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Ecological niche of the Asiatic Cheetah (Acinonyx jubatus venaticus) in the arid environment of Iran (Mammalia: Felidae)

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The Asiatic Cheetah, *Acinonyx jubatus venaticus*, is a species of global conservation concern and a small population occurs in Iran in fragmented habitats located in the central parts of the country with a continental, arid climate. Naybandan Wildlife Refuge (NWR) holds the largest population in Iran. To understand better the factors which determine the occurrence of cheetahs in these areas, we applied an Ecological Niche Factor Analysis (ENFA) to assess the relationship between occurrences of cheetahs across the NWR and topographic, biological, and anthropogenic factors. ENFA analysis results suggested that cheetahs have a tendency to inhabit areas different from the mean conditions of the study area and live in a narrow set of conditions. They prefer mountainous habitats far from flat areas, habitats near to water resources, and habitats with high prey densities. 13% of the NWR can be classified as suitable habitat for the cheetah, indicating a high conservation value of this reserve for the species.

Keywords: Asiatic Cheetah; habitat suitability modelling; ecological niche factor analysis; Naybandan Wildlife Refuge

Introduction

The Asiatic Cheetah, *Acinonyx jubatus venaticus* (Griffith, 1821), is one of the most threatened mammals in Iran (Ziaei, 2008). It is also globally classified as vulnerable (Vu) by IUCN (2013). The habitats where cheetahs are found are fragmented and face several threats. Our knowledge about the cheetah's habitat requirements in this environment is limited, as well as our knowledge of the factors which limit the distribution and population size in Iran. To understand better these factors, we studied cheetahs in the Naybandan Wildlife Refuge, one of the most intact and pristine habitats of Asiatic Cheetahs throughout Iran (Darvishsefat, 2006). The low level of disturbance in this reserve makes it possible to analyse the response of cheetahs to the harsh environmental conditions prevailing there.

There are two main approaches for habitat suitability modelling: presence/absence and presence only methods (Jacklin, 2009). Achieving a credible absence point dataset is a major challenge for the latter approach. Therefore, a variety of habitat suitability modelling methods are developed to build models with only presence data, such as the Ecological Niche Factor Analysis (ENFA) (Hirzel, Hausser, Chessel, & Perrin, 2002) and the Genetic Algorithm for Rule-set Production (GARP) (Stockwell & Peters, 1999). We applied the ecological niche factor analysis (ENFA) to the occurrence data of Asiat-

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ic cheetahs and the environmental conditions of Naybandan Wildlife Refuge as an example of arid habitats in Iran, to develop a habitat suitability model. We attempted to find out what are the most important factors affecting the distribution of cheetahs in the wildlife refuge, and what is the potential of the Naybandan Wildlife Refuge for conserving this critically endangered species.

Material and methods

Study area. Naybandan Wildlife Refuge (NWR) has been legally protected since 1994 and was promoted to a wildlife refuge in 2001. The creation of NWR was aimed at protecting rare animal species such as Jebeer Gazelle (*Gazella bennettii*) and Cheetah (*Acinonyx jubatus*). NWR is the largest wildlife refuge in the country, having an area of 1.5 million ha. It is located in the South Khorasan province of Iran (Figure 1). It comprises plain, hilly, and mountainous areas, with vast salt plains and altitudes ranging from 570 to 2965 m. The mean annual precipitation ranges between 50 mm and 150 mm, with a mean annual temperature between 14.5 and 19.5°C, which has resulted in temperate, extra-arid and warm air climates (Yare Ernani, 2013). Frequent springs and wells are the main water supply of the area. The occurrence of moving sand dunes and dense saxaul (*Haloxylon ammodenderon*) forest stands in the heart of the desert is a unique feature of the region. The area is rich in plant and animal biodiversity with over 200 plant species identified (Irannezhad Parizi, Mosleh, & Karimian, 2013; Sarhangzadeh, Najafi, & Tazeh, 2013). Mountain almond (*Amygdalus scoparia*), fig (*Ficus johannis*), tamarisk (*Tamarix ramosissima*), goat's wheat (*Athraphaxis spinosa*), wormseed (*Artemisia sieberi*), been caper (*Zygophyllum eurypterum*), giant fennel (*Ferula hirtella*), bitter apple (*Citrullus colocynthis*), and *Acantholimon scorpius* are the main plant species (Irannezhad Parizi, et al., 2013). The region is the most important habitat for the Asiatic Cheetah in Iran (Farhadinia, 2004, 2015; Sarhangzadeh et al., 2013). This subspecies is critically endangered and its occurrence is confined to Iran (Farhadinia, 2004). Other animal species include Wild Sheep (*Ovis orientalis*), Wild Goat (*Capra aegagrus*), Hyaena (*Hyaena hyaena*), Blandford's Fox (*Vulpes cana*), Caracal (*Caracal caracal*), Houbara Bustard (*Chlamydotis undulata*), Pleske's Jay (*Podoces pleskei*), Chukar Partridge (*Alectoris chukar*), See-see Partridge (*Ammoperdix griseogularis*), Egyptian Vulture (*Neophron percnopterus*), Golden Eagle (*Aquila chrysaetos*), Horned Viper (*Pseudocerastes persicus*), Saw-scaled Viper (*Echis carinatus*) and Desert Monitor (*Varanus griseus caspius*) (Sarhangzadeh et al., 2013).

Cheetah distribution data. The cheetah occurrence data were gathered during a field survey between January 2008 and October 2012. The survey was conducted on a daily basis by the game wardens. In each survey, the direct observation or signs of cheetah presence (such as scats) were recorded using GPS. There was no large carnivore in NWR except Hyaena (*Hyaena hyaena*) and the characteristics of foot prints and scat of cheetahs were identifiable with acceptable precision (about 90 per cent) (as was previously carried out by Zamani, 2010). Field surveys were made with the assistance of the NWR game wardens, who use motorbikes while traveling at a speed of less than 30 km/h. Efforts in all parts of NWR were not the same because of low security in some parts, but we tried to cover all areas. Furthermore, the former surveys (camera trapping program) conducted by the Yazd Department for Environment and the Cheetah Conservation Project have determined the areas where cheetahs are known to be more frequent, so we focused on these areas (central eastern part of NWR). 181 presence points of cheetahs (both direct observation and signs of cheetahs) were recorded (Figure 1).

Habitat variables. Based on a review of cheetah habitat requirements (e.g. Zamani, 2010; Bissett & Bernard, 2007; Broekhuis, 2007; Pettorelli, Hilborn, & Broekhuis, & Durant, 2009; Marker, 2002), we selected variables representing topographic, geomorphological, climatic, anthropogenic, and biological aspects of NWR habitats (Table 1). Topographic data (elevation, slope, aspect) were extracted from a 1:250,000 digitized topographic map of the area provided bz the Iran National Cartographic Center (1995). A geomorphological map of the study area was produced by field surveys and photogrammetry (Ekhtesasi & Zare Chahooki, 2013). We used the geomorphological maps of the area to extract the different geomorphological classes (e.g. mountainous, plain and playa habitats) of NWR.

Table 1. Brief description of environmental variables used in ENFA analysis.

Variable	Description
Vegetation	For each vegetation type in NWR, the nearest distance and frequency of that type was calculated for each 100-m pixel of the area.
Geomorphology	Distance from and frequency of each geomorphological type of the area was calculated for each 100-m pixel of the area.
Built up areas	Distance from nearest human resources (villages) was calculated
Water	Distance from nearest water source for each 100-m pixel of the study area
Elevation	Digital elevation model for NWR was developed
Slope	Slope (percent) for each 100-m pixel of used or unused sites measured on a digital elevation map of the study area was calculated
Aspect	Distance from and frequency of each aspect category (flat, north, east, south and west) for each 100-m pixel of the study area was used
Prey density	Distance from and frequency of each category of prey (wild sheep, wild goat, and chinkara) density (low, medium, and high) was calculated
Temperature	Mean annual temperature of the study area was calculated based on the synoptic and climatology stations data inside and across the NWR

Data gathered from synoptic and climatology stations inside and around the NWR was analysed to produce an isothermic map of the area (Ernani, 2013). Recent studies on the dietary habits of cheetahs in NWR reveal that wild sheep and wild goat are the main prey items of cheetahs (43.9% and 27.5% of diet, respectively) (Zamani, 2010). The density map of these two ruminants produced by Sarhangzadeh et al. (2013) were entered in the analysis as the main prey items of cheetahs. The density of these two prey species was classified as high, medium, and low. As all environmental layers need to be quantitative in an ENFA analysis (Hirzel et al., 2002), qualitative variables such as aspect, vegetation type, and prey density class were quantified by calculating distance and frequency maps. The vegetation cover map of NWR (Irannezhad Parizi et al., 2013) was used to derive variables representing the vegetative characteristics of the area. Permanent stream location across the NWR was recorded and used to calculate the distance to water map. All habitat variable maps were in raster format with 100-m resolution. The data was checked for normality (Kolmogorov-Smirnov test in Biomapper) and correlation (Pearson correlation coefficient) of habitat variables. The box-cox transformation was used to normalize variables (Box & Cox, 1964). We excluded one of the pair of variables with correlation higher than 0.8. All the maps were produced by IDRISI software (Ver. Kilimanjaro).

Ecological Niche Factor Analysis (ENFA). It was almost impossible to acquire reliable absence data due to the vast distribution of cheetahs across the area. Therefore, our Ecological Niche Factor Analysis (ENFA) is based exclusively on presence data and habitat variables. ENFA is based on the extraction of marginality and specialization factors. Marginality indicates the difference between the average environmental conditions of locations used by species and the average of the entire study area. Specialization presents the range of species distribution along environmental gradients. The tolerance index, reciprocal of specialization, indicates how much variation in environmental condition variables is tolerable by the species (Hirzel et al., 2002). ENFA results in factors with numbers equal to variables. The first factor explains 100% of the species marginality and some of the specialization. However, other factors only explain specialization. Broken stick model (MacArthur, 1957) was used to choose the factors which meaningfully explain marginality and specialization. This model compares the calculated eigenvalues with expected random values to identify the significant factors. In order to understand the importance of environmental variables in habitat suitability of cheetahs, a score matrix was interpreted. This matrix indicates the correlation between each variable and each of the factors (Hirzel et al., 2002). This model was evaluated by k-fold cross validation, the P/E curve, and the resulting continuous boyce index (Hirzel, Le Lay, Helfer, Randin, & Guisan, 2006).

Table 2. Score matrix for 30 variables in the habitat suitability model for the cheetah in NWR (the percentages indicate the amount of specialization accounted for by the factors).

Habitat variable	Marginality factor (23.3%)	Specialization			
		Factor 1 (31.54%)	Factor 2 (11.18%)	Factor 3 (7.68%)	Factor 4 (5.26%)
Northern hillsides (frequency)	0.187	- 0.002	- 0.027	-0.013	0.002
Flat areas (freq.)	- 0.224	0.012	- 0.067	- 0.022	0.014
Distance to eastern hillsides	- 0.141	- 0.005	0.014	- 0.010	- 0.018
Distance to southern hillsides	- 0.181	- 0.017	- 0.032	0.036	- 0.033
Western hillsides (freq.)	0.124	0.011	- 0.019	0.009	0.012
Elevation	0.264	0.022	0.106	- 0.017	- 0.036
Distance to areas with high density of prey	- 0.271	- 0.005	- 0.042	- 0.008	- 0.170
Distance to areas with medium density of prey	- 0.179	- 0.004	- 0.039	- 0.013	- 0.046
Distance to clay pan	0.114	0.205	- 0.214	- 0.457	- 0.467
Distance to fine grain plain	0.124	0.019	- 0.086	- 0.189	- 0.131
Distance to medium grain plain	0.176	- 0.045	- 0.154	0.284	0.123
Distance to hilly areas	0.181	- 0.006	0.043	- 0.082	0.283
Alluvial fan (freq.)	0.004	0.011	0.008	- 0.005	0.283
Frequency of mountainous area	- 0.291	- 0.001	0.285	0.005	0.121
Distance to playa	0.141	- 0.383	0.032	0.676	0.086
Distance to salty pan	0.080	0.677	0.135	- 0.391	0.218
Distance to sand dune	0.088	- 0.072	- 0.535	- 0.042	- 0.259
Slope	0.118	0.009	- 0.007	0.002	- 0.038
Bare lands (freq.)	- 0.115	0.008	0.044	0.021	0.067
Distance to *Artemisia-Amygdalus*	- 0.265	0.106	0.012	0.114	0.246
Distance to *Artemisia-Zygophyllum*	- 0.149	0.011	0.151	0.042	0.083
Distance to *Hammada - Artemisia-Zygophyllum*	0.161	- 0.018	- 0.065	0.004	0.027
Distance to *Haloxylon*	0.099	0.129	- 0.041	0.112	0.239
Distance to *Haloxylon-Tamarix*	0.178	- 0.068	0.330	- 0.070	- 0.452
Distance to *Hammada*	0.035	- 0.021	- 0.213	0.034	- 0.061
Distance to *Seidlitzia*	- 0.006	- 0.021	- 0.044	0.014	0.216
Distance to *Seidlitzia-Haloxylon-Tamarix*	0.052	- 0.539	0.492	0.130	0.309
Frequency of *Seidlitzia- Tamarix* (freq.)	- 0.019	0.018	- 0.059	0.012	0.081
Distance to village	- 0.301	- 0.138	- 0.283	- 0.055	0.099
Distance to water	- 0.423	0.010	0.014	0.004	- 0.003

Habitat suitability mapping. All four algorithms (median, geometric mean, harmonic mean, and minimum distance algorithms) used by the biomapper software (Hirzel & Arletaz 2003; Hirzel, Hausser, & Perrin, 2004) were compared using the continuous boyce index. The algorithm with the highest index was used to calculate and illustrate the habitat suitability map. The related P/E curve was used to determine the suitability threshold to classify the map into suitable and unsuitable areas.

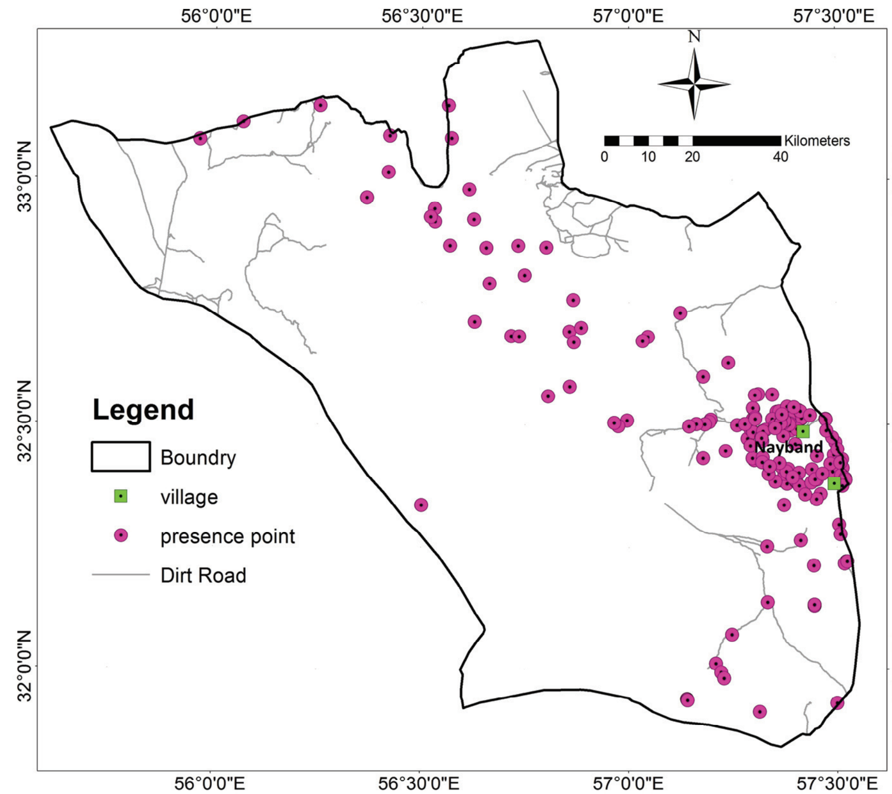

Figure 1. Location of records of the Asiatic Cheetah in Naybandan Wildlife Refuge.

Results

The 30 habitat variables used for the model were reduced to five factors explaining 100% of cheetah marginality and 78.9% of specialization. The global marginality value for cheetahs (2.402) indicates the tendency of the species to inhabit areas with environmental conditions higher than the average condition of NWR. The high specialization value (3.144) and low tolerance value (0.318) could be interpreted as the dependence of cheetahs on a narrow set of environmental conditions and therefore their highly specialized behaviour in NWR.

Table 2 shows coefficient values for environmental variables on marginality factors (explaining 23.3% of specialization), indicating that distance to water was the most important variable in predicting habitat suitability for cheetahs, as they prefer areas near to water (-0.423). Moreover, cheetah habitat suitability is positively related to high density of prey species, high elevation, and high slopes (Table 2). Coefficients for environmental variables for the second factor (explaining nearly 32% of specialization) indicated that cheetahs mostly specialize in avoiding salty plains (Table 2).

By comparing the validity of the habitat suitability maps produced by the three different algorithms, the harmonic mean was found to be the most precise algorithm in correctly predicting the presence of cheetahs with the highest continuous boyce index (0.931±0.0433 SD). Therefore, this algorithm was used to produce the habitat suitability map for cheetahs (Figure 2).

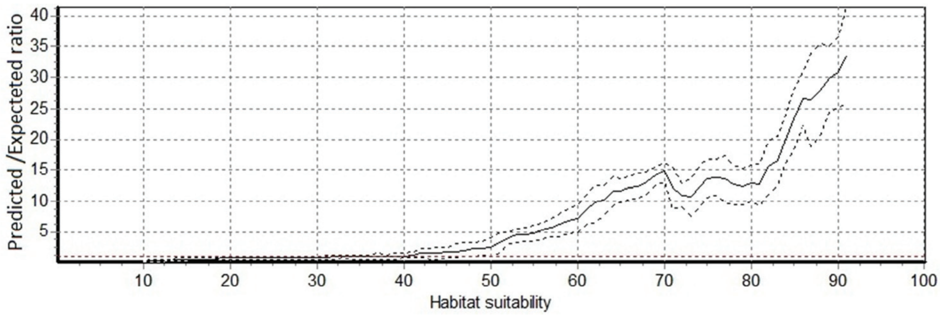

Figure 2. Ratio of Predicted / Expected presence points for Harmonic mean algorithm for habitat suitability map.

The P/E curve indicates the proportion of presence points correctly classified as suitable by the model by increasing the predicted suitability. In our research, this curve shows a positive trend and therefore the acceptable predicting power of the model (Figure 3). Considering this curve, 33% was selected as a suitability threshold because at this threshold model predictions become better than in a random model (Hirzel et al., 2004). This threshold was applied to classify the habitat suitability map into two classes of suitable and unsuitable habitats (Figure 4). This classification makes the habitat suitability map more applicable for management decisions. As a result, more than 209,387 hectares of NWR are considered as suitable for cheetahs. Nearly, 38% of these suitable habitats are situated inside the core zone of the study area which receives more field patrols and higher conservation efforts.

Discussion

Previous studies on habitat selection by cheetahs in Africa suggest that environmental variables such as vegetation cover, roads, geomorphological forms, availability of prey species, and availability of water are the most effective parameters that are responsible for the presence of cheetahs (Caro, 1994; Broomhall, Mills, & du Toit, 2003; Muntifering et al., 2006; Bissett & Bernard, 2007; Pettorelli et al., 2009). The results of our study suggested a different habitat selection pattern by the Asiatic Cheetah. We found that cheetahs in Iran are more attracted towards the topography of the habitat instead of the vegetation and they prefer habitats near mountains. In contrast, cheetahs in Africa showed vegetation to be the most important factor in habitation (Pettorelli et al., 2009). Water sources are critical for both cheetahs and their prey items (Durant et al., 1998). However, these sources attract other carnivores in the area (Hopcraft, Sinclair, & Packer, 2005). In NWR, severity of heat and lack of water sources force prey to gather around the existing water sources. Absence of competitor predators such as Grey Wolf (*Canis lupus*) and Leopard (*Panthera pardus*) in the study area make habitats near water sources highly preferable for cheetahs. Humans are the main cause of carnivore mortality (Cardillo et al., 2004), both inside and outside of protected areas (Woodroffe & Ginsberg, 1998). As a result, it is expected that cheetahs avoid these areas. However, in NWR, some villages are almost empty and cheetahs use habitats around these villages. There is no report of cheetah attacks on livestock, and the conflict between cheetahs and

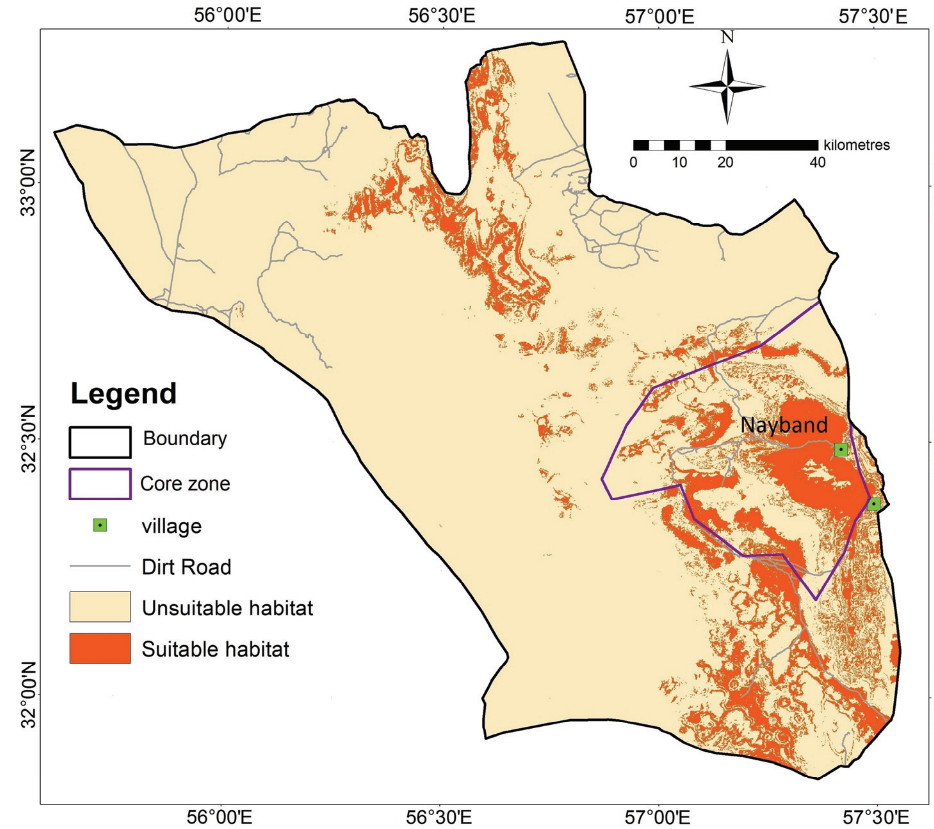

Figure 3. Classified habitat suitability map for the Asiatic Cheetah in Naybandan Wildlife Refuge.

local people is only for exploitation of the same prey (Wild Sheep, *Ovis orientalis*, Wild Goat, *Capra aegagrus*, and Jebeer gazelle, *Gazella bennettii*).

Cheetah specialization is higher in the Dare-Anjir Wildlife Refuge, situated near NWR (4.973: Sarhangzadeh, Akbari, Mossavi, & Poorchitsaz, 2014). These two reserves are close to each other and their main difference is a smaller surface area in Dare-Anjir Wildlife Refuge. The cheetah's preference for mountains could be due to the low density of prey in flat habitats and the greater availability of preferred prey items (Wild Sheep, Wild Goat) in mountainous habitats (Zamani, 2010). Therefore, it may be concluded that the harsh environmental conditions of arid environments affect cheetah distribution indirectly by their influence on prey distribution.

The core zone of the study area encompasses 38.3% of suitable habitat for cheetahs in NWR. Abundance of water sources, prey, and high security make this zone preferable for conservation of cheetahs in the future. However, this core zone only covers the eastern suitable habitats for cheetahs across the NWR. Therefore, we suggest that the northern suitable habitats should be selected as another core zone in the study area.

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References

Bissett, C., & Bernard, R. T. F. (2007): Habitat selection and feeding ecology of the cheetah in thicket vegetation: is the cheetah a savanna specialist? *Journal of Zoology (London), 271,* 310–317.

Box, G. E. P., & Cox, D. R. (1964): An analysis of transformation. *Journal of the Royal Statistical Society, 26,* 211–243.

Broekhuis, F. (2007): *Habitat selection patterns of Cheetahs Acinonyx jubatus in the Serengeti, Tanzania*. London: Institute of Zoology and the Royal Veterinary College, M.Sc. Thesis.

Broomhall, L. S., Mills, M. G. L., & du Toit, J. T. (2003): Home range and habitat use by cheetahs in the Kruger National Park. *Journal of Zoology, 261*, 119–128.

Cardillo, M., Purvis, A., Sechrest, W., Gittleman, J. L., Bielby, J., & Mace, G. M. (2004): Human population density and extinction risk in the World's carnivores. *PLOS Biology, 2,* 909–914.

Caro, T. M. (1994): *Cheetahs of the Serengeti plains: group living in an asocial species*. Chicago (IL): The University of Chicago Press.

Darvishsefat, A. A. (2006): *Atlas of protected areas of Iran*. Tehran: University of Tehran.

Durant, S. M., Caro, T. M., Collins, D. A., Alawi, R. M., & Fitzgibbon, C. D. (1988): Migration patterns of Thomson's gazelles and cheetahs on the Serengeti plains. *African Journal of Ecology, 26*, 257–268.

Ekhtesasi, M. R., & Zare Chahooki, A. (2013): *Environmental planning of Naybandan Wildlife Refuge, Part 2: Geology and Geomorphology* [in Farsi]. Yazd: Departmentof the Yazd Environment.

Farhadinia, M. S. (2004): The last stronghold: Cheetah in Iran. *Cat News, 40,* 11–14.

Farhadinia, M. S. (2015): *How many Asiatic Cheetahs persist in Iran? The First Country-Scale Demographic Assessment*. Tehran: Iranian Cheetah Society (in press).

Hirzel, A. H., & Arletaz, R. (2003): *Modeling habitat suitability for complex species distribution by environmental distance geometric mean*. New York: Springer.

Hirzel, A. H., Hausser, J., Chessel, D., & Perrin, N. (2002): Ecological-niche factor analysis: how to compute habitat suitability maps without presence data. *Ecology, 83,* 2027–2036.

Hirzel, A. H., Hausser, J., & Perrin, N. (2004): *Biomapper 3.1*. Division of Conservation Biology, University of Bern. Available at www.unil.ch/biomapper.

Hirzel, A. H., Le Lay, G., Helfer, V., Randin, C., & Guisan, A. (2006): Evaluating the ability of habitat suitability models to predict species presences. *Ecological Modelling, 199,* 142–152.

Hopcraft, J. G. C., Sinclair, A. R. E., & Packer, C. (2005): Planning for success: Serengeti lions seek prey accessibility rather than abundance. *Journal of Animal Ecology, 74,* 559–566.

Irannezhad Parizi, M. H., Mosleh, A., & Karimian, A. A. (2013): *Environmental planning of Naybandan Wildlife Refuge, Part 6: Vegetation* [in Persian]. Yazd: Department of Environment.

IUCN (2013): IUCN Red List of Threatened Species. www.iucnredlist.org.

Franklin, J. (2009): Mapping species distributions: Spatial inference and prediction. Cambridge: Cambridge University Press.

MacArthur, R. (1957): On the relative abundance of bird species. *Proceedings of the National Academy of Sciences of the United States of America, 43,* 293–295.

Marker, L. L. (2002): *Aspects of cheetah (Acinonyx jubatus) biology, ecology and conservation strategies on Namibian farmlands*. University of Oxford: Ph.D. Thesis.

Muntifering, J. R., Dickman, A. J., Perlow, M. L., Hruska, T., Ryan, P. G., Marker, L. L., & Jeo, R. N. (2006): Managing the matrix for large carnivores: a novel approach and perspective from cheetah habitat suitability modelling. *Animal Conservation, 9,* 103–112.

Myers, N. (1975): *The status of the cheetah in Africa south of the Sahara.* Morges (Switzerland): IUCN.

Pettorelli, N., Hilborn, A., Broekhuis, F. & Durant, S. M. (2009): Exploring habitat use by cheetahs using ecological niche factor analysis. *Journal of Zoology, 277,* 141–148.

Sarhangzadeh, J., Akbari, H., Mossavi, J., & Poorchitsaz, A. (2014): Modeling of Asiatic Cheetah habitat suitability in Dareh-Anjir Wildlife Refuge in Yazd Province. *Iranian Journal of Arid Biome, 3,* 40–50.

Sarhangzadeh, J., Najafi, B., & Tazeh, M. (2013): *Environmental planning of Naybandan Wildlife Refuge. Part 7: Wildlife and Habitats* [in Farsi]. Yazd: Department of Environment.

Stockwell, D., & Peters, D. (1999): The GARP modelling system: problems and solutions to automated spatial prediction. *International Journal of Geographical Information Science, 13,* 143–158.

Woodroffe, R., & Ginsberg, J. R. (1998): Edge effects and the extinction of populations inside protected areas. *Science, 280*, 2126–2128.

Zamani, N. (2010): *A comparison study on food habits of Asiatic Cheetah in Naibandan and Darreh-Anjer Wildlife Refuge, Yazd Iran* [in Farsi]. Tehran: Tehran University (M.Sc. thesis).

Zare Ernani, M. (2013): *Environmental planning of Naybandan Wildlife Refuge, Part 4: Climate and weather.* Yazd: Department of Environment.

Ziaie, H. (2008): *A field guide to the mammals of Iran* [in Farsi]. Tehran: Department of the Environment.