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Research Article

Habitat evaluation of Levantine viper *(Macrovipera lebetina* Linnaeus, 1758) in Haftad-Gholleh protected area, Iran

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Abstract

Haftad-Gholleh protected area located in the central plateau of Iran host one of the mountainous vipers, Levantine viper (*Macrovipera lebetina*), which can be regarded as west and northeastern subspecies. Habitat destruction and illegal live trapping to extract venom can be considered as some of the essential factors which threats the species viability. To determine the most critical factors which affect the species habitat use, I tried to use to modeling approaches of MaxEnt and Logistic regression, focusing on the eight different independent variables and 15 locations of the species present. Both models with high validation criteria (AUC> 0.98) indicated that around one percent of the protected area could be regarded as a potential habitat for the target species. Two distal factors acted in the reverse direction as distance from the Human related landuse (7 km) showed the highest priority. In contrast, the distance from traffic roads indicated the lowest effect on the species habitat usage. Two other most significant variables which affect the species habitat selection were distance to the water resources and altitude. The present work's outputs can be used in the species protection in Haftad-Gholleh protected area.

Keywords: Habitat modeling, Logistic regression, *Macrovipera lebetina*, MaxEnt modeling approach

Introduction

Levantine viper (*Macrovipera lebetina*) has been recorded from central Asia and the Middle East (Ananjeva *et al.* 2006, Gçmen *et al.* 2006). Montivipera genus includes three species of *M. latifii*, *M. kuhrangica* and *M. raddei* in Iran (Rajabizadeh 2011); however, there is debate on the number of species and subspecies yet (Rastegar Pouyani *et al.* 2014). Montivipera genus members are restricted to the mountainous habitats of the Iran-Anatolian region, and regarding their selected habitat variables in such a fragile ecosystem, they are more sensitive to the potential threatening factors (Latifi 2000, Rajabizadeh *et al.* 2011). Habitat destruction and illegal live trapping to extract venom for medical purposes threats their viability (Kian *et al.* 2011, Esmaeili Jahromi *et al.* 2016). Previous investigations indicate that *M. lebetina* is the only venomous reptile throughout the study area, which needs special conservation consideration (Salemi *et al.* 2015). Levantine viper usually can be found in an average temperature of 46.28 °C, moisture around 16%, and elevational range of 2138.73 meters above sea level with maximum activity in June (Pashaeirad *et al.* 2016). Except for Pashaeirad *et al.* (2016) study, there is no other documented research in Iran that describes the species habitat affinities (Asadi *et al.* 2014), however, similar investigations had been carried out on other vipers like *Vipera albicornuta* (Sheikhii *et al.* 2012). Habitat modeling of *V. albicornuta* using logistic regression analysis and selecting input variables of altitude, terrain slope, azimuth, land properties (bare soil, rocky areas, etc.) and distal factors in 25 recorded localities indicated that the rocks percentage coverage play the most critical role in the species habitat use (sheikhii *et al.* 2013). MaxEnt modeling approach is one of the most common algorithms in machine-based learning investigations, which is based on the maximum

entropy theory (Phillips *et al*. 2006). 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 wildlife species distribution and their habitat affinities has great importance in the wildlife management and conservation. To this aim, I tried to get a habitat suitability model for the target species and help local authorities to enhance the conservation program's quality toward the targeted vipers' protection and conservation.

Material and Methods

Study Area

With an area of more than 97400 ha, Haftad-Gholleh protected area (Fig. 1) located 25 km from the eastern Arak and 15 km of Mahallat city (33°, 55′ to 34°,20′N and 49°, 56′ to 50°, 24′E). Mean annual rainfall in the study area is about 349 mm, and temperature fluctuates from -30 to 38°c. These mountainous protected areas host wild goat (*Capra aegagrus*), wild sheep (*Ovis orientalis*), Persian leopard (*Panthera pardus*), Wolves (*Canis lupus*), Wild cat (*Felis silvestris*), Caracal (*Caracal caracal*), Badger (*Meles meles*), Hedgehog (*Erinaceus concolor*), Spur-thighed tortoise (*Testudo graeca*), Common hyena (*Hyaena hyaena*), Fox (*Vulpes vulpes*), Jackal (*Canis aureus*), Indian crested porcupine (*Hystrix indica*), Houbara bustard (*Chlamydotis undulata*), Perdicinae (*Alectoris chukar*) black-bellied sandgrouse (*Pterocles orientalis*). Different families from snakes can be found in the study area like: Typhlopidae (*Xerotyphlops vermicularis*), Viperidae (*Macrovipera lebetina*), Boidae (*Eryx miliaris* and *E. tataricus*), Lamprophiidae (*Malpolon insignitus*), Colubridae (*Eirenis punctatolineatus*, *E. collaris*, *Platyceps ventromaculatus*, *Platyceps najadum*, *Hemorrhois ravergieri* and *Natrix tessellate* (Salemi *et al.* 2015).

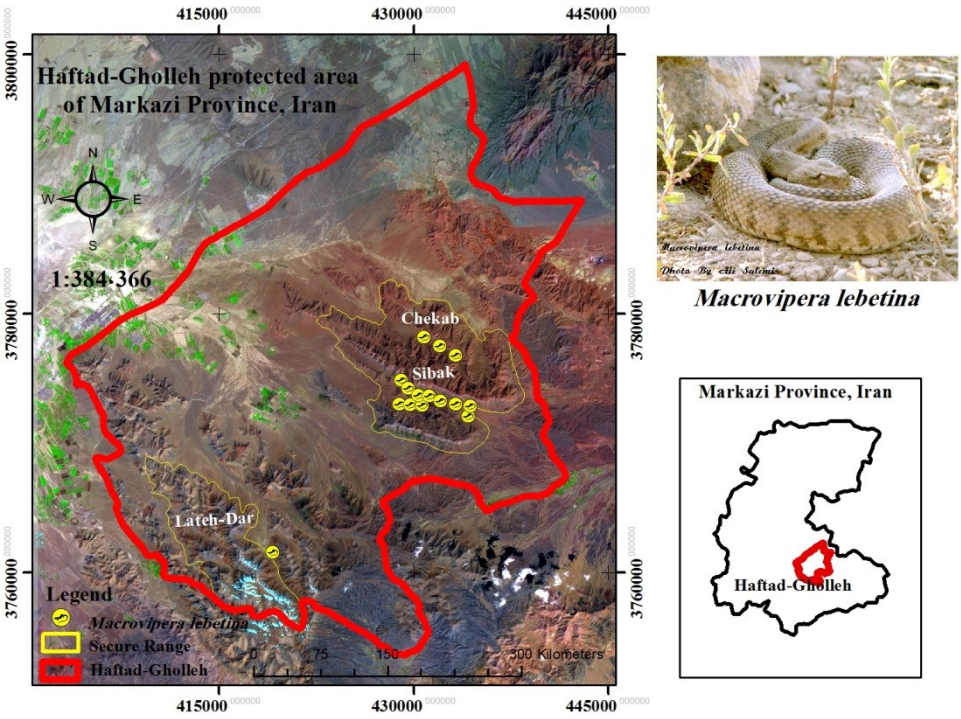

Figure 1. The location of the study area in Markazi province, Iran

At first, a 1:50000 digital elevation map of the study region converted to a raster map with 30×30 pixel size and variable groups like topographical and distal were extracted. On a random basis, I tried to collect the species points by traversing line transects on foot, and total of 15 activity points were recorded. Moving in a randomly selected direction up to around 500 m from the species observation point can be located as an absence point after an intensive search in a circular plot of 30 m radius (Sahragard and Ajorlo 2018). Variables were

selected by reviewing the literature (Brito 2003, Luiselli 2006, Lagory *et al.* 2009, Sheikhii *et al.* 2012) and measured at the species' presence points. Some of the human activity related variables like distance to the farms, human settlements, and livestock husbandry areas, as well as the distance from the traffic roads, were measured as well (Sheikhii *et al.* 2013). MaxEnt and Logistic regression method were used for habitat modeling, and criteria like Area Under ROC (the receiver operating characteristic) curves was used for comparing the model ability to predict the most suitable areas and affecting variables (Phillips *et al.* 2006). AUC, as a single threshold-independent measurement of model performance, can be used as an essential criterion (Thuiller *et al.* 2005).

Results

MaxEnt model indicated the importance of the water resources in the species habitat use (Fig. 3). Other most important variables have been presented in table 1.

Table 1. Percent contribution and significance of each variable in the MaxEnt model of species habitat use.

Variable	Percent contribution	Permutation importance	Optimal conditions
Distance from water resources	46.6	92.9	0
Percent of vegetation	19.9	0	75-100%
Percent coverage of rocky areas	19.5	4.4	50-75%
Distance from Human related landuse	7.1	0	7 km
Slope	6.3	2.2	5-10 (degrees)
Azimuth	0.4	0.6	250
Distance from traffic roads	0.2	0	2700 m
elevation	0	0	2900 m

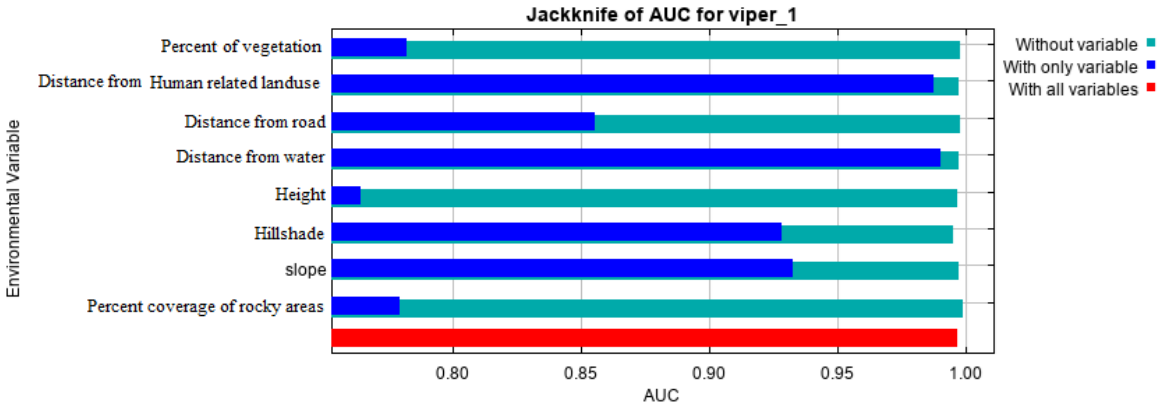

Figure 2. The jackknife test results for the significance of each variable

Figure 2. Jackknife test of variable importance, which helps to identify those variables, has more contribution to the outputted model. This test indicated that the presence of the water resources, distance from the Human related landuse, terrain slope, and elevation from sea level (altitude) had the most contribution.

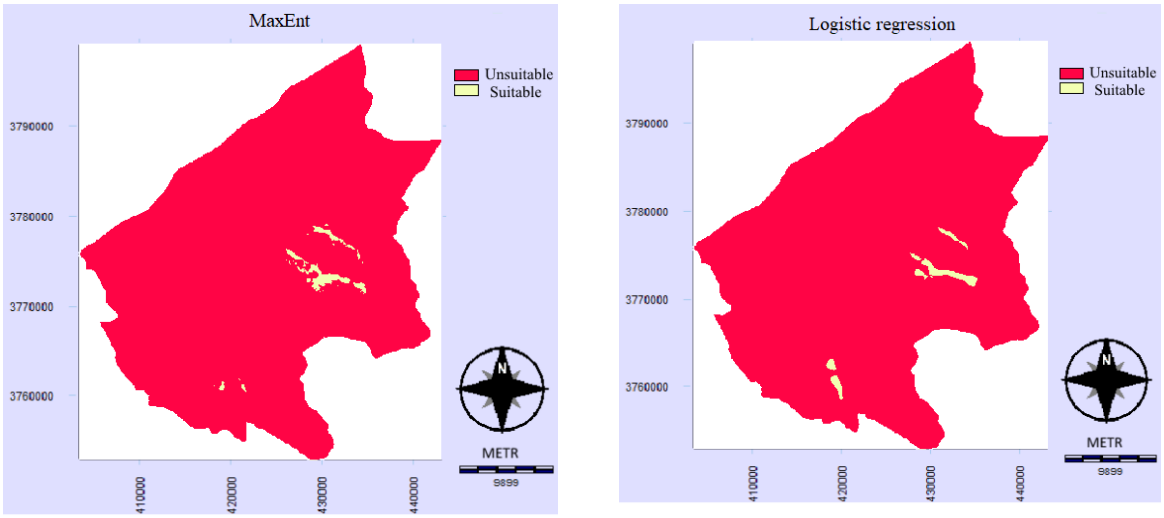

Figure 3. Habitat suitability models for the target species based on two modeling approaches of Maximum Entropy and Logistic regression.

Both modeling approaches indicated that around 1.03 percent of the protected area could be regarded as potentially suitable habitats for this viper (Fig. 4). The percent coverage of the potentially suitable habitats resulted from two modeling approaches has been presented in table 2.

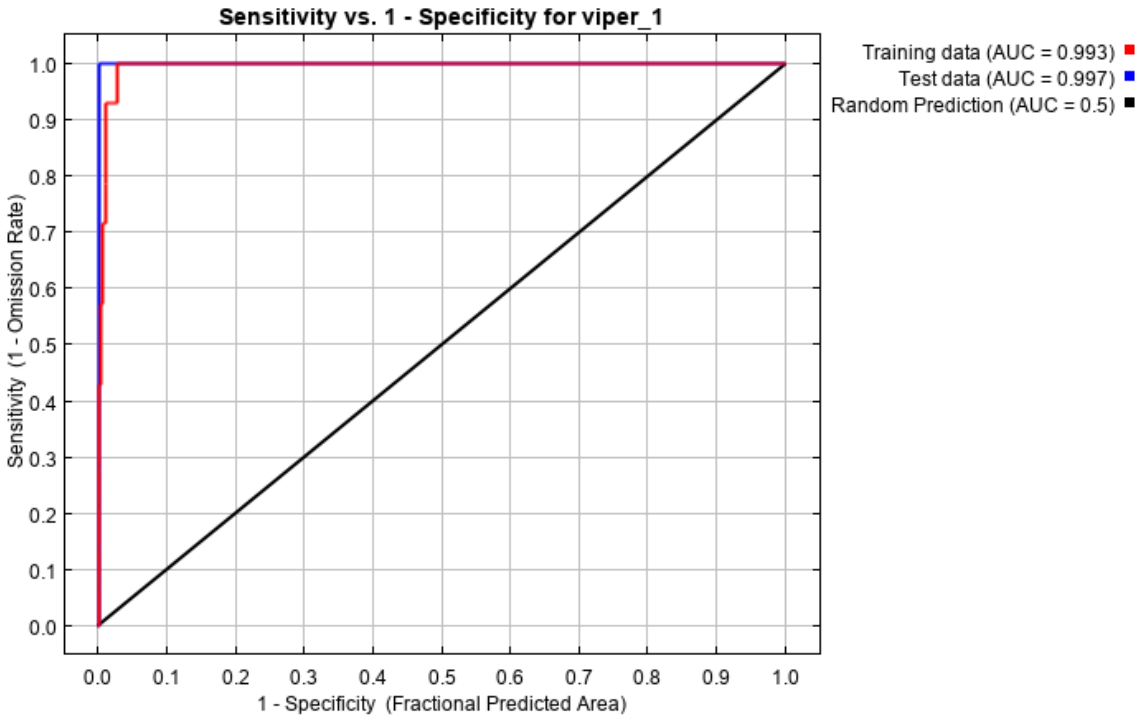

Figure 4. The receiver operating characteristic (ROC) in MaxEnt modeling procedure

The percent and suitable habitat area of the models using the MaxEnt and Logistic regression are present in Table 2. Comparing the models' validity in Table2 shows that the validity of the maximum entropy model is 0.997, and the Logistic regression is 0.985, suggesting that the MaxEnt model has better predictability for the presence points with the probability of 989% that confirms its high validity.

Table 2. The percent coverage of the suitable habitats using two different modeling approaches as well as value of the receiver operating characteristic

Class name	MaxEnt			Logistic regression		
	Area (ha)	Percent	ROC	Area (ha)	Percent	ROC
Suitable	994.68	1.03	0.997	1002.78	1.03	0.985
Unsuitable	96442.47	98.97		96434.37	98.97	
Total	97437.15	100		97437.15	100	

Discussion

The ROC criteria were indicating the superior performance of both methodologies in the species habitat modeling (Giovanelli *et al.* 2010). The ROC curve plot the sensitivity (the probability of predicting a real positive will be positive) against 1-specificity (the probability of predicting a real negative will be positive). Among the human-related variables, the highest score has been given to the distance from the Human related landuse (7.1) while the lowest contribution is assigned to the distance from roads (0.2) (Brito 2003). For the ecological variables, the highest contribution rate (46.6), significance (92.9), and distance from the optimum condition (0) are assigned to the presence of the water resources. In contrast, the lowest contribution rate (0.1), significance (0), and the optimum condition (2500 m) are obtained for the height parameter (Lagory *et al.* 2009). Accordingly, among the development variables, the highest effect on the Levantine viper habitat is related to distance from human uses. At the same time, the lowest impact is assigned to distance from the road.

Moreover, among the ecology variables, the highest and lowest impacts are related to distance from water and height, respectively (Luiselli 2006). The most suitable habitats which identified by the models have been located in the Sibak, Chekab, and Latah-Dar where shows variables like dense plant cover, rocky surfaces, far away from traffic roads and human activity centers, closeness to the water resources, slopes with more capability of sunlight absorption, altitude between 1980 and 2250 meters above sea level, the slope of 5 to 10 degrees. These conditions can be found in small parts of the study area where constitute critical parts of the habitat for the target species as well (Pashaeirad *et al.* 2016). Most of the potentially suitable habitat for Levantine viper is located in the core areas of Haftad-Gholleh, which has the lowest human disturbances and the ideal environmental conditions like topography, cover, and food. The Levantine viper in Iran is undoubtedly deserved of intensive research and conservation efforts as they are currently endangered in local scale and case of delay in urgent conservational activities, the local extirpation of the species from the study region is not far-fetched. One of the significant factors which threaten the species viability refers back to habitat fragmentations as a result of human activity and land-use change (Ansari 2009). Knowledge of the ecology of the Levantine viper and its biology should be investigated rapidly to enhance the conservation measures' effectiveness. The phylogenetic status of the target population(s) in Haftad-Gholleh protected area and its genetic peculiarities like genetic diversity highly recommended.

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