A geo-statistical approach to model Asiatic cheetah, onager, gazelle and wild sheep shared niche and distribution in Turan biosphere reserve-Iran

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ABSTRACT

Presence data for four mammals in the Turan Biosphere Reserve in Iran including the Asiatic cheetah (*Acinonyx jubatus venaticus*), the Persian onager (*Equus hemionus onager*), the wild sheep (*Ovis vignei*), and the gazelle (*Gazelle Bennettii*) were used to analyze and model their potential interaction, facilitation, habitat coverage and niche dimensions. A geostatistical approach using the spatial autocorrelation between the locality points, and their relationship with habitat resources and characteristics with application of remotely sensed maximum enhanced vegetation index (EVI) and surface temperature, elevation, aspect, vegetation cover and soil moisture was used to predict herbivores species niche. The potential suitable habitat of herbivores along with environmental variables was used to model the predator species (cheetah) niche. The model results were tested using fivefold cross validation by area under the curve (AUC) values on set of independent testing data and were compared to more commonly used models of generalized linear model (GLM) and MaxEnt. The results show that cheetah's potential suitable habitat has 61% overlap with wild sheep, 36% with onager, and 30% with gazelle. Onager habitat has 64% overlap with gazelle and 60% the wild sheep. Wild sheep on the hand, shares only 37% of its habitat with gazelle. The most prey and predator interaction exists between cheetahs and wild sheep, while onagers provides facilitation for gazelles and wild sheep by potentially providing extra water sources. Among the implemented modeling techniques, spatial GLM showed better performance over GLM and MaxEnt. We suggest that conservation effort should focus more on maintaining the population of wild sheep and onagers to support other species in the habitat.

1. Introduction

Human pressures on ecosystems have raised the concern of the trophic niche and the question whether different species share similar habitat and how much of their niche is shared. In spite of improvements in species distribution models (SDMs), there is still a lack of technique and attention in the trophic niche of a species, and defining whether different species have common ecological requirements is rarely tested. In this regard, analyzing niche relationships between species can provide more accurate species distribution maps. Species distribution models, also known as habitat suitability models, have been widely used in different fields of ecology, such as control of invasive species (Bisrat et al., 2012; Gallien et al., 2010; Václavík and Meentemeyer, 2009), effect of climate and environmental change on species distribution (Franklin, 2010; Tang and Beckage, 2010; Taylor and Kumar, 2013), design of biodiversity protective network (Wilson et al., 2005), and conservation biology (Nazeri et al., 2012, 2014; Rood et al., 2010). These models are based on Hutchinson's (1957) fundamental niche theory, which lies at the core of ecological research, arguing that each species has a unique, n-dimensional array of ecological resources and environmental needs. By integrating species presence or absence data (biological data) with total habitat structure (environmental data), models can predict suitable areas that can provide species vital requirements for survival. However, these models have some limitations and restrictions.

Generally, these models compute the potential niche based on the occurrences of species of concerns and other eco-geographical variables. On the other hand, the idealized niche of species is driven by three main factors: abiotic variables, dispersal limitation, and biotic interactions (Soberón, 2007). Biotic interactions can involve intraspecific or inter-specific interactions, and may have direct or indirect effects on populations. These effects can change the resource availability, the abundance of other species through competition, and can provide ecological

facilitation (Lortie et al., 2004). However, biotic factors such as species interactions have been mostly neglected in distribution modeling as they might act at different spatial scales (Kneitel and Chase, 2004).

In order to know about species interactions in terms of competition and possible ecological facilitation in a shared habitat, we quantify four species niches including a predator in the Turan Biosphere Reserve in Iran using SDMs. First we use species presence points that are representing species abundance in the habitat, to characterize species realized niche, and next by using the relationship between species occurrence data (presence and pseudo absence) with a set of environmental variables, we predict the potential suitable habitat for each species using spatial generalized linear model (GLM) (Hengl et al., 2009; Pebesam, 2004), and test the results with (GLM) (Nelder and Wedderburn, 1972), and MaxEnt (Phillips et al., 2006). In an effort to identify the percentage of niche space shared by two or more species, we measure the overlapping potential suitable habitat by species. Finally, we compare the results of spatial GLM with GLM and MaxEnt using receiver operating characteristic (ROC) curves and AUC values on a set of independent testing samples.

2. Methods

2.1. Study area and species

The study site encompassed the Turan Biosphere Reserve (Fig. 1) with an area of 14,400 km², located in Northeastern Iran (55–57.02 E, 35–36.22 N [WGS 84]) in the Universal Transverse Mercator (UTM) boreal zone, 40. Turan consists of a Protected Area, a National Park and a Wildlife refuge, and was established in 1975, mainly as a protection for the Persian onager population and its habitat. Turan is located in cold winter deserts with a mean annual precipitation of 200 mm. The landscape is generally flat, but mountains with an altitude of 2200 m can also be found. The Turan Biosphere Reserve is one of the most important reservoirs for conservation of cheetah, onager, wild sheep and gazelles. The critically endangered Asiatic cheetah (*Acinonyx jubatus venaticus*) is a species of high international conservation concern and survives only in Iran (IUCN, 2009). Currently, cheetah can be found in fragmented reserves of Turan Biosphere reserve and the Kavir National Park, Dareh-Anjir and Bahram-e-Gur in Yazd province and Naybandan
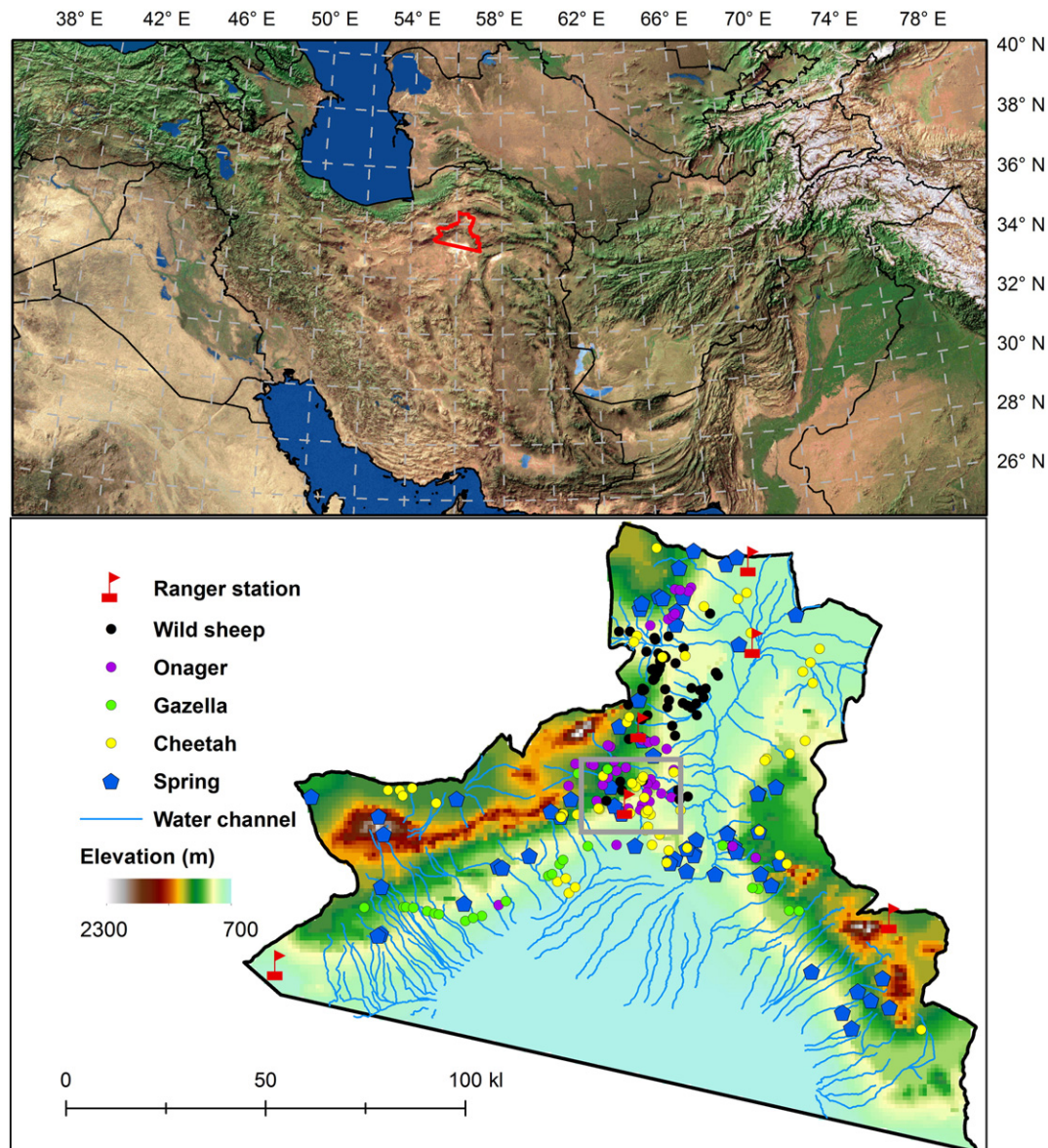

Fig. 1. The location of Turan Biosphere Reserve in Iran (Top panel). Presence points of studied species, park ranger stations, spring and water channel on digital elevation map (DEM) in Turan Biosphere Reserve (Bottom panel). Gray rectangular show the Majarat region, one of the core areas in the habitat.