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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 December 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

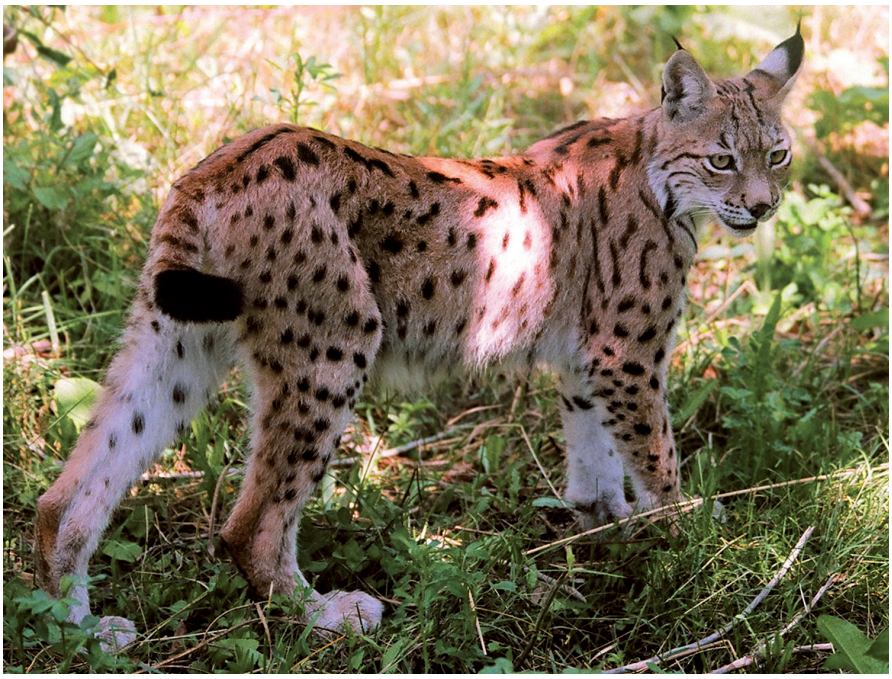

Fig. 1. A free-ranging human-habituated lynx photographed in Sarab, East Azarbayjan Province in 2003 (Photo F. Heidari).

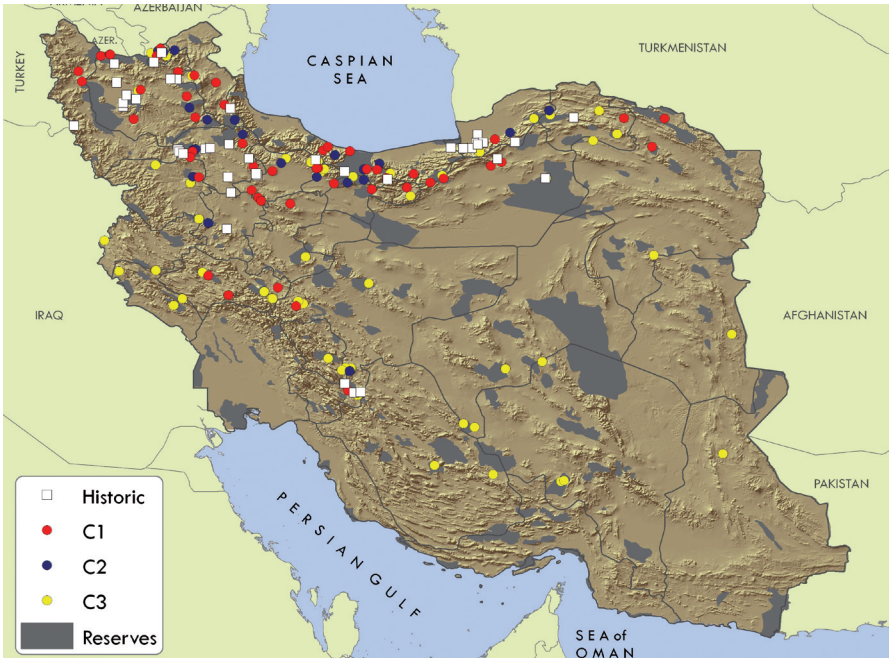

Fig. 2. Distribution of historic (<2000) and present (≥2000) observations of the Eurasian Lynx in Iran. White square: historic occurrence; red dot: C1; blue dot: C2; yellow dot: C3.

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 Caucasus are considered as crucial habitats for the species (Moqanaki et al. 2010). How-

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 (Ziaie 2008)
Tail length:
11-24cm
Weight:
18-38 kg

Global Population:
unknown
Iranian Population:
unknown

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

IUCN Red List:
Least Concern (2014)
CITES:
Appendix II

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

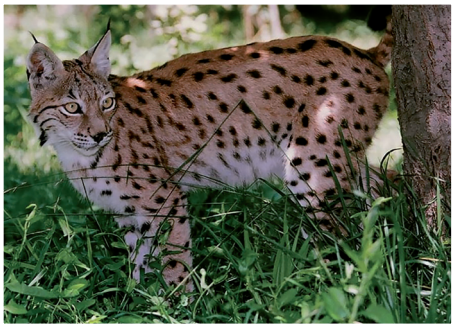

Photo F. Heidari

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).

ever, these landscapes are threatened due to clear-cutting and intensive logging (Sagheb-Talebi 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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