



Cheetah (*Acinonyx jubatus venaticus*) (Felidae: Carnivora) feeding ecology in Central Plateau of Iran and effects of prey poor management

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Received: 26 September 2018 / Revised: 3 November 2018 / Accepted: 6 November 2018 / Published online: 9 November 2018. Ministry of Sciences, Research and Technology, Arak University, Iran.

Abstract

Asiatic Cheetah (*Acinonyx jubatus venaticus*), as the most charismatic mammalian species of Iran, is faced with a high probability of extinction (CR category) throughout the country. In this study, the species preferred feeding items were investigated based on collected scats across the extra-arid habitats of central Iran. The scat samples were collected during 2015-2016 from Dareh-Anjir wildlife refuge located in Yazd province. All collected samples were examined based on standard protocols and all their animal remaining such as hairs were used to the identification of the prey items which used by the species. Our findings based on scats analysis indicated that Jebeer Gazelles (*Gazella bennettii*), constitute the main preferred feeding item of the Cheetah's population. With regard to the low abundance of this Gazelles in the study area, it looks that lowering prey items induced from poor habitat management during recent decades can be regarded as one the main cause of Cheetahs sever population declining. It seems that large herbivores extirpation from the study area will doom the Cheetahs toward the extinction.

Keywords: Asiatic Cheetah, food preferences, Jebeer, poor prey management, scat analyses.

Introduction

Iran host the last remained populations of the Asiatic Cheetahs as the subspecies has become extinct from other parts of its Asian range (Hunter *et al.* 2007). Asiatic Cheetahs are one of the most critically endangered cats throughout the world which their geographic range has been limited to Iran with lower than 50 individuals (Durant *et al.* 2017). Cheetahs' population in the country is composed of two patches, the northern is located in the northeast, covering Semnan and North Khorasan provinces and the southern one which is dispersed in the central parts of the country including Yazd, Esfahan, Southern Khorasan and Kerman provinces. The northern habitats where constitute of Touran Biosphere Reserve, Miandasht Wildlife Refuge and Kavir National Park, are the most reproductive population areas. The southern habitats including Naybandan Wildlife Reserve, Ravar Wildlife Refuge, Kalmand-Bahadoran Protected Area, Bafgh Protected Area, Siyahkooch National Park, Abas Abad Protected Area, Dareh-Anjir Wildlife Refuge and Ariz No-Hunting Area have been regarded as the core population up to 2010 (Figure 1). In southern habitats, except Naybandan Wildlife Refuge and Dareh-Anjir where a couple of reproducing females as well as a coalition of two male Cheetahs have been recorded (Conservation of Asian Cheetah Project 2016, Nezami 2018), there is no documented record of the species since 2010. Although there are some records from the long commute between Naybandan and Dareh-Anjir (Farhadinia *et al.* 2013), Cheetahs, especially in

the southern habitats, are faced with a critical situation.

Cheetah has a special and narrow feeding behaviour in choosing preys and has mainly adapted to pursuing and hunting gazelles distributed in the plains and foothills (Hayward *et al.* 2006). Although the historical distribution of the Cheetah (Nowell and Jackson 1996) indicated that, it is capable to use various habitats to hunt different prey items (Kok and Nel 2004, Farhadinia and Hemami 2010). However, the main reasons of the subspecies severe population declining can be related to two main factors including extirpation of its main preys like gazelles (Hunter *et al.* 2007; Nezami 2018) as well as habitat loss (Marker and Schumann 1998, Nowell and Jackson 1996, Hayward *et al.* 2006). As a result of these events, the current distributional range of the subspecies is highly fragmented and they compulsorily seek for alternative mountain dwelling preys like wild sheep (*Ovis orientalis*) and wild goats (*Capra aegagrus*), which are less preferred preys in unsuitable habitats (Hunter *et al.* 2007). Therefore, protection of the Cheetahs main prey is an absolute priority, in order to conserve the Cheetahs viability in their occupied range (Wachter *et al.* 2012).

Feeding behaviour plays a key role in the animal ecology especially in the large endangered carnivore's viability (Hayward and Kerley 2008, Wachter *et al.* 2012). Other dimensions of the animal ecological niche also can be affected by the species feeding behaviour (Sinclair *et al.* 2006). Feeding behaviour is one of the less known aspects of the Cheetahs ecology in Iran, and there is still much debate about the species food preferences among the ecologists and managers regarding the paucity of data obtained from direct observations (Rezaie *et al.* 2016). Such data deficiency has resulted in poor management of the Cheetah's habitat and preys, as gazelles have become rare and endangered at present (Hemami and Groves 2001). Urgent prey recovery programs is essential to achieve the

Cheetahs viability and survival (Hayward and Kerley 2008).

The study is about Cheetah prey preferences (Hayward *et al.* 2006) and the effects of prey declining on Cheetahs' population viability. We focused on Dareh-Anjir Wildlife Refuge as our study area because of two main reasons: this area constitute core area of the Cheetahs southern range and also can be regarded as the most important corridor, where almost all Cheetahs observed in the surrounded habitats have been already recorded in the study area (CACP 2008, 2010, Ahmadi *et al.* 2017, Nezami 2018). We also aimed to test if wild sheep and wild goats are the main preferred prey items used by Cheetahs in all habitats of the country as the previous investigations said (Hunter *et al.* 2007, Farhadinia *et al.* 2013)?

Material and methods

Study area

Dareh-Anjir Wildlife Refuge covering an area of 175302 ha located in Yazd Province has been recorded as a protected area since 2002 to conserve rare mammals such as Jebeer, Wild goats, Wild sheep and Cheetahs (Figure 1) (Table 1). The mean annual temperature and precipitation of the study area is 15.5 °C and 75 mm respectively which has caused an extra-arid climate (Darvishsefat 2006). We relied on the data about the ungulates abundance throughout the study area in October 2015 which has been recorded during the seasonal wildlife census by the local authorities. These data usually recorded by the authorities using distance methods, mainly point and line transects relative to the type of the habitat Ungulates were classified according to the sex and age at the time of observation in the census forms (Yazd Dep. of Environment 2015).

Except common fox (*Vulpes vulpes*), caracal (*Caracal caracal*) and Cheetahs there is no other large resident carnivores in the study

area. Dareh-Anjir Wildlife Refuge can be regarded one of the most few areas for Cheetahs as there is no record of other large competitors like grey wolf (*Canis lupus*), Persian leopard (*Panthera pardus saxicolor*) and striped hyena (*Hyena hyena*), based on camera trapping data (CACP 2008, Sarhangzadeh *et al.* 2013, Akbari *et al.* 2014, Iranian Cheetah Society 2014). Hence, this makes Cheetah get rid of the competition and losing their preys because of kleptoparasites presence (Kruuk 1972, Schaller

1972). The landscape is now dominated by vegetation consisting mainly of *Artemisia sieberi*, *Zygophyllum eurypterum*, *Astragalus myrianthus*, *Seidlitzia rosmarinus*, *Haloxylon persicum*, *Tamarix* sp. and *Calligonum comosum* (Darvishsefat 2006, Sarhangzadeh *et al.* 2013). No conflict has been reported between local villagers, domestic animals and carnivores in the study areas (CACP 2008, 2010, Yazd Dep. of Environment 2015).

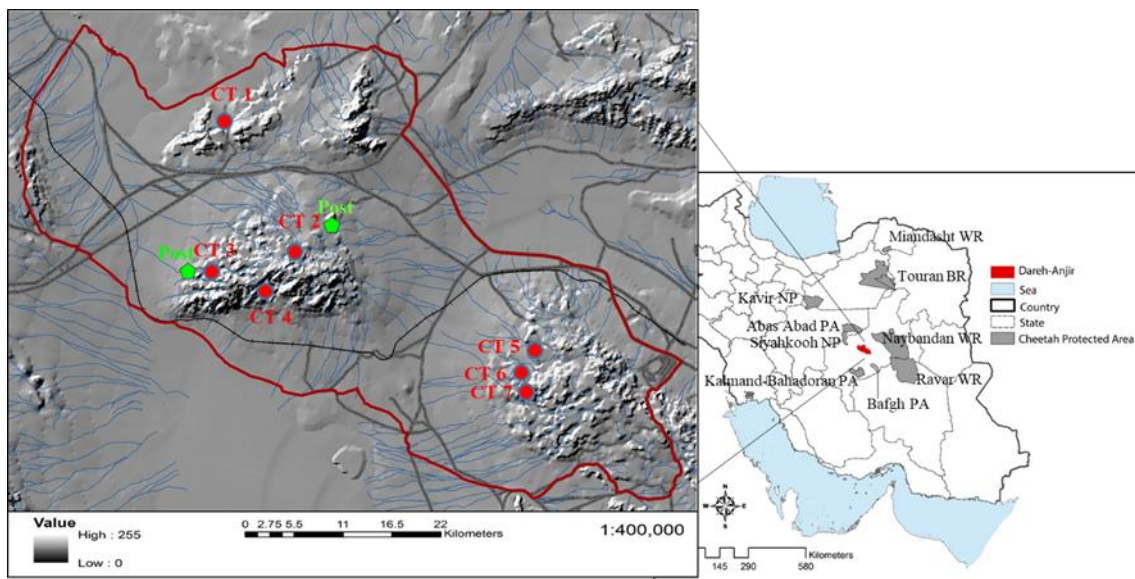


Figure 1. Cheetahs preferred habitats as well as our study area, Dare-Anjir Wildlife Refuge.

Table 1. Ungulate census data in October 2015 (after Yazd Dep. of Environment, 2015).

Area	Extent (ha)	Jebeer	Wild Sheep	Wild Goat	Sum
Dareh-Anjir	175302	60	356	620	1036

Scat collection

Field surveys for systematic scat collection were carried out in Dareh-Anjir Wildlife Refuge during June 2015 to May 2016. We tried to cover the whole study area as much as possible based on a systematic sampling design. Despite the regular searching throughout the year, most of the scats were sampled during summer with just 10 samples found during other seasons. Totally, 35 Cheetah scats were collected, three of them were liquid excrement without any hair and prey remaining. All scats were collected under the Tamarix and saxual

plants usually close to the stony area where used for scent marking (Zamani *et al.* 2017). Although, we used protocols to distinguish Cheetahs scats from other potential carnivores which are based on appearance and size of the scats (Rezaei 2014, Zamani *et al.* 2017). We also tried to check the animal tracks and activity signs (Marker *et al.* 2003). We deployed seven camera traps, for the duration of the study, mainly in places where Cheetah tracks and activity signs were recorded and then the scat samples were collected (Moreno *et al.* 2006) (Figure 1). Moreover, Cheetah's scats were

contained its hair due to the animal grooming behaviour which much helped to distinguish the samples (Marker et al. 2003). All collected samples sealed in plastic bags and labelled with the date and location of collection).

Laboratory analyses

Before washing the samples using a fine mesh, all scats were put in hot water for five days to remove oil and then we separated hairs, bones, teeth, hooves and nails to identify the prey items (Rezai 2014). We separated randomly 20 strand of hairs of each scats sample for at least four slides (Farhadinia et al. 2012, Sharbafi et al. 2016). All slides examined at 10x and 40x magnification using a Nikon microscope in the Collage of Environment (CoE) laboratory. Hair strands medulla and cubicula structure compared with already known hair samples obtained from prey species in rehabilitation centers while referring to the identification protocols (Rezaei 2014, Debelica and Thies 2009). Three of scat samples were set aside because of failing in the exact identification of the content).

Data analysis

We determined frequency of occurrence, corrected-frequency of occurrence and percentage of occurrence of each prey species, because of the tendency to overestimate the importance of smaller items (Floyd et al. 1978, Farhadinia et al. 2012). Percentage of prey items occurrence is a common indicator for investigating carnivores feeding habits, and the more food items can be found in the scats the more accurate results will be expected (Loveridge and Macdonald 2003). Finally, prey preference was estimated using Jacobs's selectivity index (Hayward and Graham 2005). Frequency of occurrence can be simply used by the following formula (Farhadinia and Hemami 2010): $FO_i = (n_i/N)*100$

Where FO_i indicates percent of Frequency of occurrence, n_i is the number of given prey were hunted and N is the total consumed preys (Klare et al. 2011).

Percentage of occurrence shows the number of

times which a specific item was found (as a percentage of all recorded items) for each prey species (Ciucci et al. 1996).

$$PO_i = (c_i/C) * 100$$

Selectivity of Cheetah among the prey species (Prey preference) was assessed by Jacobs selectivity index D (Jacobs 1974). According to the Hayward and Kerley (2005) this index minimizes the problems associated with many other preference indices.

$$Jacobs\ index.\ D = \frac{(r-p)}{(r+p-2rp)}$$

Where r is the proportion of a given prey species and p is its proportion in the free-living population. Jacobs selectivity index ranges from -1 (total avoidance) to $+1$ (completely preferred).

Results

Ten groups of prey items were identified in the examined scats, which summarized in Table 2. We found that large ungulates (percentage of occurrence = 69.43%) and rodents (19.44%) constitute main prey items which consumed by the Cheetahs in the study area. Among ungulates, wild sheep constitute the highest percentage of occurrence (36.11%) while Jebeer were ranked in the second order (percentage of occurrence=30.55%) in spite of being the rarest ungulate species throughout the study area based on census data (frequency of 5.79%). Therefore, it can be concluded that compare to the other ungulates (i.e. wild sheep and wild goats) Jebeers play an important role in the Cheetahs prey selection and preference. Despite the highest ungulates frequency of occurrence (around 59.84%) in the study area, wild goats remaining was found only in one scat sample (Table 2). Rodents remaining were found in the summer-collected scats. While livestock are prohibited to enter to the protected area, we found one scat containing domestic goat hair, which may have been preyed by the Cheetah in the boundary areas. Based on Jacobs selectivity index we found Jebeer receive higher rank ($D=0.85$) comparing to the wild sheep ($D=0.34$). The lowest preference was assigned to the wild goats ($D=-0.94$) in study

area.

Table 2. Frequency of food items in the scats samples of Cheetahs in the study area

Food item	Number	FOi	Corrected FOi	POi
Jebeer	11	37.93	36.20	30.55
Wild Sheep	13	44.82	35.62	36.11
Wild Goat	1	3.44	3.44	2.77
Domestic goat	1	3.44	3.44	2.77
Rodent	7	24.13	13.20	19.44
Hare	1	3.44	3.44	2.77
Insect	1	3.44		2.77
Bird	1	3.44		2.77
Plant material	2	6.89		
Unknown	3			
Empty	3			
analysed scat	29			
Total scats	35			
Total food items	36			

Discussion

Prey dependence

Scat analysis revealed that three ungulates, Jebeer, wild sheep and wild goats, constitute Cheetahs main prey items however, Jebeer and wild sheep are more preferred by this carnivore (Rezaei *et al.* 2016). Predation of wild sheep is according to their distribution in hilly area and their abundance (against wild goat are distributing on mountainous areas) (Hayward *et al.* 2006, Shams Esfandabad *et al.* 2010). African adult Cheetahs weight normally between 30 to 72 kg, which means they need to prey upon large vertebrates (45% of their own body mass) to satisfy their energetic demands (Stuart and Stuart 2000). While according to the data about two adult Cheetahs in the captive breeding center of Tehran, adult Asiatic Cheetah weight can be regarded with precaution between 24 to 38 kg, because of low small data set. Some anatomical configurations like fragile teeth as well as skull and jaw musculature largely restricts Cheetahs to feed on flesh (Van Valkenburgh *et al.* 1990).

In the study area, the wild goats constitute the most abundant ungulates (n=620, 59.84%), nevertheless the species had low proportion in Cheetahs' diet. But contrary to that, Jebeer has the lowest abundance among the selected prey

items (n=60, 5.79%, less than 0.035 per square kilometer) (YDoE 2015), while it constitute the second preferred feeding item in the study area (Hayward *et al.* 2006, Zamani *et al.* 2017). Our analyses revealed that livestock compromise very small proportion of the Cheetahs diet (only one record) (Wachter *et al.* 2012, Zamani *et al.* 2017).

Our data showed that rodents and other small mammals like hares cannot be regarded as one of reliable preferred prey items for the Cheetahs (Marker *et al.* 2003, Hunter *et al.* 2007, Rezaei *et al.* 2016, Zamani *et al.* 2017). The presence of small mammals remaining in the Cheetahs scats during the summer can be related to the higher activity of this animals and lower density of large games (Ackerman *et al.* 1984, Ziaie 2008). Dareh-Anjir Wildlife Refuge supports relatively high number of game birds like See-See partridge (*Ammoperdix griseogularis*) and Chukar (*Alectoris chukar*) as based on our camera traps data such birds spent much of day length under the plants where we found the scat samples. Despite such complete niche overlap, such birds don't play significant role in the Cheetahs' diet (Saleh *et al.* 2001, Hayward *et al.* 2006). However other taxonomic groups feed on such prey items, like Caracal (Ghoddousi *et al.* 2009), as the only

competitors of the Cheetah in Dareh-Anjir Wildlife Refuge).

Poor prey management

After 2007 because of some economic pressures like fuel rationing, patrolling the protected area was restricted to the game guards posts located mainly in the mountainous areas, which can be induce statistical bias in the game guards observations in the mountainous habitats. Because of this event, CACP and YDoE collected data during 2007 to 2012 indicated that wild sheep and wild goats constitute the Cheetahs' main preys and therefore the protection programs should be concentrated on the mountainous areas (Hunter *et al.* 2007, Farhadinia and Hemami 2010, Morovati *et al.* 2014, Nezami 2018). Consequently, Jebeer were excluded from protection priorities, in the study area and elsewhere. Meanwhile, illegal poaching throughout unprotected and even protected areas led to the intensive degradation of the Gazelles' population (Akbari *et al.* 2014). Upon sever declining of such games (Akbari *et al.* 2014) Cheetahs are shifting from their original suitable habitats toward rough terrain searching for wild sheep and wild goats as alternative preys (Hunter *et al.* 2007, Sarhangzadeh *et al.* 2013). Depredation on wild goats are mostly happened around water troughs placed in hillsides that attract goats from the top of mountains in such an arid environment (Sarhangzadeh *et al.* 2013). Poor angulates management and conservation and consequent sever decline of Jebeer in the central Iran can be regarded one of the most important reasons of the Cheetahs population shrinkage in the southern habitats).

Conclusion

The Cheetahs' diet analysis based on scats' remaining suggests that they are mainly use plains and hilly habitats (Ahmadi *et al.* 2017) and are dependent to the Jebeer and wild sheep. In spite of sever decline in the Jebeer population density, however, it plays a key role in the Cheetahs' feeding preferences. Conservation

and creating new protected areas in the country are mainly relied on the presence and density of wild sheep and wild goats. Because of non-effective wildlife protection in the plain areas, especially in non-protected areas among the protected habitats, Jebeer and Goitered gazelle populations were decreased extremely and extirpated even in some areas.

Except Naybandan Wildlife Refuge and Tabas deserts, other Cheetah southern habitats where mainly located in the vicinity of our study area totally host less than 1000 gazelles. According to the Hemami and Groves (2001), of the 29 known populations of the gazelles, 12 populations have become extinct within the protected areas. Such poor management of the gazelles' population induced negative impacts on the Cheetahs' viability in the central plateau of Iran. The sever decline of main preys among the main habitats and connecting corridors doomed Cheetahs toward extinction vortex (Woodroffe and Gingsberg 1998). Jebeer population rehabilitation throughout the central plateau of Iran is necessary to insure Cheetahs survival and viability (Novaroa *et al.* 2000).

Acknowledgements

We would like to appreciate the Ardakan DoE, particularly Mr. Morteza Azizi and Dareh-Anjir WR game guards for their companionship during the sampling period. Our gratefully acknowledge to Wildlife Picture Institute specially Mr. Fatholah Amiri and Mr. Ali Shams for camera trapping and companionship in the field survey. We would like to thanks Mr. Mehdi AliMohamadi for a helpful review. We are also grateful Dr. Farhad Atai the Head of Collage of Environment laboratory).

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