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# Habitat evaluation for Persian Gazelle in the Southern half of Markazi province, Iran

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## Abstract

Markazi Province with its extended deserts and plains provides a suitable habitat for the Persian Gazelle. The habitat fragmentation due to the human-initiated activities is one of the major threatening factors against the species viability, especially Persian Gazelle. The present study is conducted using the MaxEnt method based on the maximum entropy or near to reality approach with 10 different variables and 30 focal points of Persian Gazelle. The study results show that a 215150.6 ha area equivalent to 14% in the southern half of Markazi Province covers a favorable habitat for the Persian Gazelle. The ROC model specifies that the validity of habitat suitability model is 0.985, suggesting the superior performance of MaxEnt method. Among the development variables, the highest impact on the Persian Gazelle ecology is assigned to distance to mines variable (10 km) while the lowest impact is related to distance from unpaved road variable. Further, among the ecologic variables, the highest and lowest impacts were detected for slope (0-5%) and height variables, respectively. The main objective followed in the present work is the protection of the extant population, inter-regional corridors, as well as live capturing, sending, and restoring the Persian Gazelle from other regions to Haftad Qolleh, West Haftad Qolleh, and Muteh.

**Keywords:** MaxEnt, *Gazella subgutturosa subgutturosa*, Habitat fragmentation, Haftad Qolleh.

## Introduction

The destruction of natural habitats due to human activities is one of the most important threatening factors against the survival of many species. Then, the remaining areas as wildlife habitats are often very limited and separated by poor lands. The habitat fragmentation has many potentially destructive effects on the population residing in these areas including the population confinement and inter-population genetic exchange unfeasibility. Such effects result in an increase the endogamy, and in the long runs intensifies the extinction danger. Different species show a variety of reactions to the phenomenon based on their various characteristics and requirements (Malekian 2007). As a consequence of habitat fragmentation, different areas with dissimilar geographic structures are formed; which are incompatible to some of the individual species. The strongest threatening factor posed to the biodiversity is the habitat isolation because the large habitat division into the isolated areas endangers the biodiversity (Fahrig 2003). The The percentage of variables contribution in the

habitat evaluation for Persian Gazelle using the MaxEnt method (Table 1) reveals that the distance from the irrigated farm variable and then the slope variable have the highest contribution to the model while the smallest impact is related to the distance from unpaved road variable.

method is one of the most common algorithms for machine-based learning. The principal of MaxEnt method is based on the maximum or close to reality entropy. Shannon (1984) describes the entropy as a criterion for the number of involved choices in the case of an event occurrence (Behdarvand 2012). Determining the status of distribution of wildlife species, habitats under their occupation, and habitats favorable for species is of great importance in the wildlife management. One approach for modeling the habitat suitability of Persian Gazelle (*Gazella subgutturosa subgutturosa*) is to apply the Multi-Layer Perceptron (MLP) neural network (Karami et al. 2016). Knowing the distribution of this species and its habitat requirements is important in designing efficient conservation measures for its rehabilitation (Bagherirad et al. 2014). According to the International Union for Conservation of Nature, the Persian Gazelle is classified as a vulnerable species (IUCN 2015). Presently, three species of the Gazella live in Iran. Among these species, only *G. S. Subgutturosa* there lives in the Markazi Province (Ziaie 2008). Mouteh Wildlife Refuge area is known as one of the most important and suitable habitats with the largest population of Persian Gazelle (*G. S. Subgutturosa*) in Central Iran (Hazeri et al. 2009). In the last three decades, the habitat and population of Persian Gazelle have been reduced severely and this species disappeared in most plains of Markazi province. Presently, only few Persian Gazelles exist in the plain of Cyan (West Haftad Qolleh) and Isfahan's Muteh area and in the Mahallat and Delijan in the Markazi province (Ansari 2009). The main objective of this study is to evaluate the habitat of Persian Gazelle *(G. s. subgutturosa*) in the southern half of Markazi Province (Iran) and provide management solutions.

## Material and methods

### Study Area

The study was undertaken from May 2016 to May 2017 in a 1536790 ha area in the southern part of Markazi Province. The study zone included the protected area of Haftad Qolleh with 97,437 ha area and the plain of Cyan (West Haftad Qolleh) with 20 Persian Gazelle population in Isfahan's Mouteh wildlife habitat, Markazi Province with 60,000 ha area with a 4000 Persian Gazelle population, Jasb's wildlife habitat in Delijan with 17,234 ha area, Rasvand's wildlife habitat in Shazand with 1,067 ha area, the protected area of Alvand in Khomain with 8618 ha area, and the protected area of part of Qom Palang Darreh in Markazi Province with 31,735 ha area. Due to the road construction activities, mining activities, changes in land use, etc., the corridors connecting the adjacent areas have interrupted the Persian Gazelle population, making it impossible for them to traverse across the adjacent areas.

### Modeling approach

At first, the study region was modeled in the form of a raster map with 100×100 pixel size and a 1:50000 scale. Then, the dependent variables (presence of studied species and absence of studied species) were collected. In order to develop the species presence map, the field survey and observation data (30 focal points of Persian Gazelle) of the species were recorded using a GPS device. Afterward, the independent ecological variables including topographic features (slope angle, and height), ecological data, and the impacts of human-based activities (distance to the human-built locations,

roads congestion, a:nd mines) were identified. The MaxEnt method is based on the comparison of the ecological features of the species presence points with the ecological features of the region as a whole. Data analysis was performed using MaxEnt data preparation, data verification, data correlation, habitat suitability mapping, models validation, and habitat suitability map classification were also carried out (Phillips et al. 2006).

## Results

The percentage of variables contribution in the habitat evaluation for Persian Gazelle using the MaxEnt method (Table 1) reveals that the distance from the irrigated farm variable and then the slope variable have the highest contribution to the model while the smallest impact is related to the distance from unpaved road variable.

**Table 1**. Percentage contribution and significance of each variable in the habitat evaluation for Persian Gazelle (DFI: distance from irrigated farms, DFA: distance from Asphalt roads, DFD: distance from dry farms, DFM: distance from mines, DFP: distance from paved roads, ELV: Elevationn, DFC: distance from cities, DFR: distance from all roads, DFU: distance from unpaved roads).

| Variable | Percent contribution | Permutation importance | Optimal conditions |
|---|---|---|---|
| slope | 19.7 | 24.1 | 0-5% |
| DFI | 18.8 | 1 | 4Km |
| DFA | 16.2 | 39.8 | 10Km |
| DFD | 14.9 | 12.9 | 10Km |
| DFM | 12.8 | 6.6 | 10Km |
| DFP | 5.5 | 4.8 | 2Km |
| ELV | 3.9 | 0.8 | 2Km |
| DFC | 3.5 | 1.7 | 5Km |
| DFR | 3.3 | 6.5 | 100m |
| DFU | 1.4 | 1.8 | 100m |

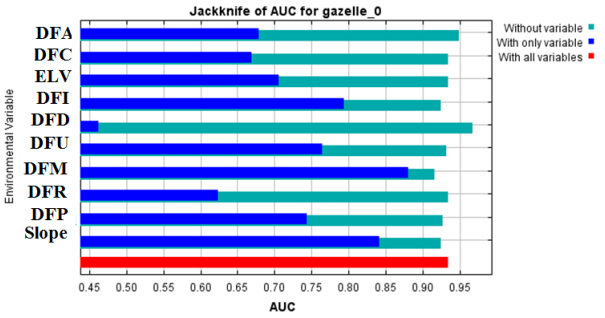


**Figure 1.** The jackknife test results for the significance of each variable in the habitat evaluation for Persian Gazelle. For abbreviations refer to table 1.

As the results of jackknife test (Fig. 1) indicate, the most significant variables regarding the habitat suitability are mine, slope, irrigated farm from distance, and unpaved road from distance in the order of their appearance while the smallest impact is obtained for the distance from dry farm variable (Fig. 2).

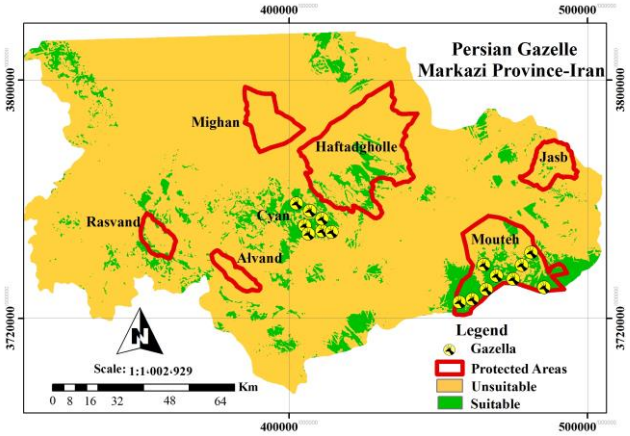


**Figure 2.** Habitat evaluation for Persian Gazelle using MaxEnt method in the southern half of Markazi Province, Iran.

According to the MaxEnt method, suitable habitat area is 215,151 ha (14%) while the ROC validity is 0.985 (Fig. 3). The percentage and suitable habitat area of the model using the MaxEnt are present in Table 2. Comparing the models' validity (AUC= 0.985±0.08) shows that the validity of the maximum entropy model is 0.985, suggesting that the MaxEnt model has a better predictability for the presence points with the probability of 98.5% that confirms its high validity.

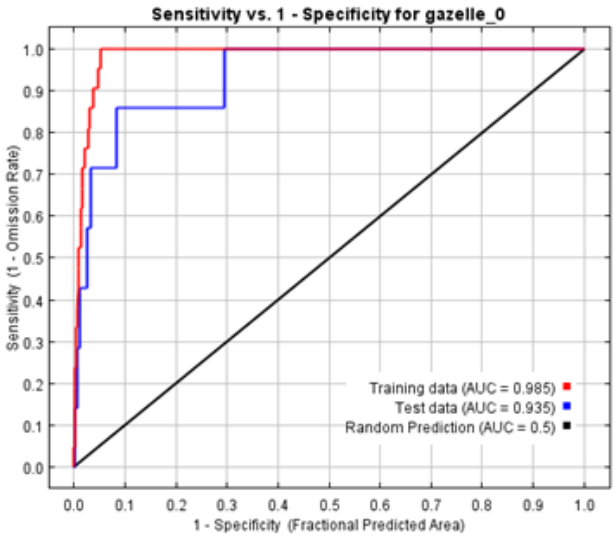


**Figure 3.** The ROC validity of habitat evaluation for Persian Gazelle based on MaxEnt method

**Table2.** The percentage and area of habitat evaluation for Persian Gazelle using the MaxEnt method.

| Classes | MaxEnt | |
|---|---|---|
| | Area(ha) | Percent |
| Sutiable | 215150.6 | 14 |
| Unsutiable | 1321639.4 | 86 |
| Total | 1536790 | 100 |

## Discussion

The ROC model specifies that the validity of habitat suitability model is 0.985 indicating the superior performance of MaxEnt method (Giovanelli et al. 2010). Among the human-based development activities variables, the highest rates are related to the distance from Irrigated farm (18.7), the highest significance is determined for rainfed distance from asphalt road (39.8), the highest optimum distance is obtained for distance from mines variable (10Km), and the lowest contribution is assigned to distance from unpaved roads (1.4) (Karami et al. 2016). On the other hand, the lowest significance is determined by the distance from unpaved roads and the lowest distance from the optimum condition is obtained for unpaved roads (100 m). For the ecological variables, the highest contribution rate (19.7), significance (24.1), and distance from the optimum condition (0-5%) are assigned to slope, while the lowest contribution rate (3.9), significance (0.8), and distance from the optimum condition (2 km) are obtained for height parameter (Ying et al. 2010). Accordingly, among the development variables, the highest effect on the Persian Gazelle habitat is related to distance from mine while the lowest effect is assigned to unpaved roads. Moreover, among the ecology variables, the highest and lowest impacts are related to slope and height, respectively (Bagherirad et al. 2014). The gazelles in Iran are worthy of strong research and conservation efforts as they are currently endangered. If conservation efforts are not implemented for this species in the near future, its status could be changed to the Extinct (EX) category (IUCN 2015). In the Markazi province, habitats of this species have been fragmented into multi patches located near human-based activities. Therefore, compared to other wild herbivores like wild goats and sheep, gazelles have been more exposed to risk from human activities (Ansari 2009). Knowledge of the ecology of the Persian Gazelle and their biological parameters required for effective conservation measures are currently not enough in Iran.

Recommendations: The protection of the extant population, restoring, and creating the migratory corridors and enhancing the regional security for linking the populations, especially in Mouteh and Haftad Qolleh regions are necessary. Because of the high rate of reduction in the genetic diversity in Mouteh and West Haftad Qolleh regions, urgent measures are required to make to perform a genetic study of the adjacent habitats and the identification of the closest genome to these populations. In this way, some of them will be live captured and sent to the identified regions. Preparing the Persian Gazelle restoration plan in other habitats of Markazi province, especially Haftad Qolleh and The Cyan plain in the West Haftad Qolleh would be also considered in the future works.

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