

Short Communication

Exceptionally long movements of the Asiatic cheetah *Acinonyx jubatus venaticus* across multiple arid reserves in central Iran

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Abstract Understanding spatial ecology is essential for the development of effective and appropriate conservation strategies, especially for the Asiatic cheetah *Acinonyx jubatus venaticus*, which occurs at a low density across vast arid areas of Iran. Yet, despite its Critically Endangered status, information on the ranging and movement of this species was formerly lacking. Here we present data for exceptionally long movements of a few individuals across multiple reserves in central Iran, obtained using camera traps during 2009–2013. We identified an adult female who moved c. 150 km multiple times between two reserves in 3 years, covering an estimated 3,629 km². After becoming independent her three sons formed a coalition and ranged across multiple reserves, covering an estimated 4,862 km² in their first 3 years. An adult male was also found patrolling three reserves, moving up to 40 km across an estimated 807 km². These data demonstrate that cheetahs in Iran cover vast ranges, and indicate a requirement for large, connected areas for the long-term conservation of this metapopulation.

Keywords *Acinonyx jubatus venaticus*, Asiatic cheetah, camera trapping, Iran, ranging pattern

The Asiatic cheetah *Acinonyx jubatus venaticus*, categorized as Critically Endangered on the IUCN Red List (Jowkar et al., 2008), formerly occurred across west and south Asia (Caro, 1994). In Iran, however, relatively few individuals of this subspecies have been recorded in the last 3 decades (Farhadinia, 2004). Monitoring and estimation of population size are essential for conservation of the Asiatic cheetah but the species is difficult to monitor because it uses

large ranges, is shy and elusive, and occurs at low densities (Hunter et al., 2007). Camera traps are useful for studying cryptic species (Balme et al., 2009), including cheetahs, because individuals can be recognized from their unique spot patterns (Caro, 1994). However, despite regular application of this technique for large carnivores (e.g. Karanth et al., 2004; Balme et al., 2009) it has been rarely used for cheetahs, except in southern Africa (Marnewick et al., 2008; Marker et al., 2008). Problems bedevilling the study of cheetahs with camera traps include their use of large areas of open habitat, which makes it difficult to identify reliable camera-trap sites; other carnivores frequently use trails (Karanth et al., 2004; Balme et al., 2009).

Formerly, there were no data regarding the movement of Asiatic cheetahs in Iran but in 2007 a coalition of two collared males in Bafq Protected Area covered > 1,700 km² in 5 months (H. Jowkar et al., unpubl. data). Here we describe the movements of several individual cheetahs that have been photo-trapped in multiple areas, illustrating the species' ranging activity in Iran and providing an insight into the spatial dynamics of this lesser-known subspecies.

The monitoring programme was conducted across four reserves: Dare-Anjir Wildlife Refuge, Bafq Protected Area, Ariz No-hunting Area and Siah-Kouh National Park and Protected Area (Table 1, Fig. 1). The landscape of these areas comprise arid plains, hilly terrain and rolling mountains. They are predominantly covered with vegetation communities of wormwood *Artemisia sieberi* and bean caper *Zygophyllum* sp. The wild goat *Capra aegagrus* and sheep *Ovis orientalis* are the most common ungulates (at densities of 0.4–1.6 km⁻² and 0.2–0.91 km⁻², respectively) and there are also low numbers of chinkara *Gazella bennettii* (0.02–0.08 km⁻²; Yazd DoE, 2011).

To monitor cheetahs, camera traps were opportunistically deployed between 2009 and 2011, followed by an intensive programme across all areas during winter–spring 2011–2012, and then continued extensively until January 2013. Multiple camera brands were deployed, mainly CamTrak (CamTrak South Inc., Watkinsville, USA), Panthera (New York, USA), and Cuddeback Capture (Green Bay, USA). Camera locations were along dried watercourses or signing posts, where cheetahs regularly visit

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TABLE 1 Characteristics of the four study areas in central Iran (Fig. 1).

Reserve name and category	Area (km ²)	Year of establishment	Other confirmed sympatric large predators
Siah-Kouh National Park & Protected Area	2,057	2001	Grey wolf <i>Canis lupus</i>
Dare-Anjir Wildlife Refuge	1,753	2002	Striped hyena <i>Hyaena hyaena</i> (rarely)
Ariz No-hunting Area	1,313	1999	Persian leopard <i>Panthera pardus</i> (occasionally)
Bafq Protected Area	885	1996	Persian leopard

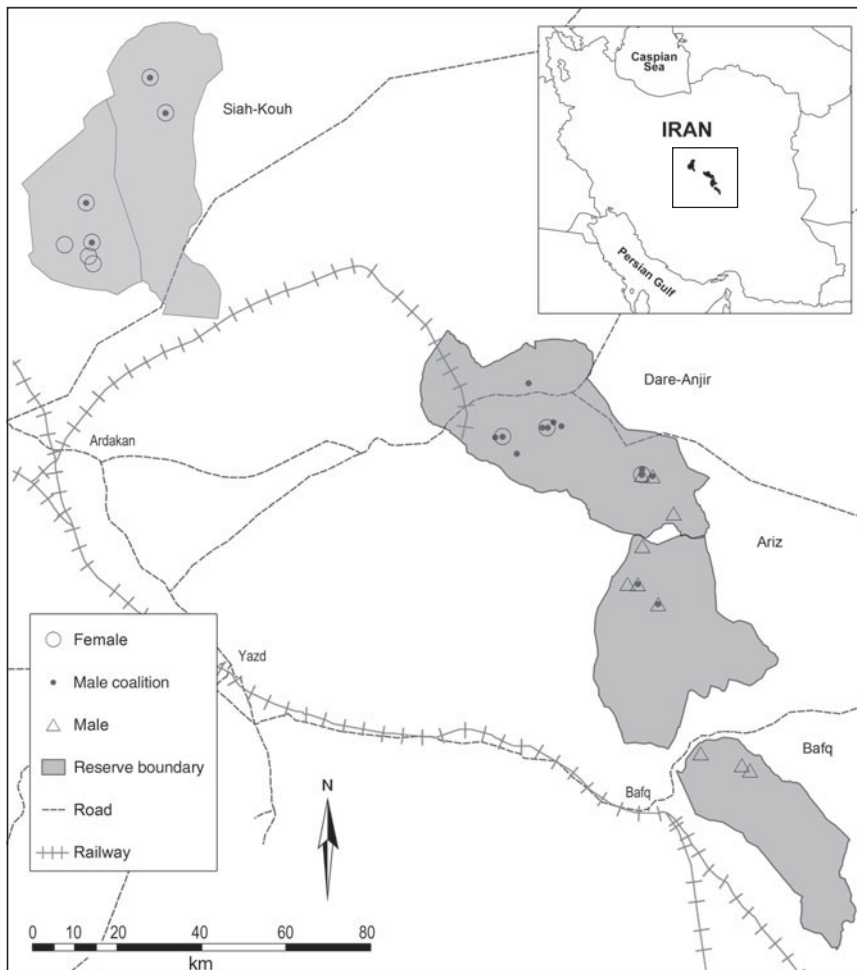


FIG. 1 The locations, recorded by camera traps, of the adult female Asiatic cheetah *Acinonyx jubatus venaticus*, the coalition of three young males (her sons), and the adult male across four arid protected areas (Table 1). The rectangle on the inset indicates the location of the main map in central Iran.

for scent marking. Individuals were identified using comparison of spot patterns, and sexed and aged. Presence data were plotted using *ArcMap v. 9.3* (ESRI, Redlands, USA) and the minimum area covered was calculated as the area confined within the outer camera-trap stations.

In 2009 an adult female was photo-trapped twice in Dare-Anjir Wildlife Refuge: in September and then in November c. 25 km further south. In June 2010 she was photographed c. 150 km away, with three cubs, in Siah-Kouh National Park, which was established in 2001 to safeguard the cheetah and its prey. As the cubs were small when they were first seen (> 4 months) it is likely they were born in the Park. The family was seen by game wardens on several

occasions up to February 2011, when the mother, with one of her juveniles, was photo-trapped.

In August 2011 camera-trap photographs revealed that the female and three siblings, all males, had returned to Dare-Anjir. The female was not camera-trapped again until late February 2012, when she was photographed alone in Siah-Kouh, indicating that after her sons became independent she returned from Dare-Anjir (Fig. 1), thus covering an area of at least 3,629 km². Meanwhile, the three brothers roamed in a coalition. The siblings, estimated to be c. 20 months old in January 2012, showed regular marking behaviour, mainly through urinating at sign posts. Camera-trap photographs indicated that they roamed Dare-Anjir until the end of February 2012 and then headed south

towards Ariz No-hunting Area. Until February 2013 the three males roamed Dare-Anjir and Ariz, which are contiguous, covering a total of c. 4,862 km² (Fig. 1) between their birth and 3 years of age. They could also have roamed in areas in which camera traps were not deployed, and thus it is possible that they ranged further.

An adult male was photo-captured in summer 2010 in eastern Dare-Anjir, repeatedly visiting most of the camera-trapped signing posts, indicating that he was a territorial male (Caro & Collins, 1987). Until the end of 2011 he was present in most camera-trap photographs in Dare-Anjir. However, he was highly mobile. During 2012 he regularly moved from Dare-Anjir through Ariz to Bafq and vice versa (a distance of c. 40 km; Fig. 1), with a minimum range of 807 km².

These camera-trapping data indicate that these five cheetahs ranged across multiple reserves in central Iran, some of which are geographically separate. The female crossed two roads, Ardekan–Choupanan and Yazd–Tabas (once accompanied by her three sons). An adult male was killed on the latter road in May 2011 (Yazd DoE, 2011). The single male that was photo-trapped in multiple reserves also regularly crossed the Bafq–Koushk road, on which a female was killed in November 2005 (Yazd DoE, 2011). The reason for such long movements, particularly out of the well-established Dare-Anjir Wildlife Refuge, through vast deserts that have depleted prey and poor security, is unclear. The ranging of these cheetahs across multiple areas supports the hypothesis that Iranian cheetahs have extremely large home ranges (Hunter et al., 2007).

In the Serengeti resident males are known to occasionally travel up to 30 km from their territory (Caro & Collins, 1987). A female was found c. 100 km from her territory in Namibia, where cheetahs roam extensively across large home ranges (Marker, 2003). Females tend to roam over larger ranges than males (Caro, 1994; Marker, 2003). The long-distance movements of cheetahs elsewhere, particularly of females, have been attributed to seeking out migratory prey (Caro, 1994). However, even in Namibian bush-encroached farmlands, with a non-migratory prey base, both sexes and all social groupings range extensively (Marker, 2003). We have no evidence of ungulate migration between the four protected areas in central Iran. However, patches of widely dispersed habitat that maintain essential resources, particularly medium-sized prey, can result in a large home range (Bissett & Bernard, 2006). It is likely that low prey density, which could be related to poor vegetation cover in this arid climate, and to poaching, could trigger the lengthy movements of the Asiatic cheetah in Iran.

In Africa, mobility has been suggested to be the key to the coexistence of cheetahs with larger predators, particularly lions *Panthera leo* and spotted hyenas *Crocuta crocuta*, where kleptoparasitism occurs (Durant, 1998). Therefore, by constantly moving, cheetahs may be able to avoid their main

competitors, facilitating coexistence (Pettorelli et al., 2009). In Dare-Anjir, where all five individuals were recorded, there is no evidence of the presence of other large carnivores. However, a collared male cheetah was found dead in Bafq in June 2007, supposedly killed by a leopard while on a wild goat kill (H. Jowkar et al., unpubl. data). The presence of leopards could cause cheetahs to spend relatively less time in this protected area.

The high mobility of the Asiatic cheetah across multiple areas suggests that this subspecies would best be managed in a metapopulation framework across connected areas. Irrespective of the reasons for movement, conservation of the cheetah, with its typically large home range, requires large tracts of suitable habitat, and this requirement will often compete with other forms of land use (Bissett & Bernard, 2007), particularly outside protected areas. The inadequate size of many protected areas means that effective management outside formally protected areas is of paramount importance for conservation of the cheetah (Muntifering et al., 2006). Any development plans should therefore be carefully considered by the Iran Department of Environment, to prevent or mitigate potential adverse effects on the connectivity of protected areas. Understanding the factors influencing the spatial ecology of the cheetah in Iran is fundamental to developing effective and appropriate regional conservation strategies for this subspecies, and smaller reserves, particularly Dare-Anjir, are ideal sites to implement telemetry studies of movement. Our findings indicate the likelihood of transboundary movements by the cheetah and could therefore be of value for conservation of the subspecies in neighbouring countries, particularly Turkmenistan, Afghanistan and Pakistan.

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