence in Iran, including several reserves: Salouk and Sarigol National Parks NP, Shaskouh Protected Area PA, as well as Heidari WR, Tandoureh NP, Gharchegheh PA, Helali PA, and southward to Dorouneh PA. Furthermore, the animal has been confirmed from vicinity of a number of urbanised areas, such as Chenaran, Torghabeh, Jajarm and Esfarayen. Camera trap deployed for leopard *Panthera pardus* in Salouk, Sarigol and Tandoureh NPs, North Khorasan Province, have photo-captured the Pallas's cat in multiple occasions (M. S. Farhadinia, unpubl. data; Fig. 1).

According to Rustamov & Sopyev (1994), the manul also exists in southern Turkmenistan, neighboring north-eastern Iran. Pocock (1939) also reported a specimen from east-

Fig. 2. Carcass of an erytristic morph of the Pallas's cat in Bafq, Yazd Province, in January 2008 (Photo Yazd DoE).

ern Ashkabad, close to the Iranian border in Turkmenistan. However, more recent surveys by Lukarevsky (2001) did not reveal new hard evidences from this region. The only verifiable record of the Pallas's cat we found from eastern Iran was a photo of an individual from Qaen County, South Khorasan Province (A. Khajavi pers. comm.). In neighboring Afghanistan, the manul has been predominantly recorded from the eastern part of the country, far from the Iran-Afghan border zone (Habibi 2003).

Contemporary records: central and south-central Iran (Qom, Markazi, Semnan, Esfahan, Yazd, Fars, and Kerman Provinces)

Previous hard evidences from this region were restricted to Khosh Yeilagh WR in Semnan Province (Fig. 3; Ziaie 2008). Since the 2000s more records from the south-central provinces have become available. In Semnan Province, several individuals have recently been captured westwards along the Alborz Mountains, Khonar, Miami Mountain, vicinity of Shahmirzad, Seydoua NP and Damghan County (Fig. 4). In north-central Iran in mid-Alborz, the presence of the Pallas's cat has been confirmed in Khojir NP (Chalani et al. 2008) and Firouzkouh highlands, Tehran Province. Toward the west, we have also observed a stuffed specimen from Tafresh, Markazi Province, in a private collection. In addition to the mountainous northern territories, unexpected reports of the manul have been recently collected as far south as Semirom, Faridan and Karkas PA (Esfahan Province), Mehriz, Taft and Bafq (Yazd Province; Fig. 2), Rafsanjan, Sirjan, Shahr-e Babak and Bidou'eeyeh WR (Kerman Province) and Abadeh (Fars Province; Joolaee et al. 2014).

Contemporary records: Northwestern Iran or the Iranian Caucasus (Gilan, Ardabil, East and West Azarbayjan Provinces)

Northwestern Iran has been historically considered within the species range, and this has been confirmed by additional recent reports (Aghili et al. 2008). In north-western Iran, the Pallas's cat has been rarely recorded in the Caucasus, including south Armenia and south Azerbaijan (Ognev 1935, Heptner & Sludskii 1972, Alekperov 1989, Aghili et al. 2008). All of these sightings have been on the northern side of the Araz (or Aras) Valley that forms the border with Iran. Trapping of an adult female in Azar-Shahr, East Azarbayjan, in June 2008 finally confirmed the presence of the Pallas's cat in the Iranian Caucasus (Aghili et al. 2008).

Habitat

The Pallas's cat is most often sighted in stony alpine steppes and upland hilly areas, but is generally absent from lowland sandy desert basins. It seems that rocky and talus outcrops are predominantly preferred, and the geographical range of the Pallas's cat ends where the steppes meet forests (Heptner & Sludskii 1972). Semi desert landscapes of Central Asia are also inhabited by the species (Munkhtsog et al. 2004). Although upland habitats are preferred, deep snow is said to be a limiting factor (Sunquist & Sunquist 2002). Availability of suitable den sites is critical for the conservation of the species (Ross et al. 2012). Evidence suggests that den sites are selected in areas with higher proportions of rocky and ravine habitats in the surroundings (Ross et al. 2010a). Den sites are used for feeding, mating, raising kittens and predator avoidance (Ross et al. 2010a). Junipers (*Juniperus* spp.) are commonly seen in parts of the Pallas's cat highland habitats in Iran.

Despite this species has been reported from above 5,000 m in Tibetan Plateau, China (Fox & Dorji 2007) and Tso Lhamo Plateau, India (Chanchani 2008), the Iranian records are limited to altitudes of 2,500 m. The majority of Iranian records of Pallas's cat have originated from arid grassland steppes and rocky mountains. But a growing number of confirmed sightings suggest the species persistence on temperate regions as well, such as the southern slopes of Alborz Mountains. The presence of manul has also been confirmed in the mountains of Yazd Province, a primarily desert region (Fig. 2). Such a wide range of habitat features from arid mountains to temperate regions suggest the adaptability of Pallas's cats.

Ecology and behaviour

As a solitary cat, both sexes maintain large home ranges with intra- and inter-sexual overlap for males. In Mongolia, Ross et al. (2012) reported average male and female territories of 98.8 km^2 (21-207 km^2) and 23.1 km^2 (7.4-125.2 km^2), respectively. Activity period in the Pallas's cat is predominantly crepuscular (Ross 2009). However, Ross et al. (2010b) judged them to be mainly crepuscular or diurnal hunters, based on temporal pattern of their main prey activity. Breeding is highly seasonal and daylight dependent (Brown et al. 2002). After a gestation period of 66 to 75 days birth peaks in March-May, and two to, rarely, 8 kittens are born (Heptner & Sludskii 1972, Ross 2009). In Iran, two litters of three and four cubs (aging less than 2 weeks at the time of detection) have been recorded in May and early June 2014 from Maneh-va-Samalqan County, North Khorasan Province, and vicinity of Tandoureh NP (Fig. 5), Razavi Khorasan Province, both in north-eastern Iran.

Prey

The Pallas's cats feed mainly on small rodents and lagomorphs, in particular pikas of genus *Ochotona*. Moreover, small ground birds, hedgehogs, lizards and invertebrates are occasionally hunted. According to Heptner & Sludskii (1972), the manul's habitat is also typified by the presence of pikas and other small rodents, which constitute the bulk of its prey. The authors found remains of pikas in 89% of scats. In Mongolia, Ross et al. (2010b) recorded the manul feeding on a broad range of prey from insects to small mammals and birds. Nonetheless, diurnal pikas were highly

Fig. 3 A Pallas's cat in Khosh Yeilagh WR in September 2015 (Photo M. A. Adibi).

selected with the highest frequency of occurrence in diet in both summer (71.1%) and winter (47.6%).

There is no empirical data about the dietary composition of the Pallas's cat in Iran. Nevertheless, the majority of the known geographical range of this species (i.e., north to northeast) falls within the range of Afghan pika *O. rufescens* and great gerbil *Rhombomys opimus* (Harrington & Dareshuri 1976).

In captivity

The Pallas's cat has never been common within Iranian zoos and facilities. Purportedly from Sarakh (B. Ketabi, pers. comm.), northeastern-most Iran, two individuals were previously kept in Tehran zoo which are mentioned by Lay (1967) and Etemad (1985). In 2011, a juvenile manul originated from Kashan, south-central Iran, was in Iran DoE's Pardisan Eco-Park in Tehran for a short time prior to being kidnapped. Additonally, another manul of unknown origin and sex was in possession of Isar Zoo, Alborz Pro-vince until early 2016 (I. Memarian, pers. comm.). Presently, to our knowledge there are two manuls kept in captivity, one male from north-eastern Iran kept in Vakilabad Zoo, Razavi Khorasan, as well as another young manul kept by Esfahan DoE, originally from Hanna area, Semirom County. Recently, two juvenile individuals both kept by local offices of Iran DoE in northeastern Iran (Fig. 5), died after a few months in captivity.

Main threats

The Pallas's cat is currently threatened throughout its range in Asia primarily due to habitat loss, hunting for the fur trade, and vermin control programs that result in depletion of its prey base and direct poisoning (Nowell & Jackson 1996, Ross et al. 2015). Unlike global concerns suggesting the fur trade as a major threat to the viability of manul populations (Brown & Munkhtsog 2000), the Iranian population seems not to suffer significantly from poachers, partially because of their rarity and elusive habits. However, human activities such as mining and traditional pastoralism, particularly during summer when alpine and sub-alpine rangelands are occupied by flocks of livestock, might have adverse impact on the Pallas's cat (Joolaee et al. 2014). We were able to gather 19 verifiable records of the Pallas's cat mortality from Iran. In 16 cases the cause of death was reported and the individuals were either killed by herding dogs (n = 7) or poached (n = 2). Furthermore, seven Pallas's cat died shortly after capturing by local people. There were also six cases of manul capturing by local people in recent years, reportedly released back into the wild. According to Munkhtsog et al. (2004), human disturbance may also affect Pallas's cat home range. A considerable proportion of the species range in Iran is inhabited by nomadic people who move seasonally, thus Pallas's cats may have to alter their activi-ty patterns and spatial behavior in avoidance of seasonally settled areas. However, recent evidences suggest that Pallas's cats are capable of inhabiting human-disturbed landscapes (Webb et al. 2014).

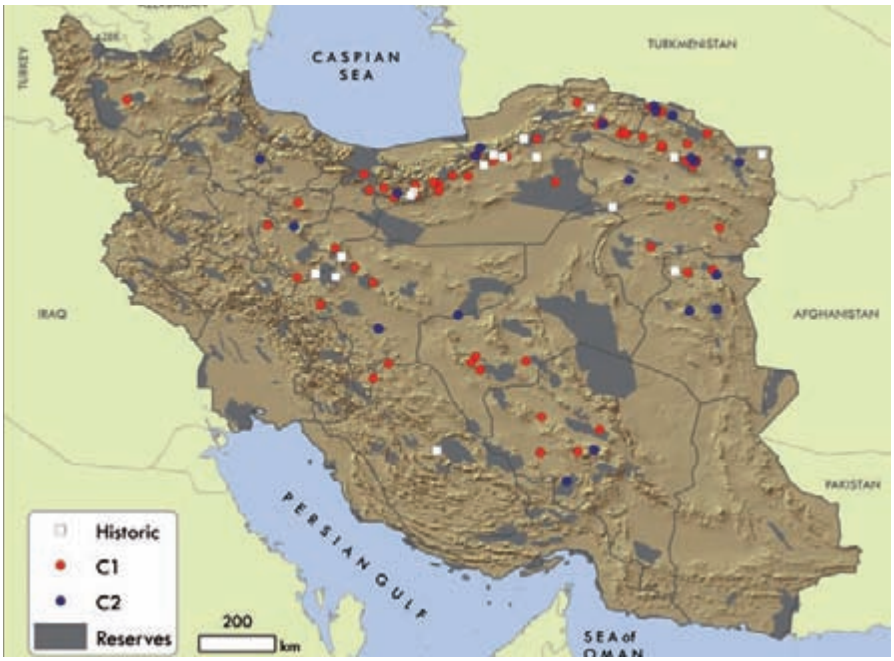

Fig. 4. Current distribution information for the Pallas's cat in Iran (1960-2015). Historical records (white square): confirmed presence records before 2000, including data from literature; C1 (red dot): hard evidences, such as photos, videos and dead specimens; C2 (blue dot): soft evidences, such as reliable field observations, either verified by us or via a trained person.

Protection measures

IUCN Red List of Threatened Species considers the manul's status as "Near Threatened" (Ross et al. 2015). In Asia, the Pallas's cat is also included in CITES Appendix II. Iran Hunting and Fishing Law 1967 (last revision 2015) classifies the Pallas's cat in Category II, defined as fully protected near threatened species. In addition, poaching will result in a fine of IRR 100,000,000 (1 USD ≈ 35,000 Iran Rials).

The recent increase in the number of captured Pallas's cats from different locations in Iran is of concern and necessitates awareness raising programs, particularly for herders who occasionally confuse the animal with small cheetah (e.g. in Bafq and Khabr NP, Yazd Province) or leopard cub (e.g. Tandoureh NP, Razavi Khorasan Province; Fig. 5). Recent conservation prioritization analysis based on evolutionary distinctiveness and globally endangered score has given the Pallas's cat a high priority for research and conservation actions in Iran, i.e. first ranking among Iran's lesser cats and one of top ten country's carnivore species (Farhadinia et al. 2016).

Fig. 5. A Pallas's cat cub perceived as a leopard cub and captured by a local herder in Tandoureh NP in April 2014 (Photo A. Moharrami).

The lack of scientific understanding of the Pallas's cat in Iran restricts our ability to conserve the species. The manul is difficult to detect in the wild and there are not many verifiable records from Iran. Identification and conservation of the Pallas's cat key habitats can play an important role in conservation planning for the species. Therefore, we recommend to conduct a large-scale habitat modeling exercise to better understand its potential distribution range not only within the Iranian boundary, but broader in western Asia. Although the distribution of the Pallas's cat in Iran appears much broader than it was first thought, the new range extension is not indicative of its better status in Iran. More research attentions are necessary by both national authorities and conservationists in order to assess the current conservation status of the Pallas's cat in the country.

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Supporting Online Material SOM Table T1 is available at www..catsg.org

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Status assessment of the Persian leopard in Iran

We conducted a national survey to evaluate the recent status of the Persian leopard *Panthera pardus saxicolor* in Iran. Leopard presence records were investigated in 204 areas under the auspices of the Department of Environment DoE, i.e. in National Parks NPs, Wildlife Reserves WRs and Protected Areas PAs and elsewhere outside these areas within the leopard's putative range from 2007 to 2011. Questionnaires were sent to DoE provincial and regional offices and we conducted interviews with hunters, local shepherds and villagers to investigate illegal killing and poisoning of leopards. Subsequently, records were classified into two reliability categories of confirmed C1 or probable presence C2. We plotted the most recent Persian leopard distribution map in Iran indicating the reliability of the records. Results show that leopard distribution is interrupted in a vast area covering about 6 provinces in the north-west of Iran, where formerly northern and southern leopard distributions were considerably connected. We therefore hypothesise that leopard distribution in Iran is splitting into a northern and a southern range, with the risk of fragmentation. Almost 70% of the leopard mortalities during the study period resulted from illegal killing and poisoning. While leopard occurrence is strongly related to wild goat *Capra aegagrus* densities, wild goat numbers are correlated with protection level, size and number of years under protection for each protected area. We recommend a number of research and conservation priorities such as field surveys to assess corridors connecting leopard main habitats particularly in the provinces located in the north-west of Iran to improve the current and planned conservation programmes. Further transboundary cooperation among the neighbouring countries is essential to improve the Persian leopard conservation in the region.

The Persian leopard is the last remaining Panthera species in Iran after the extinction of the Asiatic lion *Panthera leo persica* and the Caspian tiger *Panthera tigris virgata*. The leopard has therefore a unique importance for the ecological health of wide areas of natural ecosystems in the country and for the cultural heritage of Iran. The writings of various Persian authors (e.g. Ferdowsi 940–1020 CE, Manuchehri Damghani 1040, Baba Taher 1000-1055, Saadi 1184-1283, Mowlana 1207-1273) frequently referred to the leopard as a symbol of strength, intelligence, bravery, justice and valour for the public and the kings. The Persian leopard has been widely distributed in West, South and Central Asia since the times of the Pleistocene, but became extinct in some areas by the mid-20th century (Vereschagin 1959, Khorozyan & Abramov 2007). A drastic decline of the leopard population in the Caucasus in recent times has attracted much attention of local and international scientists and conservationists (Khorozyan et al. 2005, 2010). Today, Iran is thought to be the last stronghold for the Persian leopard with occurrences in most neighbouring countries (Kiabi et al. 2002, Khorozyan & Abramov 2007).

The Persian leopard is listed in the IUCN Red List of Threatened Species as "Endangered" and it is included in the Appendix I of CITES. In the national Red Data Book of Armenia the Persian leopard is considered as "Critically Endangered" (Khorozyan 2010). In Iran, the leopard has been protected by national wildlife conservation laws since 1999. The principal refuges for leopards in Iran are protected areas which are represented by national parks NP, wildlife refuges WR and protected areas PA. Some short-term protection has also been offered by No-Hunting Areas NHA, which are usually designated for a certain period of time, normally 5 years, to forbid hunting and enable wildlife to recover.

In this study we present the results of a national survey which was conducted to assess the present status of the Persian leopard in Iran. We first reviewed prior studies conducted in Iran and supplemented these data with new occurrence records that we collected. Thus, in this article we present original data but also indicate and discuss relative findings from other scientists which we collected during our literature review.

Material and methods

Distribution and status assessment

We collected data on leopard presence from 2007 to 2011 in 204 protected areas (25 NPs, 39 WRs and 140 PAs) and elsewhere outside these areas within the leopard putative range. We prepared a questionnaire that was sent to provincial DoE offices. Respondents were asked to provide information about leopard presence records, human/livestock-leopard conflicts, preliminary threats and conservation needs. Concurrently, we conducted interviews with hunters, local shepherds and villagers to investigate the illegal killing and poisoning of leopards. Whenever possible, we measured dead/killed individuals and leopards immobilised by DoE staff and collected samples for further genetic studies. Complaints of local people about human and livestock-leopard conflicts were recorded from 2004-2011.

The presence records were divided into two reliability categories: confirmed presence C1 and probable presence C2 as suggested by Moqanaki et al. (2010). C1 comprised records

Fig. 1. A female Persian leopard was photo captured in Salook NP, North Khorasan Province, north-eastern Iran while a study on the estimation of leopard population size in the area was undertaken (Photo: Asian Leopard Specialist Society).

of unambiguous leopard presence, e.g. naturally died/executed/road killed/injured/sick/trapped individuals and/or their photographs or videos. Skins, skulls, and other body parts were assigned C1 only if their place and time of origin were certainly known. Repeated or single observations and anecdotal records made by DoE staff or rangers constituted the C2 cases. Repeated observations refer to more than one record from the same locality while single observation refers to one record from each location. Human or livestock-leopard conflicts were classified as C2 only if the species concerned was verified to be a leopard by rangers and experts of local DoEs. Leopard historical range in the country was plotted using data presented in Etemad (1985), Ziaie (1996), Kiabi et al. (2002), Sanei (2004, 2007) and unpubl. records of DoE provincial offices. Mapping of leopard presence was done using Arc GIS 9.3.

Annual wildlife count data concerning numbers of the wild goat, wild sheep, goitered gazelle and chinkara was obtained from the main DoE office of each province and transformed into densities (number of individuals/km^2). These prey species were counted by DoE rangers in 2010-2011 during the autumn-winter time of rutting, when most individuals are clearly visible and less vigilant to humans. Prey count statistics were collected from 104 protected areas (14 NPs, 16 WRs and 74 PAs) out of the 204 surveyed for leopard presence. Data on the wild boar *Sus scrofa* were not used in this study because it is widely distributed, but seldom detected or reported, and is not a priority species for wildlife counting, so its data is skewed.

Analysis

We determined mutual correlation between several variables in the sites under protection by the DoE (i.e. WRs, NPs and PAs). These variables included: (1) recent (i.e. 2011) information about size of the area (ha); (2) IUCN protected area category (www.protectedplanet.net), (3) years under protection (period from the year of establishment to 2011), (4) leopard presence/absence status, (5) abundance of wild goat, wild sheep, goitered gazelle and chinkara (together), and (6) their densities.

We defined "no leopard presence detection", if no confirmed (C1) records were obtained from an area within the past decade. For example, in the mid-1970s in Orumieh NP, Provinces of West Azarbaijan and East Azarbaijan, the leopard was introduced to control the abundant wild sheep population on Kobudan Island, however, its presence has not been detected in the past decades. Therefore, the leopard status in protected areas of Iran was classified as "1" (present), "0" (no presence detection) and "-" (presence/absence status is unclear, no surveys).

Four areas (Hendurabi WR in Hormozgan Province, Kuh Asiab and Kuh Banan PA in Kerman, Chehel-Pa PA and Mish Dagh PA in Khuzestan) were excluded from statistical analyses because the establishment procedures as protected areas were still pending. Calculation of correlation was done using SPSS Statistics 17.0.

Taxonomy, morphological features and genetic variation

The leopard is known to be variable in body morphology, coat patterns and colouration, which reflects its high adaptability to environmental conditions (Khorozyan et al. 2006). Persian leopards inhabit different habitats in Iran and other parts of West, South and Central Asia, and their morphological features are also diverse (Heptner & Sludsky 1972, Kiabi et al. 2002, Khorozyan et al. 2006; Table 1). Earlier, this variability motivated scientists to describe two subspecies in Iran, viz. *P. p. saxicolor* Pocock, 1927 and *P. p. dathei* Zukowsky, 1959. The latest studies investigating craniological patterns and molecular genetics showed that Iran is inhabited only by one subspecies, the Persian leopard *P. p. saxicolor* (Khorozyan et al. 2006, Rozhnov et al. 2011). Farhadinia et al. (2015a) have conducted a study on 25 genetic samples from the leopards in Iran to examine the sequence variation in the mitochondrial NADH-5 gene. Results showed the presence of three closely related haplotypes including one commonly found across Iran, Turkmenistan and south Caucasus as well as two localised haplotypes from southern Zagros and eastern Alborz ranges.

Skins, museum specimens and photographs of more than 102 individuals originating from different parts of Iran showed a distinct variation in coat colouration: e.g. greyish to yellowish in the Golestan Province, dark and greyish in North Khorasan, pale in Lorestan, dark in Semnan, yellow to tawny in Ghazvin and tawny in Sistan and Baluchistan Province (Etemad 1985, Sanei 2007, A. Sanei pers. obs. 2002-2011; Fig. 1). Even though melanistic leopards (panthers) have not been confirmed so far in Iran and in other parts of the Middle East, local people and rangers claimed the presence of a black individual in the vicinity of Tandureh NP, Razavi Khorasan Province (Sanei 2007). Furthermore, local vil-

Table 1. Morphometric data of adult leopards in Iran.

Parameter	Mean	Max.	Min.	Sample size (n)
Total length, cm[1]	232	332	172	12
Length of tail, cm	90	104	80	13
Height at the shoulder, cm	69	79	58	14
Girth of the chest, cm	77	90	56	7
Body weight, kg	58	78	35	9
Greatest length of skull, mm[2]	248	288	210	21
Zygomatic width of skull, mm	162	191	143	15

[1]Head and body measurements were taken by staff of the Department of Environment and A. Sanei using the curve method in immobilised or freshly dead individuals. [2]Sources of skull measurements: Etemad (1985), Moradi (1999), Kiabi et al. (2002) and Sanei (2007). Two cubs about 4 months old were also measured: body length 93 cm and 101 cm, tail length 37 cm and 56 cm. Body weight for the second cub was 12 kg. Greatest length of a skull, condylobasal length, zygomatic width, length of upper tooth row were respectively 262.4, 232.6, 167.5 and 97.2 mm in a skull from Gorgan in Golestan Province and 210, 195, 134 and 81.3 in a skull from Kerman Province.

Table 2. Leopard presence areas recorded from 2007 to 2011 in Iran.

	Presence records (repeated and single records)[1]	Protected areas with presence records	Non-protected sites with presence records
C1 records	141	30	55
C2 records	413	35	233
Total	**554**	**65**	**288**

[1]Repeated records refer to the leopard occurrences registered from the same locality or close locations. Single records refer to a leopard occurrence registered from an area.

lagers reported that a black leopard was observed in 2008 in Garmsar, Semnan Province (Esfandiari, pers. comm.).

Distribution

Historical distribution

Blanford (1876), Birulya (1912) and Pocock (1930) described the leopard as common in the mountains and hills of Persia. Later, Zukowsky (1964), Lay (1967) and Harrington & Darreshuri (1977) also considered the leopard as a common species occurring in almost all ecosystems of Iran, except in vast plains and agricultural lands. Misonne (1959) and Joslin (1990) wrote that the leopard is particularly common in the Alborz Mts. running from north-west to north-east of Iran where it was reported to feed mainly on the abundant wild boars not hunted by Muslims. Ziaie (1996) indicated the leopard range in Iran to cover almost all the territory of the country, except for a small area in the south-west. According to Zukowsky (1959), until the late 1950s leopards shipped to the zoos of Germany and France had been captured in the Alborz Mts., particularly near the town of Astarabad (today's Gorgan), as well as in the Kopet Dagh Mts. to the north of Mashhad city. Overall, reports from the last decades indicate that the distribution of the Persian leopard in Iran has always been particularly conformed to two mountainous ranges: the Alborz and the Zagros Mts running from north-west to the south. However, two main deserts of Lout and Kavir located in the centre of the country have been two natural barriers separating local leopard populations in north from those in the south.

Recent distribution (post 2000) and habitat preferences

Since 2002, Sanei (2004, 2007) documented leopard presence through countrywide compilation of mortality records (individuals poisoned/executed/shot, killed on roads or found dead), human or livestock-leopard conflicts, questionnaire surveys, interviews with DoE rangers and local villagers, sign surveys, photographs and observations made by experts and knowledgeable local people, museum collections and individuals in captivity. A total of 74 protected and non-protected areas out of 90 areas investigated were found being occupied by leopards, of which 69% are located in northern Iran (Sanei & Zakaria 2011a). These studies refer to the years prior to 2006 and suggested that almost 55% of all areas, where leopards are present are protected habitats. This is in agreement with findings of Kiabi et al. (2002).

Kiabi et al. (2002) guesstimated the leopard population size in Iran at 550-850 individuals spread over a range of 885,300 km^2, which translates into a low density of 0.06-0.1 individuals/100 km^2. Ghoddousi et al. (2008a, 2010) camera trapped 7 individuals and estimated the leopard density at 1.87 ± 0.07 individuals/100 km^2 in Bamu NP, Fars Province. In contrast, the study by Kiabi et al. (2002) guesstimated the leopard number in Bamu NP at 15-20 individuals. Whether this discrepancy results from actual population decline or it derives from different methodologies is unclear.

Presence of the leopard in Boushehr Province was occasionally reported by local settlements in the years before 1993. In 1993, a leopard was found dead in Dashtestan Township by rangers of Dashtestan DoE office. Later on the species was recorded in Dashtestan Township, Eram district in 2005 and 2009 and Borazjan city in 2007 (Jokar 2011, Boushehr Provincial DoE Office unpubl. records). In 2008, an adult male leopard was camera-trapped in Khaeez area, Bushehr Province, thus confirming the predator's presence in this area (Abdoli et al. 2008). Ongoing camera trapping surveys (1,600 trap nights) in Gisekan non-protected area in Bushehr Province, identified 1 female and 2 male leopard individuals (Sanei 2016a). Leopard detections were also made in Abbas-Abad WR, Esfahan Province (Farhadinia et al. 2008).

Leopard numbers were estimated at 2-3 leopards in Marakan PA, 10-12 in Kiamaki WR and 7-9 in Arasbaran PA. However, the reliability of these estimates has still to be tested. Only sporadic leopard occurrence was detected in Lisar PA (Lukarevsky et al. 2007).

To study the current distribution, a total of 190 questionnaires were filled by provincial DoE offices about presence records, human/livestock-leopard conflicts, threats and conservation needs from 2007 to 2011. Data from interviews with hunters, local shepherds and villagers were only accepted if relative hard facts and proofs were found. We refused to use non validated information from interviews with local shepherds and villagers for mapping the leopard presence localities mainly because these data is not reliable enough. Complaints from local people about livestock-leopard conflicts were accepted if confirmed by any of us, DoE experts or wildlife wardens. We accumulated a total of 554 leopard records (141 records classified as C1 and 413 records classified as C2) including both repeated (two or several records referring to the same location) and single

Panthera pardus saxicolor

Names:
پلنگ Palang
Persian leopard

Head and body length:
137 cm (mean n = 20)
Tail length:
90 cm (mean n = 13)
Weight:
58 kg (mean n = 9)

Global Population:
<871-1,290
Iranian Population:
550-850 (update required)

Distribution in Iran:
Along Zagros and Alborz mountainous ranges, Kopet Dagh, mountainous habitats in south, east and central Iran

IUCN Red List:
Endangered (2008)
CITES:
Appendix I

Iran environmental conservation laws & regulations:
Protected species

Photo S. B. Mousavi

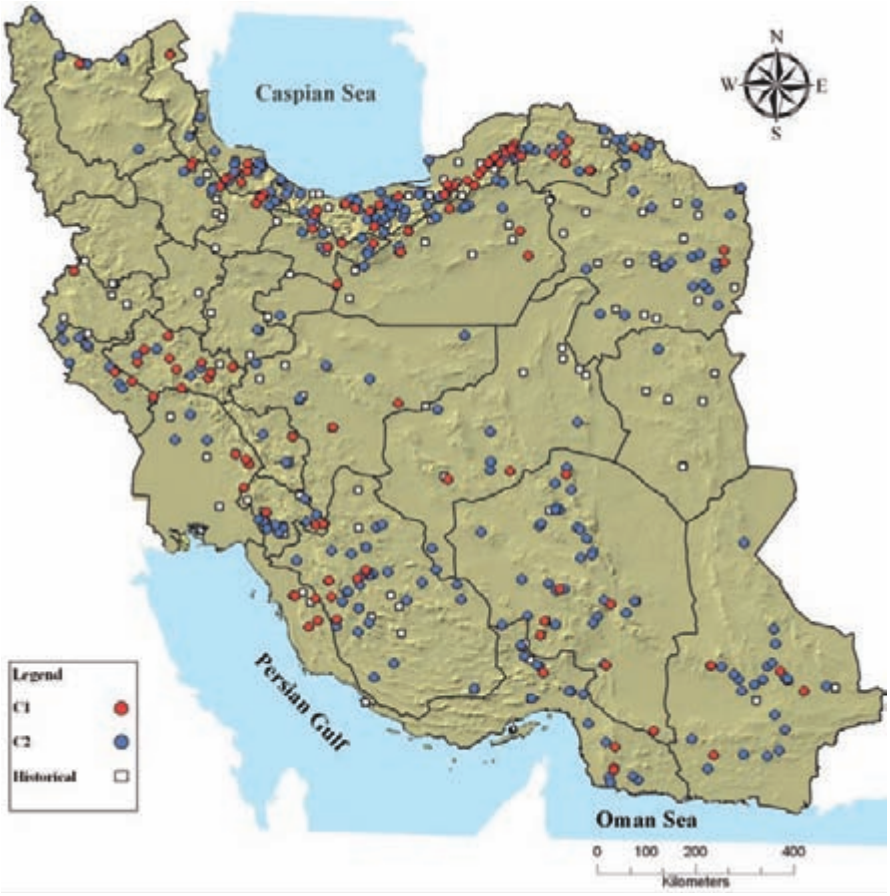

Fig. 2. Leopard presence point locations in Iran assessed from 2007 to 2011. C1 = confirmed presence, C2 = probable presence; sources for the historical records: Etemad (1985), Ziaie (1996), Kiabi et al. (2002), Sanei (2004, 2007) and unpubl. reports of DoE provincial offices. Administrative division of provinces refers to the initiation of data collection activities in 2007.

records. A total of 65 protected areas out of 204 (31.9%) were identified as leopard presence areas, of which 30 were classified as C1 and 35 as C2. In fourteen protected areas (6.8%) leopard is absent and in 125 (61.3%) protected areas the presence/absence status is unclear. PAs identified as leopard absence areas are non-suitable habitats with confirmed long-term and historically non-presence of the leopard. Unclear presence/absence status implies that even though the area has been surveyed, non-detection does not certainly mean absent due to the cryptic nature of the leopard and availability of suitable habitat types in the relative 125 PAs. Furthermore, 55 localities in non-protected habitats were categorised as C1 and 233 localities in non-protected habitats as C2 (Table 2; Fig. 2). Previous studies, related to the years before 2006, reported a total of 74 protected areas with leopard presence (Sanei & Zakaria 2011a) while there are 65 sites in the current study. It is unclear whether the other nine areas no longer contain leopards or surveys failed to detect the species. These nine areas are: (1) Muteh WR, Esfahan Province, (2) Haftad Gholeh PA, Markazi Province, (3) Sorkheh Hesar NP, Tehran Province, (4) Lar NP, Tehran Province, (5) Bisotun WR and PA, Kermanshah Province, (6) Buzin and Markhil PA, Kermanshah Province, (7) Varmanjeh, Kermanshah Province, (8) Ruchun WR, Kerman Province, and (9) Oshtoran Kuh PA, Lorestan Province. These sites should be given priority for leopard surveys.

In Markazi province a single leopard track and faeces were detected in Haftad Gholeh PA (Talebi pers. comm.), where leopards were previously recorded (Sanei 2007). After completion of data collection for this assessment (2011), camera trappings in Haftad Gholleh PA successfully recorded leopard presence in the area (Markazi provincial DoE office unpubl. data).

Habitat

Throughout their range in Iran, Persian leopards are mostly confined to the mountainous areas (Sanei & Zakaria 2011a). Mobargha (2006) showed that elevations of 1,100-1,200 m and slopes of 30-65° contain the most suitable leopard habitats in Turan NP and PA, Semnan Province, while unsuitable plateaus occupy most of the study area. Omidi et al. (2010) concluded that the best leopard habitats in Kolah Ghazi NP, Esfahan Province, are located at 1,800-2,400 m, on 20-70° slopes and in rocky mountainous areas. Gavashelishvili & Lukarevskiy (2008) concluded that leopards avoid snow cover, deserts and anthropogenic landscapes. Sanei & Zakaria (2008, 2011a) reported that leopards in Iran live in temperatures ranging from -23.1 °C to 49.4 °C. However, leopards were mostly recorded in areas with mean annual temperature of 13-18 °C, duration of ice cover <20 days/year and precipitation >200 mm/year.

Ecology and behaviour

Ghoddousi et al. (2008b) studied the frequency and distribution of territorial marking of leopards in Bamu NP by scrapes (mean length 39.3 ±1.06 cm, mean width 22.7 ± 0.66 cm, mean depth 4.7 ± 0.18 cm, n = 48), often combined with urination and defecation, all over the park. Most of scrapes were produced in winter during mating season which is similar to a report from Sarigol NP, North Khorasan Province, where the mating season was demonstrated to last from January to February (Farhadinia et al. 2009; Fig. 3).

Disease

Diseases of the Persian leopard are poorly studied, thus, their implications for the conservation of this large cat species is unknown. Youssefi et al. (2010) reported about *Ancylostoma tubaeforme* in a young female leopard shot in the Ahovan County near Damghan city, Semnan Province. Investigates of Masoudi Zanjani (2004), cited in Sanei (2007), report no parasites in leopard scats from Tandureh NP, Razavi Khorasan Province. Sanei (2006, unpubl. report) carried out a parasitological survey throughout Golestan NP, Golestan Province and found Shistosoma spp. in the Degarmanli site. More recently in 2011, a leopard suffering from infectious disease was found near the Rashvanlu village, North Khorasan Province.

Prey species

The staple prey species are the wild goat *Capra aegagrus*, wild sheep *Ovis orientalis*, wild boar and Indian crested porcupine *Hystrix indica* with 100%, 95%, 65%, and 65%, respectively, conformity of distribution with the leopard range in 43 study sites across

the country . Other species, such as the goitered gazelle *Gazella subgutturosa*, chinkara *G. bennetti*, roe deer *Capreolus capreolus*, red deer *Cervus elaphus*, and Persian onager *Equus hemionus onager* have limited distribution as well as less conformity with leopard range (Sanei 2007, Sanei et al. 2011; Fig. 4). Likewise, more detailed studies identified the main prey species as wild goat and wild sheep in Tandoureh NP, Razavi Khorasan Province and wild boar followed by wild sheep and wild goat in Golestan NP, Golestan Province (Chalani 2005, Sherbafi 2010). Meanwhile, wild goat was identified as a principle determinant for leopard presence in Kolah Ghazi NP, Esfahan Province (Omidi et al. 2010).

Fig. 3. Three new-born leopard cubs in a small cave located in a Forest in Neka Township, Mazandaran Province found by a local villager in May 2009 while their eyes were still closed (Photo: H. A. Khanehsari Naghash).

Main threats

Sanei & Zakaria (2011b) describe seven threats to leopards in Iran, in decreasing order of incident frequency: (1) habitat destruction, degradation and fragmentation; (2) illegal hunting and poaching of both leopards and prey species, poisonous lures, capturing juveniles of prey species; (3) animal husbandry and presence of livestock in the leopard range; (4) lack of conservation facilities; (5) low environmental awareness; (6) droughts and unsuitable habitat conditions; (7) aftermath of Iran-Iraq war (i.e. unsafety in habitats, excess of gun among people, reduction in prey population, presence of land mines in the habitats). Kiabi et al. (2002) indicated that accidental and deliberate killing and habitat loss are the principal threats to the leopards in Iran. Ghoddousi et al. (2008a, 2010) describe habitat loss and fragmentation as the main threats to leopards in Bamu NP, Fars Province. We recorded a total of 71 cases of mortality throughout the country from 2007-2011 (see also Sanei et al. 2012). Intentional killing and poisoning (n = 50, 70% of total mortality) followed by road accidents (n = 13) were the main causes of leopard mortality in recent years. Other detected causes of mortalities were disease (n = 3), flood (n = 1), intraspecific conflicts (n = 1), natural death (n = 1) and 2 cases of unknown reasons. It is worth mentioning that, these results could have a bias since natural mortalities are scarcely detected.

Habitat encroachment and development projects also bring about human-leopard conflicts, which increase every year. Sanei (2007) and Sanei & Zakaria (2011b) studied human-predator conflict cases in Iran in 2002-2003 and revealed that in 2002, ranking of conflicts with leopard was second after conflicts with wolf *Canis lupus*. Yet in 2003, human/livestock-leopard conflict was in the third place, after conflicts related to wolf and brown bear Ursus arctos. We recorded known cases of such conflicts from 2004-2009. These cases include attacks of the leopard on cattle, camel, domestic sheep and goat, donkey, horse and herding dog. Rarely, attacks on humans, causing injuries, were also recorded (data available from the first author).

Recently, an innovative insurance model has been developed to address livestock-leopard conflicts and relative revenge killings by local people. Since the wolf distribution in Iran is comparable to that of the leopard in the country, attempts by local people for revenge killing (e.g. using poisonous lure in the habitat) may also affect the leopard. Therefore, even though livestock depredation by wolf is known to be much more frequent than by leopard, this insurance model has addressed both species at the same program to practically settle the issue (Sanei 2016b). Data on livestock – leopard/grey wolf conflicts from 2013 to early 2015 (26 months) shows that the most attacks include medium sized livestock (i.e. a total number of 7,090 goat and sheep) and less depredation on large sized cattle (i.e. caw, horse, camel, donkey and mule; 208 kills). Conflicts in the Provinces of Sistan and Balouchistan, Hormozgan, Razavi Khorasan, Kohgiluyeh and Boyer Ahmad, Kerman, Mazandaran, Fars and Ardebil were recorded to result in more than 500 losses/year in each province. Yet, we believe much cases of livestock losses particularly in Provinces of Gilan, Mazandaran and Golestan (within Hyrcanian forests range), remain unknown/not reported and thus, there could be significantly more cases than reported here.

Droughts and dry conditions in various habitats have become a serious threat for wildlife species in recent times. Numerous springs have also dried up because of unwise cultivation programmes and overuse of underground waters (Sanei & Zakaria 2011b). According to DoE, dry conditions in a number of habitats under the auspices of DoE entail distant migrations of ungulates, particularly from protected areas to outer human-dominated landscapes. Sistan and Baluchistan Province is one of the driest provinces in Iran where long-term livestock-leopard conflicts ignited by droughts and prey deficiency have not been solved for more than a decade.

Discussion

Fragmentation of the Iranian northern and southern leopard range

Comparing leopard presence sites reported earlier (Sanei 2004, 2007, Sanei & Zakaria 2011a) with those in this assessment (Fig. 2) suggests a considerable reduction in leopard distribution range over the past years. Considering this result, we hypothesise that leopard distribution in Iran is in the process of splitting into a northern and a southern range. The conjunction of two mountainous ranges of Alborz and Zagros in north-west of Iran has historically provided a link connecting the northern to the southern leopard range. Yet, we did not find any strong evidence of leopard presence in the 4 Provinces of Kordestan, Hamedan, Markazi (except for a camera trap record after data collection span) and Ghom. In Kermanshah Province only one dead leopard was found in 2008 in Paveh township located in the north-west of the Province. Furthermore, no recent record is available from the central and southern parts of West

Azarbaijan Province. In Hamedan Province, leopard absence for over three decades (Sanei 2004) might be a result of high village densities. Local authorities explained that historically the species inhabited Ghafelanteh Mountain located in Shara PA in this province (Nouri, pers. comm.). Even though, questionnaire surveys also failed to detect any C1 or C2 record of leopard presence, unconfirmed evidences of leopard presence were reported by local villagers in Marivan township in Kordestan Province. This may indicate that the species still inhabits the area (Imani and Veisi, pers. comm.).

The main Persian leopard population is known to be in Iran (Kiabi et al. 2002, Stein et al. 2016) and could potentially support leopard presence in the neighbouring countries (Sanei et al. 2013, Farhadinia et al. 2015b). But rapid development is affecting its survival in various regions of its range. Sanei & Masoud (2014) reported that much of the leopard habitat in East-Azarbaijan Province (bordering Armenia and Azerbaijan) is fragmented by cultivation lands and settlements while only few prime habitat in the north (i.e. above 37° 00' N) is still reasonably vast and connected.

A preliminary analysis

Estimation of the correlation between prey variables, size and IUCN category of protected areas, and the years under protection in 104 protected areas out of 204 sites where leopard presence study was conducted has revealed interesting patterns:

1. The IUCN category of protected areas strongly correlates with prey numbers and densities (r = -0.38 to -0.31, P = 0.000 to 0.001): The higher the protection status, the higher are ungulate numbers and this relationship is equally strong for all studied prey species, except for gazelles. Hence, in general NPs contain more prey than WRs and those more than PAs. This could be a result of more resources available and higher awareness together with stricter law enforcement in the higher-ranked sites.
2. The size of protected area is strongly linked to wild goat numbers (r = 0.29, P = 0.003), i.e. the larger the area, the more wild goats.
3. The number of years under protection is important for wild goat and wild sheep numbers (r = 0.29, P = 0.003 and r = 0.28, P = 0.005, respectively) which implies that performance of the protected area network in Iran has been significant so far.

Study of protected areas with leopard presence (1)/absence (0) together with data on prey species shows that leopard occurrence in Iran's protected areas is strongly linked with wild goat densities and, to a lesser extent, with wild sheep densities. This is in agreement with findings of previous studies about co-occurrence of the leopard with wild goat followed by the wild sheep (Sanei et al. 2011). Wild boar is also one of the staple prey species for the Persian leopard. Boars faced intensive poaching and hunting in some regions more recently. Thus, information and monitoring of its abundance, distribution and principle threats is essentially required.

Protection measures and recommendations

DoE implements certain compensation programmes for agricultural products lost to wildlife, but it is practically impossible to recoup all the actual losses inflicted by leopards, ungulates and porcupines and to monitor this work in villages scattered throughout the country. Furthermore, local people in numerous rural villages are not aware of compensation regulations and laws. Currently, a particular and innovative insurance programme for livestock to compensate and reduce losses caused by leopards and wolves is ongoing as a part of the Persian leopard national conservation and management action plan (Sanei 2016b). Informing local villagers about these programmes followed by compensating the losses in a reasonable period of time may effectively reduce revenge killings (Fig. 5).

Golestan Province contains vast areas of suitable habitat connecting leopard range in the north-east with the northern parts of the country. Among all 24 mortalities recorded in Golestan Province from 2002 to 2011, 5 cases were road kills, 1 individual drowned in a flood, 1 died from unknown causes and 17 (70.8%) were shot or poisoned. Moreover, 12 individuals were intentionally killed in this province since 2007 (Shakiba, pers. comm., Golestan DoE General Office, unpubl. records). Since the leopard has been considered a protected species in Iran, there could be a higher number of individuals shot or intentionally killed throughout the country that we failed to detect, as people may not report cases due to fear of legal prosecution. We believe that conducting community based programmes to empower local communities to effectively protect their herds and livestock could be a practical solution to reduce revenge killing by local herders and villagers. Road accidents comprise about 18% of the assessed leopard mortalities in Iran from 2007 to 2011 (see also Sanei et al. 2012). This has been a particular threat to the leopard in various provinces; e.g. a highway crossing Golestan NP in Golestan Province is a threat to the leopard and other wildlife, such as red deer, in this area. A proposal of relocating and replacing the highway is under consideration. Yet, assessment of leopard road kill hotspots and spatial patterns to identify the mitigation measures and priorities together with evaluating the use of wildlife bridges or underpasses in certain areas where the highest numbers of animal collisions with vehicles occur is required.

Fig. 4. Landscapes of the leopard habitat and its main prey species in North Khorasan Province (left: wild sheep, right: wild goat; Photos Behrouz Jafari).

As the Iranian leopard serves as a source population for neighbouring regions, identification of transboundary leopard habitats and corridors among Iran and bordering areas as well as transboundary cooperation among neighbouring countries to improve the Persian leopard conservation in the region is a vital step towards the maintenance of free movements of leopards. In this regards, distribution modelling of the Persian leopard potential habitats in north-east and north-west of Iran as well as elsewhere across the country has been completed (Sanei et al. 2013, Sanei 2016b). Agreements to establish joint transboundary protected areas (i.e. peace parks) between Iran and Iraq as well as Iran and Armenia, have been signed. Besides, an urgent priority should be given to investigating the risk of fragmentation and the consequences of splitting the leopard distribution range in Iran into a northern and a southern range. Field surveys to assess corridors connecting leopard main habitats particularly in the provinces in north-west Iran are needed. Further conservation programmes, improving legislations and protective measures need to be planned accordingly.

To address all the aforementioned threats affecting the Persian leopard in Iran, DoE together with Asian Leopard Specialist Society has embarked on the preparation of a national conservation and management action plan since 2012. Subsequently, the plan was finalised and endorsed on January 2016 while it is covering a total of eleven main subjects at the local, national and international scales. These subjects are (1) awareness raising, training and empowerment, (2) habitat, (3) media, (4) veterinary and disease, (5) rehabilitation centers, (5) transboundary habitats and international cooperation, (6) genetic conservation, (7) compensation and innovative Persian leopard insurance program, (8) Persian Leopard National Network, (9) research, evaluation and monitoring, (10) protection unit and wildlife wardens and (11) laws and regulations (Sanei 2016b).

Fig. 5. Leopard killed by villagers in Darab, Fars Province, South of Iran (Photo Fars Provincial DoE Office).

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Distribution, characteristics and conservation of the jungle cat in Iran

The jungle cat *Felis chaus* is among the least known felids worldwide. A national survey was conducted to assess and document the status and distribution of this species in Iran. A total of 280 jungle cat presence records have been collected, including road kills, injured animals, hunted and trapped specimens and observations and reports made by experts. Observations reported by local communities living inside or close to jungle cat habitats and by inexperienced people were also recorded. We then classified the data into three categories (i.e. C1: confirmed presence, C2: probable presence, C3: unconfirmed presence) on the basis of confirmability of records. Findings indicated that the jungle cat is distributed at least in 23 out of the 31 provinces of Iran. A total of 69 records came from protected areas, i.e. National Parks NPs, Wildlife Reserves WRs and Protected Areas PAs, covering an area of 38,343 km², which is 23.5% of the total area of all protected areas under the auspices of the Department of Environment DoE of Iran. The species was found at altitudes ranging from 45 m to 4,178 m and in a variety of habitat types from plains and agriculture lands to the mountains. However, it was mostly recorded in shrub lands and woodlands. We suppose that the diet of jungle cat in Iran mainly consists of fish, birds (waterfowl, poultry and galliform birds) and rodents. More detailed studies and status assessment of the species on a local scale, particularly in the areas affected by land use changes and severe dry condition are essential. Several conservation measures are recommended to improve the status of the species in Iran.

Among the 10 native felids of Iran, the jungle cat is considered as one of the least known species. It is also known as reed cat or swamp cat. It occurs in North Africa and is widespread in Asia from the Middle East, South-west Asia, Central and South Asia over to South-east Asia, reaching Indochina and possibly the Malayan Peninsula (Nowell & Jackson 1996, Sunquist & Sunquist 2002, Abu-Baker et al. 2003, Duckworth et al. 2005, Sanei & Zakaria 2010). Jungle cats are primarily associated with dense riparian vegetation, especially reed beds and marshes, but cats have also been recorded in shrubby woodland, grassland, evergreen forests, deciduous forest, lowland dipterocarp forests, desert, agriculture lands and forest plantations (Roberts 1977, Tikader 1983, Khan & Beg 1986, Trinh 1991, Abu-Baker et al. 2003, Duckworth et al. 2005, Ogurlu et al. 2010). Its occurrence in arid environments, such as sand deserts, is rare (Rais et al. 2010).

Ten subspecies of the jungle cat have been proposed so far based on the diversity of morphological traits (Pocock 1939, Heptner & Sludskii 1972), but no genetic or cranial analysis was carried out yet to test this hypothesis (Duckworth et al. 2008). The species is considered as Least Concern LC on the IUCN Red List of Threatened Species (Gray et al. 2016). However, information on its ecology, distribution and status is still sparse (Nowell & Jackson 1996, Sunquist & Sunquist 2002).

This paper represents the first compilation of jungle cat records and status assessment, focusing on the distribution, characteristics and conservation of the jungle cat in Iran which could be used to promote species research, conservation and sustainable management in the country.

Methods

The most reliable information, e.g. camera-trap pictures, road kills, captive individuals, injured animals, trophies, skulls and stuffed specimens, was compiled to assess the jungle cat status and distribution in Iran. Jungle cat observations, the related habitat characteristics and other information (date, time, weather condition, behaviour of the cat when it was observed, biometry of dead individuals) were recorded during the most recent annual wildlife counts (2010) undertaken by staff and rangers of the DoE in 14 National Parks, 16 Wildlife Refuges, 73 Protected Areas and 164 unprotected and No-Hunting Areas in 31 provinces of Iran. Interviews with hunters and local communities living inside or close to jungle cat habitats were also conducted at irregular intervals during the study. Questionnaires were prepared, sent out to provincial DoE offices and filled out by the responsible a few times per year since 2004.

We classified data into 3 categories: C1 as confirmed presence, C2 as probable presence and C3 as unconfirmed presence (suggested by Moqanaki et al. 2010). Confirmed presence includes photos, videos, injured individuals and carcasses or remains of the species obtained and recognized. Probable presence includes presence records reported by trained people, e.g. park rangers, other DoE staff or wildlife experts. Unconfirmed presence are observations that have not been confirmed by a trained person. Historical occurrence of the species is linked with records provided in old reports and unpublished records of the DoE. We used the records provided by Etemad (1985), Darvish (2001) and Sanei (2007) for historical occurrence of the species. These four main sources (i.e. C1, C2, C3 and historical occurrence of species) were used to map the current and historical distribution of the

Fig. 1 A jungle cat in Mianroud, Khouzestan Province in the south-west of Iran in 2012 (Photo B. Farahanchi).

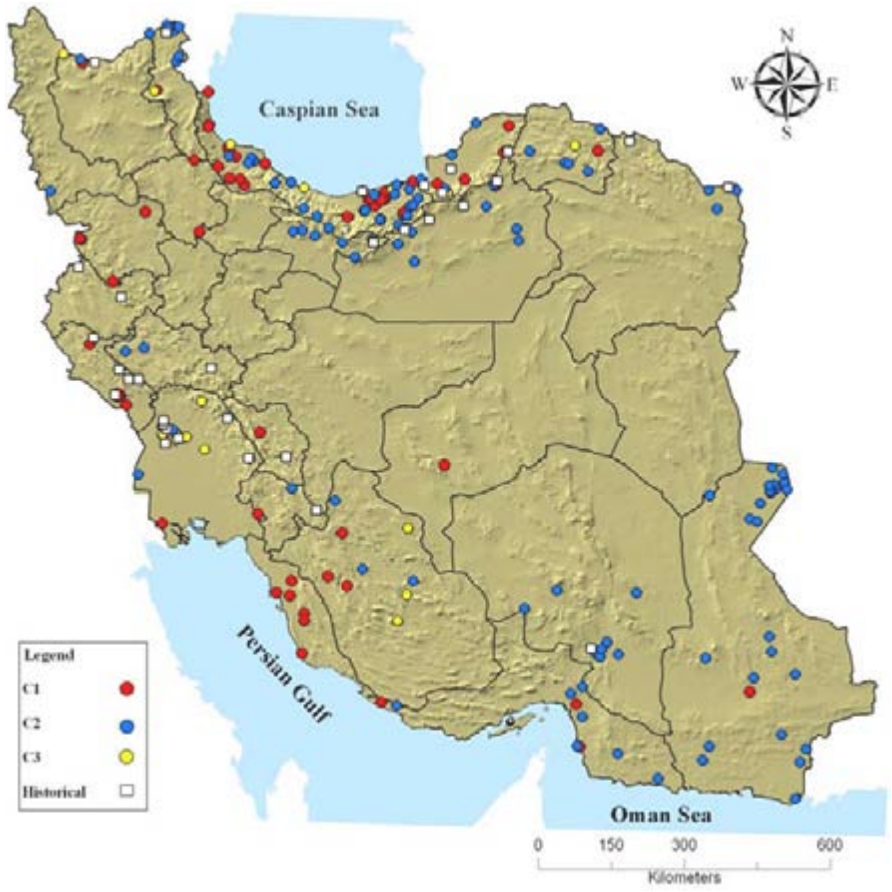

Fig. 2 Distribution of the presence locations of the jungle cat in Iran.C1 refers to the confirmed jungle cat records such as presence of carcasses, road kills and injured individuals, photos and videos (red dots); C2: Observations made by research team members and DoE staff and rangers (blue dots); C3: reports made by untrained people (yellow dots); Reference for historical records (white squares): Etemad (1985), Darvish (2001) and Sanei (2007). Presence records in the map are based on data compiled until March 2012. Repeated records in the same location are represented by one symbol. Division of provinces refers to early 2010.

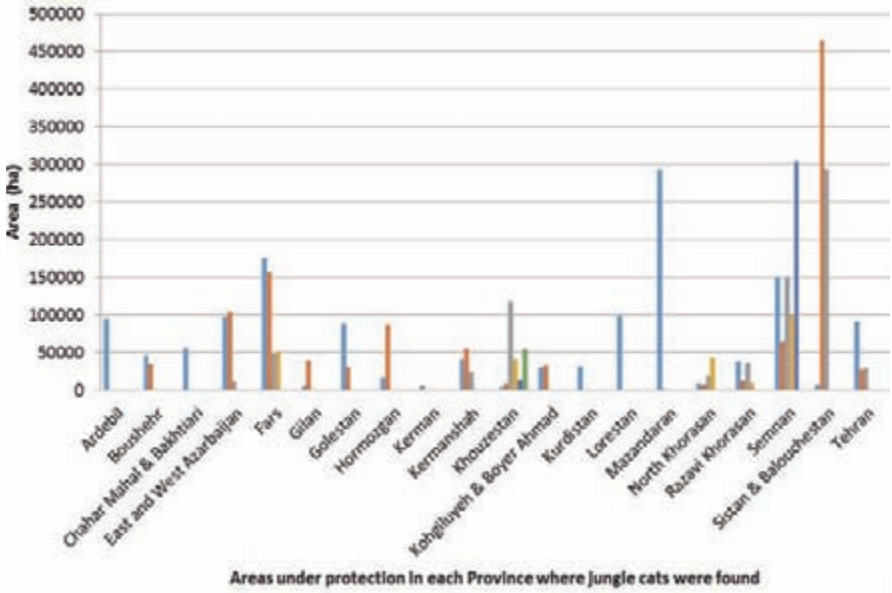

Fig. 3 Extent and number of the PAs, WRs and NPs with jungle cat detection in each province. Each bar illustrates size (ha) of one area under the auspices of DoE where jungle cat was detected. Dasht-e-Naz PA (59 ha) with jungle cat detections in Mazandaran Province is not visible on the graph due to its small size. Various colours of the bars are only to facilitate the differentiation of the bars.

species in the country. Mapping was done using Arc GIS 9.3. Biometric measurements were taken from road kills and post-mortem autopsy was carried out whenever possible.

Results

Morphological description

A study conducted by Mukherjee & Groves (2007) has revealed that jungle cats in western parts (≤ 50.0°E longitude) are obviously larger and heavier than those in the eastern parts (> 60.0°E longitude). In Turkey, a jungle cat specimen was reported to be yellowish-brown with a white neck and black-tipped reddish-brown ears (Ogurlu et al. 2010). Individuals of this species are known to have a relatively short body with long legs. They have a plain and uniformly coloured coat, but their legs are marked by clear lines and the tail has rings (Jutzeler et al. 2010).

All trapped, hunted and road killed jungle cats that we recorded had plain greyish colouration and visible stripes on front and hind legs. The coat on the flanks and the belly has tints of yellow and the tail is greyish with black stripes. The throat is light cream and the bottom part of the paws is black (Fig. 1).

A young adult female from western Iran (Zarivar, Kordestan Province 2011) had a total body size of 87 cm, including a tail of 20 cm, and a body weight of 4.89 kg. The height of the shoulder was 39.5 cm, the girth of the head 25.5 cm, the girth of the chest 31 cm and the girth of the belly 30 cm. The canine length measured by callipers (accuracy 0.02 mm) was as follows: 12.24 mm upper right, 12.36 upper left, 10.66 mm lower right and 10.24 mm lower left. The adult male found in western Iran close to Khaeez Protected Area (Kohgiluyeh and Boyer Ahmad Province, 2009) was slightly bigger: total body length 90 cm including tail length 27 cm and shoulder height 44 cm (Supporting Online Material SOM Table T1).

Distribution and habitat

The jungle cat is known to be widely distributed in Iran (Firuz 2000, Ziaie 2008). Darvish (2001) identified the species ranging from the northern parts of the country, from the Provinces of Golestan and Mazandaran westwards along the Caspian Sea coastline and Hyrcanian forests to the West Azarbaijan Province. Sanei (2007) indicated 13 protected areas in the Provinces of Razavi Khorasan, Golestan, Semnan, Chahar-Mahal and Bakhtiari, Kerman, Kermanshah and Khuzestan in northern, central, western and

southern parts of Iran where this species was previously reported.

We have collected a total of 280 single and repeated (i.e. two or more records from the same locality) jungle cat records, of which 74 records were confirmed through road kills, injured individuals and photos captured by DoE staff, rangers, wildlife experts and hunters (C1); 179 observation records were made by experienced rangers and staff of DoE (C2) and 27 records were reported by local communities (e.g. local shepherds and farmers) and inexperienced persons (C3).

Since in most of the cases we do not know whether detected jungle cats in each series of repeated records in the same area are the same or different individuals, all records in this manuscript are counted individually. However, in the distribution range provided in Fig. 2, repeated records fall within the same presence point on the map.

We recorded the species presence in 23 out of 31 provinces of Iran (Fig. 2). A total of 73 records originated from the Provinces of Mazandaran, Gilan and Golestan with Hyrcanian forests in the north (altogether 26.07% of all records). Surprisingly, many records were from Sistan and Balouchestan Province located in the south-east of Iran (53 out of 280, 18.92%). Fewer records were from Tehran and Semnan Provinces located in central Iran (38, 13.57%). Jungle cats killed on roads were found in Sistan and Baluchestan, Semnan, Kordestan, Ilam, Kohgiluyeh and Boyer Ahmad, and Golestan Provinces. All these records are classified as C1 (Fig. 2). A list of the areas where jungle cats were detected in this study is available from the first author upon request.

Out of 280 jungle cat records available at the time of writing this paper, only 69 records were from protected areas (i.e. PAs, NPs and WRs) which altogether cover 38,343 km² out of 163,215 km² (23.5%) of all protected areas in Iran (Fig. 3). No Hunting Areas are excluded as their protection status is changing over time. Based on this finding, we suppose that in Iran jungle cats are found largely outside protected areas. They can also live close to humans (e.g. fish farms or irrigation canals) or agricultural landscapes. We have recorded specimens frequently close to fish pools, poultry farms and agricultural lands.

Habitat identification checklists were completed by DoE rangers who conducted annual wildlife counts in 12 provinces (Table 1). Incomplete reports and checklists are excluded from the results. Jungle cats were found in diverse habitat types from plains and agriculture lands to the mountains, however, most of them were detected in shrub lands and woodlands (n = 6, 31.5%). Furthermore, jungle cats were found at different altitudes ranging from 45 m to 4,178 m with an average of 494 m, with 67.0% of detections at altitudes less than 160 m (Fig. 4).

Felis chaus

Names:
گربه جنگلی Gorbeh Jangali
jungle cat

Head and body length:
65 cm (mean 1 female and 1 male)
Tail length:
23 cm (mean 1 female and 1 male)
Weight:
4.89 kg (1 female)

Global Population:
Unknown
Iranian Population:
Unknown

Distribution in Iran:
Northern, western, southern, eastern and central Iran

IUCN Red List:
Least Concern (2016)
CITES:
Appendix II

Iran environmental conservation laws & regulations:
Protected species

Photo B. Farahanchi

Prey and their extension

Food habits of the jungle cat were studied by Mukherjee et al. (2004). This study has revealed that in a semi-arid environment of western India jungle cats feed largely on rodents and less frequently on birds and invertebrates. However, they are also capable of hunting on larger prey such as young swine, sub-adult gazelles and chital fawns (Sunquist & Sunquist 2002). Ogurlu et al. (2010) reported that in the vicinity of the Lake Egirdir in Turkey jungle cats feed mainly on fish and also on restaurant leftovers and dead waterfowl.

The post-mortem autopsy of a jungle cat killed on a road (Zarivar, Kordestan; by Marashi, Sanei, Mousavi in Tehran DoE, June. 2011) showed that its stomach mostly contained fish and plant material. Since we have recorded jungle cats frequently on the shorelines, close to poultry farms and in pheasant habitats, we suppose that the diet of jungle cats in these habitats mainly consists of birds (waterfowl, poultry and galliform birds), fish and rodents, well in agreement with Lay (1967).

In general, jungle cats are reported to consume a great variety of prey including rodents, reptiles, amphibians, fish, eggs and fruits (Heptner & Sludskii 1972, Sunquist & Sunquist 2002, Mukherjee et al. 2004). Rodents are very diverse in Iran (e.g. rats and mice Murinae, voles Arvicolinae, squirrels Sciuridae, jerboas Dipodidae, hamsters Cricetinae, jirds and gerbils Gerbillinae, and dormice Myoxidae), just like the lagomorphs (hares Leporidae and pikas Ochotonidae), all of which can provide meals to jungle cats (Firuz 2000, Ziaie 2008).

Threats and conservation implications

The jungle cat is listed as Least Concern on the IUCN Red List of Threatened Species (Gray et al. 2016), but in Iran it is protected under the national Wildlife Conservation Law enacted in 1999.

Unlike most felids, the jungle cat is known to be resistant to some forms of human-driven landscape alteration and is often recorded on cultivated lands (Tikader 1983, Khan & Beg 1986, Rais et al. 2010). These habitats are effortlessly accessible for people and specimens could be easily trapped and hunted. Furthermore, as mentioned above, only a small portion of jungle cat records in Iran come from

Table 1. Jungle cat habitat identification in 12 provinces of Iran based on regional assessments.

Province	Habitat Type							
	Shrub land/woodland	Forest[1]	Mountain[2]	Hill[3]	Reed beds	Agriculture land	Plain[4]	Pasture
West Azarbaijan	X							
East Azarbaijan	X							
Ardebil	X						X	X
Semnan								X
Mazandaran		X	X	X				X
Golestan		X						
Fars	X							
Kerman			X	X				
Kordestan					X			
Kohgiluyeh & Boyer Ahmad		X						
Khuzestan	X					X		
Sistan & Balouchestan	X							
Total %	31.5	15.7	10.5	10.5	5.2	5.2	5.2	15.7

[1]Refers to the forests in the plains, on the hills or the mountains. [2]We considered mountains as natural elevated land forms rising abruptly to a peak while [3]hill was defined as a landform extends to some extent higher than the surrounding areas and less craggy than a mountain.

[4]Plain was defined as the flat and not elevated topography (i.e. mountainous forests or forests on the hills or plains were still classified as forest).

protected areas where they could be efficiently protected from poaching and trapping.

As a species associated with riparian habitats the jungle cat can be significantly affected by extensive droughts (Abu-Baker et al. 2003). As regularly monitored by Iran Meteorological Organization (http://www.irimo.ir/english/), dry conditions have recently seriously hit the western and southern parts of Iran. Furthermore, according to provincial DoE offices, several springs, some rivers and lakes have dried out because of false agricultural activities, overuse of groundwater resources and establishment of dams. Even though prey is not considered generally as a limiting factor for jungle cats with their catholic diet (Rathore & Thapar 1984, Nowell & Jackson 1996, Mukherjee et al. 2004, Ogurlu et al. 2010), a population reduction in prey species like rodents and birds by either drought or land use changes could be considered as a potential threat to this felid.

As mentioned earlier, in combination with other threat factors, road crashes could also pose a risk to jungle cats in Iran. The development of road networks has been a serious conservation issue for many wildlife species in various regions of the country. In our sample, jungle cats killed on roads were found in the Provinces of Kohgiluyeh and Boyer Ahmad, Ilam, Kordestan, Ghazvin, Golestan, and Sistan and Baluchestan. Some other larger mammals, like leopard (*Panthera pardus*), red deer (*Cervis elaphus*) and others also fall victim to collisions on roads crossing the Golestan National Park (Kiabi et al. 2002, Sanei 2007, our data, unpubl.).

Golestan National Park and several other forests in Iran have been struck by fires which urged jungle cats to leave these areas. They then came close to human settlements and were killed by villagers. Also, as jungle cats often live near poultry farms and crop fields, some of them would undoubtedly be eliminated as pest animals. Even though DoE provides compensation for the loss caused by jungle cats (and other predators) to domestic animals, in some cases local people prefer killing the cat to prevent further attacks rather than to apply to the authorities for refunding as payment procedures are usually very slow. Additionally, in the spots where migratory birds seasonally visit the area (e.g. Fereydoun Kenar wetland), local illegal hunters believe that the presence of jungle cats is disturbing the hunting of birds. Therefore, they live trap and/or execute the jungle cats in the area.

Taking into account Iran's law on wildlife protection and the enforcements of existing regulations, people generally do not respond to claims about hunted animals. Thus, the level of poaching remains unknown, but stuffed jungle cats can still be found in some local tourist shops, particularly in the Provinces of Gilan and Mazandaran (northern Iran).

Since the jungle cat in Iran has received little attention of researchers so far, we suggest a number of conservation measures based on our current knowledge about the species in the country. We also recommend several research topics to improve the understanding about this species in Iran:

Research priorities and conservation measures:

- Local status assessment, especially in areas affected by severe droughts and other threats (conflicts with humans, fires, roads);
- Impact of natural and human disasters (droughts, fires, floods, land use changes) on population viability and resistance;
- Research of human-cat conflicts and ways of conflict resolution such as antipoaching practices using long term awareness raising programs in the areas where trapping and hunting of the jungle cats are affecting the species;
- Estimation of population size, structure, distribution and trend with scientific robust methods;
- Evaluate whether construction and maintenance of underpasses and road fencing, in the hot spots with numerous jungle cat and other wildlife road crashes could be considered as an appropriate conservation measure for the species (e.g. in Golestan National Park);
- Genetic and cranial analysis for taxonomic review and test for the existence of previously morphologically categorized subspecies of the jungle cats.
- Studies on species ecology and biology in the areas of confirmed presence that are reported in this study;

- Establishment and maintenance of waterholes in protected areas of confirmed presence and affected by droughts;
- Acceleration of payment processing in compensation programs to reduce revenge killings and executing the cats by local shepherds and communities because of preventing further attacks on their poultries
- To establish more strict regulations for hunting and killing of jungle cats (e.g. updating amount of financial penalties for each hunted or killed individual regularly).

Fig. 4 A jungle cat in its natural habitat on the coastline of the Zarivar Lake, Kordestan Province (Photo A. Imani, Kordestan DoE Provincial Office).

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Supporting Online Material SOM Table T1 is available at www.catsg.org

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Sand cat in Iran - present status, distribution and conservation challenges

For studying the distribution, ecology and threats of the smallest felid species in Iran, the sand cat *Felis margarita*, we gathered all published and unpublished data from across the country and categorised them into hard fact C1 and anecdotal data C2. Based on 46 presence points (C1 = 26 and C2 = 20) from 6 out of 31 provinces, sand cat distribution in Iran is limited to the desert habitats in the centre, east and south-east of the country. Sand dunes with Saxaul trees are the main habitats for sand cat in Iran, as well as arid flat plains with little plant distribution. Potential prey species are desert rodents, reptiles, hare and probably some bird species. Killing by shepherd dogs and trapping by locals in houbara bustard snares are the major threats to survival of this elusive cat in Iran. Desert safaris and road accident may become a potential threat to the existence of sand cats in fragile desert habitats. For better conservation actions, more fine-scale distribution studies especially in eastern and south-eastern parts of the country, diet, estimate of home range size and density of sand cats in Iran are required.

The sand cat is a small cat, with size and build smaller than the wildcat *Felis silvestris* (Sliwa 2013). It is the only felid found primarily in true deserts and has a wide but apparently disjunct distribution through the deserts of northern Africa and south-west and central Asia. (Hemmer et al. 1976, Nowell & Jackson 1996). The head is flat and broad, and the ears are broad and set low down on the sides of the head without apical tuft. The legs are short and the tail is long with a black tip. The light yellow fur is soft and dense and there are thin russet-brown stripes particularly visible on the front legs and the tail (Aulagnir et al 2009, Hunter, 2011, Sliwa 2013; Figs. 1-3).

Based on morphological data, there are four distinct subspecies: Saharan *F. m. margarita*, Arabian *F. m. harrisoni*, central Asian *F. m. thinobia* and Pakistani *F. m. scheffeli* sand cat (Hemmer et al. 1976). *F. m. thinobia* from the sand deserts of Turkmenistan, Uzbekistan, Kazakhstan, and possibly northern Iran and north-eastern Afghanistan (SIiwa 2013) and *F. m. scheffeli* from Pakistan are two possible subspecies present in Iran. However, this classification needs further validation in the future.

Fig. 1. Sand cat in Abbas'abad Wildlife Refuge (Photo Naein DoE).

The sand cat is the smallest cat of Iran and there is little information about this cat in the country, and only in recent years, the information about the distribution of this species has been improved.

The main purpose of this study is to review the distribution status of the sand cat in Iran. Additionally, information about the ecology, biology and threats to this species were gathered from across the country and are presented. The present status assessment of sand cat in Iran will hopefully act as a first step for future studies and conservation planning for this elusive cat in Iran.

Methods

In this study, all the effort has been made to gather information available on this species throughout its range in Iran. Interview surveys with Department of Environment DoE staff in sand cat habitats were the main source of information. Additionally, biometry records of sand cat specimens were used. Presence records of sand cat in Iran were then incorporated into a GIS map and potential sand cat habitats and information gaps were identified.

For the sand cat, we mainly relied on data approved by hard facts, because this small felid can be easily confused with other smaller cats, particularly wildcat. Thus, records were attributed to two categories of reliability, namely "confirmed" (category C1), and "anecdotal" (category C2). Confirmation of presence based on hard fact data such as available photos or videos, sand cat carcasses or other remains of the species were approved by the authors. Observations by trained persons (e.g. field biologists, skilled rangers and wildlife photographers) were assigned to category 2.

Status and distribution

Misonne (1959) and Harrington & Dareshuri (1976) suggested the possible presence of sand cat in Iran based on its presence in the neighbouring countries such as Turkmenistan in the north-east (Heptner & Sludskii 1972) and Pakistan in the south-east (Roberts 1997). Lay (1967), who collected a large number of mammal species of Iran in an extensive survey, didn't record any sand cats in Iran. Etemad (1985) based on Weigel (1961) reported this species for the first time for Iran near Tehran (probably Kavir National Park NP). But the first picture of a sand cat in Iran was taken in 1985 in Kavir N. P. (Bayat

1985), which is still one of the main habitats of the species in the country. In the past ten years, sand cats have been recorded from several localities in the deserts of central Iran (Ziaie 2008). Also, in the past five years, several photos and video footages of sand cat have been taken by rangers, wildlife photographers and camera traps in the sand cat habitats of Iran.

In this study, we gathered 46 reports of presence for this cat, of which 26 fall within the hard fact C1 category and 20 are from direct observations C2 by experienced people (without hard fact). Most of the direct observations were made in close proximity to hard fact records and generally most of the records are from the central desert of Iran. Based on this information, sand cat distribution in Iran is limited to the desert habitats in the centre, east and south-east of the country (Fig. 4).

Kavir and Touran NPs in Semnan Province, Khaf region in Khorasan Razavi Province, Shaskooh and Mozaffari Protected Areas PAs and Petergan desert in South Khorasan Province, Abbas'abad Wildlife Refuge WR, Anarak and Khur regions in Isfahan Province, Siahkooh NP, Ariz No-Hunting Area and Eskanbiloo regions in Yazd province and Samsouri desert in Sistan & Baluchistan Province are the areas where sand cats have been recorded by hard fact data so far.

Nowell & Jackson 1996 based on Groves 1990, indicated Moteh WR in Isfahan Province as a sand cat record, but we didn't find any evidence supporting this information. Also, the picture of a small cat from Bakhtegan NP in Fars Province, which was identified as a sand cat (Ziaie 2008), was later identified as a sub-adult wildcat.

Based on the distribution map that is presented in this paper, most of the sand cat records (more than 90%) are located in central and eastern Iran. This does not mean that these areas are more suitable habitats for this species than other desert habitats, but because they have been more studied than others. The observation of three sand cats in one night survey in Samsouri desert in south-eastern Iran (M. Mousavi, pers. comm.) indicates that good potential habitats are in the vast desert habitats around Dasht-e-Lut (Lut desert) in south-eastern Iran (Fig. 2). Other parts of the country that should be investigated are the following desert areas: Iran-Turkmenistan (Turkmen Sahra and Sarakhs region) border in the north-east, the Iran-Pakistan border in the south-east and the Dehloran Desert in the south-west of Iran neighbouring Iraq.

Felis margarita

Names:
گربه شنی Gorbe sheni
sand cat, sand dune cat

Head and body length:
45-57 cm
Tail length:
28-38 cm
Weight:
1.5-3 kg

Iranian Population:
N/A

Habitat in Iran:
Found in deserts and steppes. It is also adapted with very hot and dry areas and sand dunes.

IUCN Red List:
Least Concern (2016)
CITES:
Appendix II

Photo M. R. Besmeli

Body measurements

The mean, maximum and minimum of head and body length, tail length, shoulder height and weight of 17 specimens (carcass or live from 2001 to 2012) from Abbas'abad WR (n = 14) in the centre, Qaeen and Khaf regions (n = 2) in the east and Samsouri desert (n = 1) in the south-east of the country are 47.3 cm (39-56 cm), 26.7 cm (21.5-32 cm), 26.5 cm (20-30 cm) and 2.56 kg (1.6-3.1 kg), respectively (Table 1).

Habitat and extension

Sand cats are specialists of sandy deserts, where they are unevenly distributed, localised around sparse vegetation, which can support small rodent prey. They are also found in stony deserts (Nowell & Jackson 1996), but they are absent from areas where the soil is compact (Heptner & Sludskii 1972). With thickly furred feet, the sand cat is well adapted to the extremes of a desert environment, living in areas far from water, and tolerant to extremes of hot and cold temperatures (Nowell & Jackson 1996, Sunquist & Sunquist 2002, Sliwa 2013), largely because of their fossorial (burrowing) behaviour. In Turkmenistan, it has been described as inhabiting sand dune areas or in saxaul *Haloxylon ammodendron* forests (Ognev 1935) but in Arabia, it has also been found in stony deserts (Harrison & Bates 1991). Sand cats can withstand 40° Celsius in summer (80° C at the surface of the sand) and -25° C in winter in Central Asia (Aulagnir et al. 2009).

In Iran, the species has been seen in desert habitats, from sand dunes with little plant distribution to arid flat plains with

Fig. 2. Sand cat pictured in south-eastern Iran (Photo M. Mousavi)..

Fig. 3. Sand cat picture from Eastern Iran (Photo M. R. Besmeli).

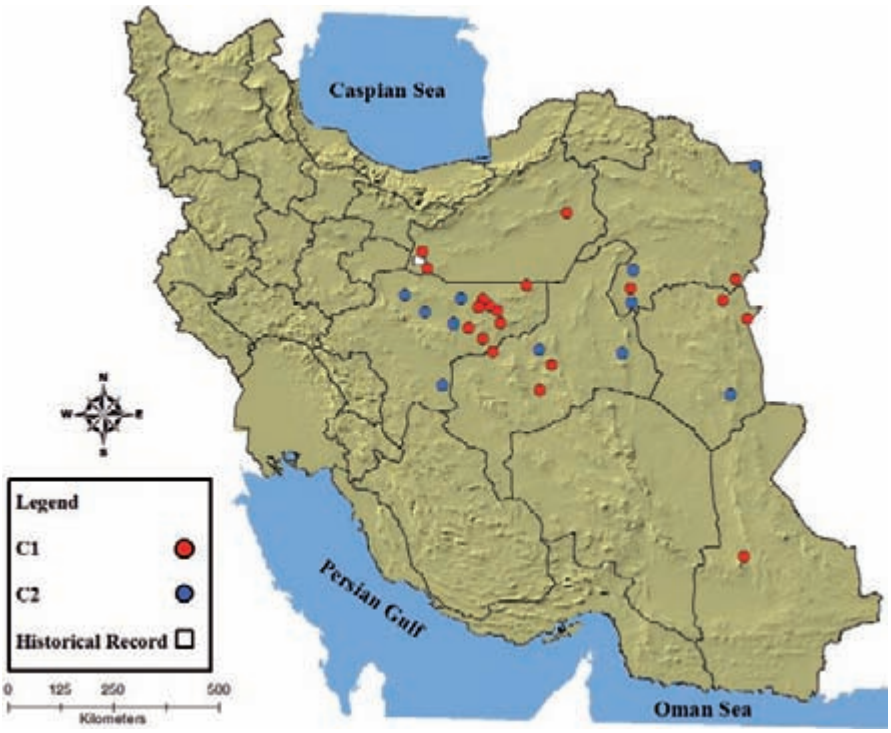

Fig. 4. Distribution of Sand cat in Iran (Historic (30 year ago) and C1 and C2).

vegetation cover consisting of *Artemisia* sp., *Zygophyllum* sp. and *Haloxylon* sp. In Abbas'abad WR, six patches of sand cat distribution have been identified, mainly consisting of sandy plains with abundant Saxaul trees (Farhadinia et al. 2008). However, in Kavir NP, most of its records are in arid flat plains and others in sandy desert, but in Petergan desert, sand cats are observed in sand dunes with Saxaul trees.

Ecology and behaviour characteristics

The sand cat is the only felid to occur exclusively in desert habitats (Macdonald et al. 2010). It is solitary and primarily nocturnal. The sexes come together only for mating. The sand cat is not a good climber or jumper, but an excellent digger. The claws do not fully retract and are rather blunt; possibly due to the sand cat's digging behaviour. It uses this digging ability to dig burrows to escape the heat of the day. The burrows are shared with other individuals, but not simultaneously. Gestation varies between 59-67 days, and in the Sahara the young are born from January to April (Sliwa 2013). The number of kittens is reported to be 2 to 4 per litter. Kittens' eyes open around the 14th day, and they begin to walk at the age of 21 days, and they emerge from the burrow and begin to dig for food when they are five weeks old. They stay with their mother for four months, when they learn to hunt for themselves (Heptner & Sludskii 1972, Nowell & Jackson 1996, Sliwa 2013).

The reproduction of the sand cat is still little studied in Iran. Based on some observations and documents (video and photos) females with cubs have been observed from April to June (Fig. 5). A female with three cubs has been recorded in Naybandan WR (Ziaie 2008) and three kittens about one month old with their mother were found in a burrow in June 2010 in Petergan desert (A. Talebi-gol, pers. comm.). In Kavir NP rangers have taken photos of a young (but independent) sand cat in spring 2010. The sand cat population was believed to be stable in the past decades; however, its population in Iran has not been studied comprehensively. In central areas, it is known that a relatively good population of sand cats live in Abbas'abad WR and Kavir NP, which need to be further studied in the future.

Prey species

Sand cats cover their scats with sand, making diet studies difficult (Macdonald & Loveridge 2010). The only scats found by Abbadi (1993), contained the remains of Cairo spiny mouse *Acomys cahirinus* and gecko S*tenodactylus* spp. Sand-dwelling rodents make up the majority (65–88%) of stomach contents from carcasses collected in Turkmenistan and Uzbekistan in the 1960s (Mallon et al. 2011). Sand cats have also been observed hunting birds and reptiles (Abbadi 1993) and drink water readily, but can survive on metabolic water (Sliwa 2013).

Hotson's Jerboa *Allactaga hotsoni*, Blanford's Jerboa *Jaculus blanfordi*, Cheesman's Gerbil *Gerbillus cheesmani* and Libyan Jird *Meriones libycus* are the main rodents present in the sand cat habitat in Iran. Additionally, hare *Lepus* sp., several reptile species and some bird species, like hoopoe lark *Alaemon alaudipes*, desert lark *Ammomanes deserti* and crested lark *Galerida cristata* share the same habitat and are potential prey.

Harvest and threats

Habitat degradation by human settlement and activity, especially livestock grazing, introduction of feral domestic dogs and cats and killing in traps laid out by inhabitants of oases targeting foxes and jackals are considered as main threats for sand cats (Mallon et al. 2011). The sand cat is not harvested in Iran and is therefore not threatened by exploitation. However, the major threats to survival of sand cats are the persecution by shepherd dogs and to be killed in traps used for capturing houbara bustard *Chlamydotis undulate*. Because herds of livestock present in and around sand cat habitat, this species has been reported to get injured or killed by shepherd dogs. In Petergan desert, sand cats have been observed, trapped and killed by local poachers (A. Talebi-gol, pers. comm.). Also, there is a report of road accident in South Khorasan Province. Sand cat habitat in Iran is located in desert areas with low human activities, thus less habitat destruction can be observed than in other regions. However, an increasing trend in unorganized and unsupervised desert safaris in Iran may become a potential threat to the existence of sand cats in fragile desert habitats.

Table 1. Biometric information on Sand cats from Iran.

	Male			Female		
	Mean	**Range**	**Sample size**	**Mean**	**Range**	**Sample size**
Head and body length (cm)	47.7	41-53	7	46.9	39-56	9
Tail length (cm)	28.1	23-32	7	25.5	21-30	9
Shoulder Height (cm)	27.4	23-29	7	26.0	23-30	8
Weight (kg)	2.8	2.5-3.1	6	2.3	1.6-2.6	6

Conservation

The sand cat is globally classified by IUCN as Least Concern LC due to concern over potential low population size and decline (Sliwa et al. 2011) and also vulnerable arid ecosystems are being rapidly degraded by human settlement and activity, especially livestock grazing (Macdonald & Loveridge 2010). Hunting of this species is prohibited in Algeria, Iran, Israel, Kazakhstan, Mauritania, Niger, Pakistan and Tunisia (Nowell & Jackson 1996). The sand cat is included in the CITES Appendix II. The Iranian DoE lists this species as "Endangered" and poaching fine is 100 m Rials (ca. 2500 Euro, 3000 $). Among 12 known areas for sand cats in Iran (C1), five sites are within NPs, WRs and PAs. To avoid trapping and persecution of sand cats by dogs in their habitat, training of livestock herders is a major activity for conservation of this elusive cat in Iran. Also, for better conservation actions, more fine-scale distribution studies especially in eastern and south-eastern parts of the country are required. Diet and estimation of home range size and density of sand cats in Iran are also interesting fields for research on this species in the future.

Fig. 5. Two sand cat cubs in Petergan desert, Eastern Iran (Photo E. Ghazanfari).

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The status of wildcat in Iran - a crossroad of subspecies?

The wildcat *Felis silvestris* is one of the least-known felid species of Iran with limited information on its taxonomy, distribution, ecology and threats available. In this paper, for the first time we conducted a review on the literature and other available resources to create baseline information for future research and conservation. Also, we gathered recent records of wildcat presence from across the country. By analysing 57 images of this species, contrary to earlier beliefs, wildcat in Iran appears to solely belong to the Asian (*ornata*) subspecies. However, future genetic analyses are essential to backup this finding and to clarify the taxonomic status of wildcats in south-west Asia. Wildcat was recorded in 27 out of 31 provinces of Iran, in a variety of natural habitats to the vicinity of human landscapes, except for extremely high altitudes or deserts. Two newly established provinces (Alborz and Qom) are suspected to have wildcat populations, but lacked any reports. However, there have been no historical or recent records from Gilan and Mazandaran Provinces, which are mainly covered by the Hyrcanian forests. The reason behind such distribution pattern requires further investigations. Road accidents, poaching as a retaliatory action against poultry depredation and by-catch in illegal snares are the main reported threats to the existence of wildcats in the country. Potential threats from shared diseases and hybridisation with domestic cats are unknown and needs further research.

We conducted a review on the status, distribution and ecology of wildcats in Iran by using scientific and grey literature, information databases, IUCN/SSC Cat Specialist Group library, websites and technical reports to create baseline information for future research and conservation. Also, we gathered recent records of wildcat presence from provincial offices of Department of Environment DoE and conservation projects throughout the country. We collected wildcat images from biologists, DoE officers, rangers, camera trapping projects, wildlife photographers, zoos and museums for identification of subspecies existing in Iran by comparison of coat patterns. Also, images of wildcat from neighbouring countries (Armenia, Azerbaijan, Iraq and Turkey) were gathered. The images were then cross checked with a number of researchers specialized in wildcat biology and coat patterns (U. Breitenmoser, A. Kitchener & N. Yamaguchi pers. comm.). Only photos of wildcat taken far from human landscapes were taken into account to reduce the chance of making any false judgments based on feral or hybrid individuals.

Fig. 1. An Asiatic wildcat from Naeen, Isfahan Province. (Photo Hossein Akbari).

Description

The wildcat, which is known to be the ancestor of domestic cats, is classified as a polytypic wild species with up to five interfertile subspecies in Asia, Europe and Africa (Driscoll et al. 2007). There is no agreement on how to relate geographical variations to the morphology and genetics of wildcat to its taxonomy and systematic (Kitchener & Rees 2009). The situation is also confusing in Iran, since it is located at a crossroad of distribution ranges of up to three different subspecies of wildcats: African *F. s. lybica*, Asian *F. s. ornata* and European *F. s. silvestris* (Driscoll et al. 2007). Wildcats of Iran are suggested to have different coat patterns, categorising them into different subspecies in the past (Ziaie 2008). However, in this paper for the first time, the status of wildcat in Iran has been reviewed systematically and by comparison of 57 images of wildcats from across the country, they all morphologically appear to belong to the *ornata* subspecies or Asiatic wildcats (U. Breitenmoser, A. Kitchener & N. Yamaguchi pers. comm.). This is contradictory to the latest mtDNA genetic study by Driscoll et al. (2007), which had considered the Asian subspecies to extend to the east of the Caspian Sea. However, in that study there were no genetic samples from Iran. Further genetic analyses are essential to backup these findings, to help clarify the taxonomic status of wildcat in south-west Asia.

Wildcat images from Iran show that they have tawny-grey, light grey or sand-coloured pelage, marked distinctly with spots, which is typical for the *ornata* subspecies. They differ from other wildcat subspecies mainly in their black or red-brown spots (Fig. 1). The spots are sometimes fused into stripes (Nowell & Jackson 1996), especially on the flanks. Asiatic wildcats have small body size comparing to the other wildcat subspecies weighing between 3-4 kg, with females smaller than males (Table 1; Nowell & Jackson 1996). They have a long, tapering tail, always with a short black tip, and with spots at the base. The forehead has a pattern of four well-developed black bands. A small but pronounced tuft of hair up to one cm long grows from the tip of each ear. Paler forms of Asiatic wildcat live in drier areas and the darker, more heavily spotted and striped forms occur in

more humid and wooded areas. The throat and ventral surface are whitish to light grey to cream, often with distinct white patches on the throat, chest and belly. Throughout its range the Asiatic wildcat's coat is usually short, but the length of the fur can vary depending on the age of the animal and the season of the year. Compared to domestic cat, Asiatic wildcats have relatively longer legs.

Felis silvestris

Names:
گربه وحشی Gorbe Vahshi
wildcat, wild cat

Head and body length:
45-80 cm
Tail length:
25-38 cm
Weight:
2.5-5 kg

Global Population:
N/A
Iranian Population:
N/A

Distribution in Iran:
Widespread throughout Iran, with limited reports from Caspian forests and arid deserts

IUCN Red List:
Least Concern (2015)
CITES:
Appendix II

Country Red List (or similar listings):
Non-protected species by Iranian Department of Environmentl

Photo S. B. Mousavi

Status, distribution and development of the population

The wildcat has the widest distribution among all the felid family in the world (Macdonald & Loveridge 2010) with the Asiatic subspecies occurring from Iran to India in the south and Mongolia and Russia to the east and north. Some recent discoveries through camera trap photos reveal the presence of the *oranta* subspecies of wildcat in the Caucasus (Armania and Azerbaijan's Nakhchivan), Iraq's Kurdistan and south-east Turkey (Batur Avgan & Igor Khorozyan pers. comm.). Nowell & Jackson (1996) based on Ognev (1930) suggested that the west of Iran and the Caucasus are the transitional zones between the three subspecies of wildcat; however, it appears that the transition line needs to be revised and moved further west.

In Iran, wildcats occupy different types of habitat, almost throughout the country and are only absent from northern Iran (Fig. 2). There is not enough data to clarify whether the distribution range of wildcat has changed dramatically in the past. However, as the wildcat is widespread throughout the country (except the mentioned areas), the range seems not to have been reduced recently. Wildcat occupies the largest range among the felids of Iran. There is no estimate on population size of wildcat in Iran, and it seems that it is present in suitable habitats. There is no information on population trend. However, Ziaie (2008) claims that the wildcat population has declined in most of Iran. Poaching related to livestock predation, road accidents and by-catch in illegal traps are among the main causes of loss in population of wildcat in Iran.

Habitat and extension

From arid plains to lush forests, coastal areas and mountains to vicinity of human landscapes, wildcats occupy different habitats (Firouz 2005), except for extremely high altitudes or deserts of Iran. However, from the gathered data through this research, wildcat appears to be absent from the Hyrcanian (Caspian) forests of Gilan and Mazandaran Provinces in the north of Iran. There is no recent report of this species in the area and historical data are also lacking. Surprisingly, wildcat is present in Golestan National Park NP and further west in Golestan Province, which is the easternmost extent of the Hyrcanian forests (Fig. 3). The reason behind such a distribution pattern needs further investigation. It has been suggested that competition with jungle cat *Felis chaus* in the Caspian forests is the cause of absence of this species in this highly productive forest habitat of northern Iran (B. Nussberger, pers. comm.). However, jungle cat is also present in Golestan NP and the rest of Golestan Province. Wildcat coexists with high number of other predator species in a variety of habitats (e.g. brown bear *Ursus arctos*, leopard *Panthera pardus*, cheetah *Acinonyx jubatus*, wolf *Canis lupus*, etc.). There is not much understanding of the role of these species in regard to the distribution pattern of wildcat in Iran.

Wildcat presence has been confirmed in 27 out of 31 Provinces of Iran with possible occurrence of wildcat in the two newly established Provinces Alborz and Qom (Fig. 4). Presence of wildcat in the remaining two Provinces, Gilan and Mazandaran, is doubtful and needs further research (see above). Wildcat can be found up to an elevation of 2,000-3,000 (Heptner & Sludskii, 1992). Because of the wide range of wildcat habitats in Iran, it is difficult to identify a prime habitat for this species in the country. It has been reported from 39 of the 140 reserves of DoE (Darvishsefat 2006). However, it is likely that they have been overlooked in many reserves. Because of its plasticity in habitat preference, it appears that slight habitat changes might not influence the survival of this species. Wildcats are often reported in the vicinity of human landscapes throughout Iran, depredating on domestic poultry (Etemad 1985).

All the wildcat photos from the different Provinces of Iran gathered through this research

Table 1. Biometric information on wildcats in Iran.

Body part	Sample size	Average length (range) cm
Head and Body	12	66.5 (45-80)
Tail length	12	29.9 (25-32)
Foot	3	12.7 (12-14)
Ear	3	6.0 (5.5-6.5)

have been identified as belonging to the *ornata* subspecies. The taxonomic status of wildcats in Iran may also justify the absence of this species in lush Caspian forests, as the Asiatic subspecies (Asiatic steppe cat) is commonly a steppe-dweller (Kitchener & Rees 2009).

Ecology and behaviour characteristics

Ecological aspects of the wildcat have not been studied in Iran. General ecological information on this species can be derived from other studies throughout its range. Wildcat hunts solitarily, is active at day and night and lives in borrows of other species (Novikov 1962). They have been observed frequently in the daytime and appear to be highly territorial (Heptner & Sludskii 1992). Female home ranges vary with habitat, from 52.7 km^2 in the United Arab Emirates (Phelan & Silwa 2005) to 1-2 km^2 in France and Scotland (Stahl et al. 1988, Macdonald & Loveridge 2010). However, there is no original ecological data on this subspecies throughout its range.

Mating season has been reported in various months of the year for Asiatic wildcat (Nowell & Jackson 1996). The gestation period is 58-62 day with a mean litter size of 2.75 (Nowell & Jackson 1996). Life span in captivity is 15 years (Ziaie 2008).

Prey species

The diet of the wildcat hasn't been studied in Iran and because of wide variety of habitats for wildcat a high plasticity in prey choice of this species is expected. From studies of wildcats in other parts of its range, rodents are considered as the preferred prey: members of Dipodidae (jerboas) and Muridae families (gerbils Gerbillinae, voles Arvicolinae, and mice Murinae; Heptner & Sludskii 1992) making up to 81% of its diet (Novikov 1962). The diet also includes hares, young ungulates, birds, insects, lizards and snakes (Heptner & Sludskii 1992). During the years with decline in rodent numbers, diet constitutes of insects, reptiles and even vegetables. They are frequently reported to raid poultry farms in different parts of Iran (Etemad 1985).

Fig. 2. A camera trap photo of an Asiatic wildcat in steppes of Touran Biosphere Reserve (Photo Persian Wildlife Heritage Foundation).

Fig. 3. A camera trap photo of an Asiatic wildcat in the Hyrcanian forest of Golestan National Park. (Photo Plan for the Land Society).

Collections

This species can be found in several private and governmental museums of the country, namely in Haft-Chenar, Tandureh National Park, Shiraz Natural History, Sabzevar, etc. On the other hand, there is not much data on the presence of wildcat specimens in zoos and private collections in Iran. There is only information on the presence of one wildcat individual in Mashhad zoo. Captive wildcats in Iran are not included in any studbook or breeding programme.

Harvest and threats

There is no legal harvest of this species undergoing in Iran. However, road accidents, poaching as a retaliatory action against poultry depredation and by-catch in illegal traps (mostly for Houbara bustard; Fig. 5 are the main threats to the existence of wildcats in the country. Wildcats also have been reported to get chased and killed by shepherd dogs in different parts of Iran.

Additionally, one of the main global threats to wildcats is their close relative, the domestic cat (Macdonald & Loveridge 2010). Domestic cats can transmit feline diseases to the wild animals, and more importantly, domestic cats cat hybridize extensively with wildcats. Such a threat may result in gradual and cryptic extinction of the wildcats in the wild (Macdonald & Loveridge 2010). Also, it can lead to misidentification of 'pure' wildcats, which make conservation efforts for this species difficult. There is no evaluation of this threat in Iran; however, several records of domestic cats being present in reserves in Iran are available.

Despite documented fur trade of this species in the region, there is no report of such action in Iran, since the pelt of wildcat is not considered of high value. Thus, there is little chance that fur trappers threaten the species.

Current and future protection measures

The wildcat is listed as "Non-Protected Species" by the Iranian DoE laws. The species is the only member of the felid family not listed as "Protected Species" in Iran. Considering the increase in level of threats to wildcats, such exclusion needs to be revised. As of new amendments to DoE laws, illegal killing of wildcat has a fine of ca. 2000 euro (1 euro: Rials 40,000).

The wildcat is generally an overlooked species by most researchers and managers and further efforts must be undertaken to raise awareness on the status and importance of this species. Hybridisation is a threat that can confuse scientists and decision-makers in how to distinguish between wild, feral and hybrid cats and this can reduce the conservation efforts for this species. Level of hybridisation needs to be evaluated as one of the priority conservation measures for wildcats in Iran. Regarding poaching, there is a need to educate farmers on the significance of wildcats and introduce them to methods to prevent wildcat attacks on poultry. Finally, there are a number of ecological and taxonomic questions regarding wildcats in Iran, which need further investigations.

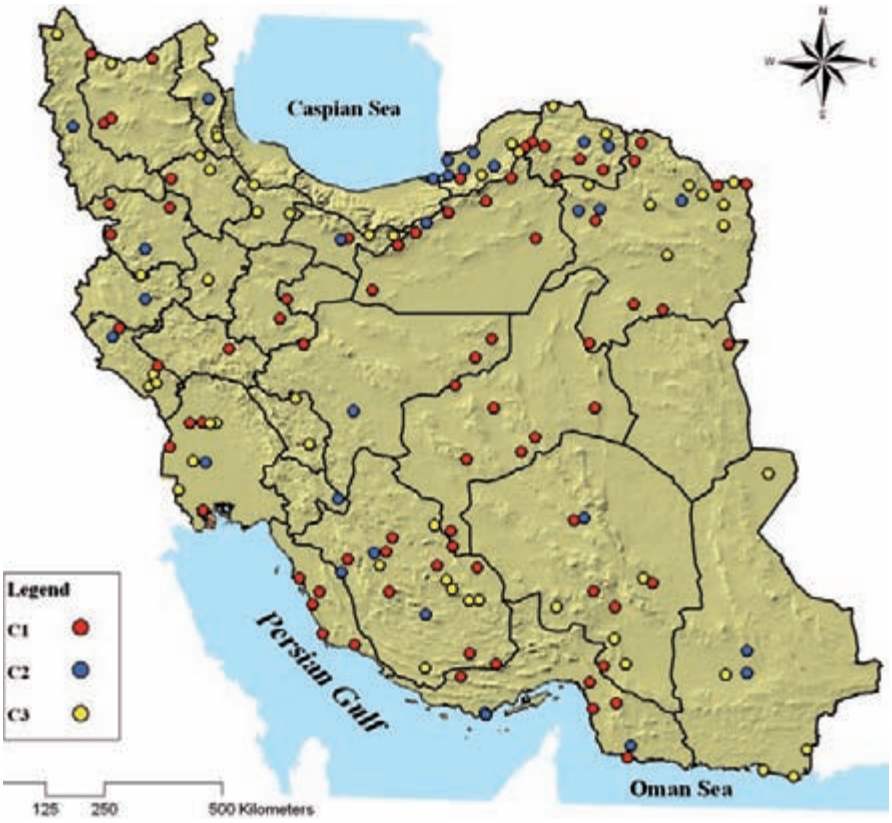

Fig. 4. Distribution of wildcat records in Iran.

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Fig. 5. A wildcat captured in a Houbara bustard trap in Southern Khorasan Province. (Photo M. Besmeli).

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