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Influence of Environmental Variables on Distribution of Wild Goat (*Capra aegagrus*), in Iraq by Maxent

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Abstract

Wild goat is belonging to bovidae family, genus with species of *Capra aegagrus*. Wild goats are present in different areas of the Zagros range from north-eastern of Iraq for example the large population is located in the Barzan area, then in Qara Dagh Mountains, and Peramagroon Mountains. Maximum Entropy (Maxent) is a presence-only modeling method with a confirmed attested potential to predict wildlife distribution. The aim of this study is attempted to establish the influences of environmental variables on the distribution of Wild goat (*Capra aegagrus*) in Iraq by using the maximum entropy method. A total of 13 Wild goat point localities from the whole Iraq were used as a presence data point as main input to build the species distribution model. The Maxent model predicted potential suitable habitats for Wild goat (*Capra aegagrus*) with performed of high success rates (AUC Training data=0.973). The environmental variables such as, land cover, altitude, precipitation, and temperature has impact on distribution of wild goat in Iraq. The results of this study can be useful as a tool in executing conservation program and wildlife management plans in the future.

Keywords: Wild goat; Maxent model; and Environmental Variables.

1. Introduction

Wild goat is belonging to bovidae family, genus with species of *Capra aegagrus* [1]. According to Weinberg [1] Wild goats are distributed disjointedly from "central Afghanistan and southern Pakistan, west through Iran, western Turkmenistan, northern Iraq, the Caucasus region (Armenia, Azerbaijan, north-eastern Georgia, and southern Russia), as far as south-western Turkey. It once occurred in Jordan, Lebanon and Syria, but is now extinct in these countries.

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It also occurred in Israel before 10,000 ago". This species listed as Vulnerable based on IUCN Red list data in 2013, as a result of over-exploitation, hunting, habitat degradation and fragmentation with spreading disease, 30% of estimated population was declined in last three generation [1].

Wild goats are present in different areas of the Zagros range from north-eastern of Iraq for example the large population is located in the Barzan area, then in Qara Dagh Mountains, and Peramagroon Mountains, the population of wild goat in these areas under threat of decline based on Nature Iraq field survey, which are conducted between 2007 to 2013, and increased fragmentation by uncontrolled hunting, logging and general habitat loss [2]. Maxent is a presence-only modeling method with a confirmed attested potential to predict wildlife distribution. This approach achieves very good in predicting spatial distribution of species data and predicting suitable habitat [3, 4].There are some studies was used model habitat suitability of caprids in Mediterranean areas[5, 6]. Furthermore, in Iran in Dare-Anjir Wildlife Refuge (DWR); Maximum Entropy (Maxent) species geographical modeling technique was used to establish how the presence of wild goat (*Capra aegagrus*) is influenced by environmental variables [7]. However, in Iraq it is the first study that was used to influence of climatic variables on distribution of wild goat by using of Maximum Entropy species distribution modeling. Therefore, the aim of this study is attempted to establish the influences of climatic variables on the distribution of wild goat (*Capra aegagrus*) in Iraq by using the maximum entropy method.

2. Materials and Methods

2.1. The study area

The study area is Iraq and it covers 438317 km2 and located in the south-west Asia continent between 29° 5' and 37° 22' N latitude and 38° 45' and 48° 45' E longitudes [8, 9]. Iraq is bounded by Iran from the east, Saudi Arabia and Kuwait from south, Syria and Jordan from the west and Turkey from the north. A cool rainy winter with hot dry summer is the description of climate of Iraq [10, 11].

2.2. Occurrence data

The occurrence data points for wild goat (*Capra aegagrus*) were obtained by the author in the project called Conservation Leadership Program (CLP) were carried out in the mountains of Qara Dagh, Peramagroon, and Barzan area, Which are collected by Nature Iraq's CLP- team during wild goat survey between 20011-2012 [12-14]. We used 13 data points and we put in to the Geographical Information System (GIS) version 10.2 (http://www.esri.com) [15] To made a layer for presence wild goat distribution. In addition, we put the coordinates to Microsoft excel in order to make a Comma Separated Values (CSV) file which is needed by Maxent program in sample file.

2.3. Environmental dataset

We used 21 Environmental variables to model the potential distribution of the wild goat (*Capra aegagrus*), 19 bioclimatic variables are related to temperature, and precipitation in raster format with 30 -seconds resolutions, which is approximately equivalent to 1-km2 cells (Table 1). I have downloaded Climate Data and Iraq Altitude layer from Global Climate Data website (http://www.Worldclim.org) [16]. These data are a set of climate layers

between (1950-2000 years) that represent information derived from monthly temperature and rainfall obtained from weather stations and then interpolated for illustrating the average value of surfaces with a spatial resolution of 1 km^2 [16, 17] and create more biological significant. World Climate variables are global, so we made the necessary cuts to cover only our country Iraq; by GIS-Arc toolbox-Spatial Analyst Tool. The layers were extracted by mask and rescale to our country. Moreover, they layers were converted from Raster format to ASCII format by conversion tools. The 19 environmental variables were resamples to the WGS84 geographical coordinate system at a resolution of ~1 km2. The Iraq Land Cover (Iraq vegetation layer) was used (Table 2). We downloaded from European Space Agency Glob Cover Portal http://due.esrin.esa.int/globcover. Version 2.3-2009 [18].

Table 1: Environmental Variables used in the model (Decimal degree units: Celsius=°C, millimeter= mm, meter at sea level=m a.s.l)

Code	Unit	Description
Species data	(Decimal degree)	Wild goat presence record data
BIO1	(°C)	Mean annual temperature
BIO2	(°C)	Mean diurnal temperature range [monthly mean (Max temp - Min temp)]
BIO3	(°C)	Isothermally [temperature variability index (P2/P7) (* 100]
BIO4	(°C)	Temperature seasonality (standard deviation * 100)
BIO5	(°C)	Maximum temperature of the warmest month
BIO6	(°C)	Minimum temperature of the coldest month
BIO7	(°C)	Temperature annual range (Max temp of the warmest month - Min temp of the coldest month)
BIO8	(°C)	Mean temperature of the wettest quarter
BIO9	(°C)	Mean temperature of the driest quarter
BIO10	(°C)	Mean temperature of the warmest quarter
BIO11	(°C)	Mean temperature of the coldest quarter
BIO12	(mm)	Annual precipitation
BIO13	(mm)	Precipitation of wettest month
BIO14	(mm)	Precipitation of the driest month
BIO15	(mm)	Precipitation seasonality (coefficient of variation)
BIO16	(mm)	Precipitation of the wettest quarter
BIO17	(mm)	Precipitation of the driest quarter
BIO18	(mm)	Precipitation of the warmest quarter
BIO19	(mm)	Precipitation of the coldest quarter
Alt	(m a.s.l.)	Altitude of Iraq
Land cover	Land cover classes	Types of vegetation as land cover for Iraq (See Table 2)

Table 2: Land cover of Iraq [18]

NO.	Value	Types of Land cover in Iraq
1.	14	Rain fed croplands.
2.	20	Mosaic cropland (50-70%) / vegetation (grassland/shrub land/forest (20-50%).
3.	30	Mosaic vegetation (grassland/shrub land/forest (50-70%) / cropland (20-50%).
4.	60	Open (15-40%) broadleaved deciduous forest/ woodland (>5m).
5.	70	Closed (>40% broadleaved evergreen forest (>5m).
6.	110	Mosaic forest or shrub land (50-70%) / grassland (20-50%).
7.	120	Mosaic grassland (50-70%) forest or shrub land (20-50%).
8.	130	Closed to open (>15%) (Broadleaved or needle leaved evergreen or deciduous) shrub land (<5m).
9.	150	Sparse (<15%) vegetation.
10.	180	Closed to open (>15%) grassland or woody vegetation on regularly flooded or waterlogged soil-Fresh, brackish.
11.	190	Artificial surface and associated areas (Urban area >50%).
12.	200	Bare areas
13.	210	Water bodies

2.4. Developing the model

We applied the maximum entropy algorithm from Maxent version 3.3.3k (downloaded on 29 January 2016 on (http://www.cs.princeton.edu/~schapire/Maxent) To make the potential distribution model of wild goat (*Capra aegagrus*), to present data only, based on the climatic variables [3]. We run the Maxent model with default settings: auto features, maximum iteration 500, and converge threshold (10-5), while random test percentage was set to 25%, which is used 3 data point for modeling in this study. The program carried out the random test percentage automatically where 75% of the occurrence data points were randomly selected to train the model, which are 13 data points in this study, and the remaining 25% occurrence data points were used to test against the general model. The program selected suitable regularization values, included to reduce over fitting, automatically. Choosing environmental variables were also selected automatically. Maxent gives a probability

of existence to each cell in the survey area. Since these probabilities must sum to 1, each cell's probability is usually very small, making model output hard to interpret.

2.5. Evaluating the model

We used Receiver Operating characteristic (ROC) curves, to evaluate the model performance. It is a standard threshold-independent method used for model evaluation and it is one of the Maxent output option [19, 20]. Furthermore, based on predicted area, the Maxent generate a single measure of model produce to evaluate the accuracy of the model and how the model good in fit. The model is over fitted if the valued close to 1, and the model is not better than expected at random if the value close to 0.5 [20]. Jackknife test is another Maxent achievement to evaluate the environmental variables' contribution to the model to recognize the impact of each variable on the gain of the model; if they are correlated they are used in isolation or are omitted. Furthermore, there are additional methods used to evaluate all the presence/absence models which are prediction errors; false negatives, and false positives, the former false negatives are an omission error under prediction rate and the later false positives are a commission error upper prediction rate [21].

3. Results and Discussion

A total of 13 wild goat point localities from the whole Iraq were used as a presence data point as main in put to build the species distribution model. Area Under Curve (AUC) are classified in to three parts: AUC Values 0.9 =very good, 0.8=good and 0.7= useful [22]. The Maxent model predicted potential suitable habitats for wild goat (*Capra aegagrus*) with performed of high success rates, according to Swets [22] Our result is very good because the AUC Test data=0.977; AUC Training data=0.973, which are better than random prediction at 10 percentiles training presence at threshold of 0.490 with standard deviation 0.007 [23]. The probability of getting 30% (0.3) of testing omission rate based on fractional predicted area 0.037(3.7%) of the test has been successful and was highly significant ($P < 0.005$, and $P = 4.041E\text{-}3$) [19, 24]. The Prediction of wild goat by Maxent is ranged from 0 to 1; the red color is much more predicted of wild goat by Maxent and equal to 1 and it is suitable habitat to distribution of wild goat, while the blue color is equal to 0, which is unsuitable habitat for wild goat distribution (Figure 1, right figure). But, after reclassify the predicted area at 10 percentile, because we are not certain 100 per cent of the dataset [3, 24]. The suitable habitat is shrink to smaller area and more accurate, the black color is suitable habitat and the grey color is unsuitable habitat to distribution of wild goat (Figure 1, left figure).

According to the response curve of our result, the land cover is very important to prediction presence of wild goat in Iraq, it shows that the present of wild goat in mosaic cropland (50-70%) / vegetation (grassland/shrub land/forest (20-50%) is very high, while in bare areas is very low (Figure 2a). Because, the wild goat is herbivorous animal therefore it accepted that its very high population in vegetation areas [1, 7]. Furthermore, the precipitation of the coldest quarter _BIO19 has positively correlated on the distribution of the wild goat. The presence of wild goat is increased from 100 mm to 550 mm with increasing the precipitation of the coldest quarter (which is the winter season in Iraq), but its stable after 550mm precipitation/season (Figure 2b). The winter precipitation in Kurdistan Region is higher than the rest of the country [9].

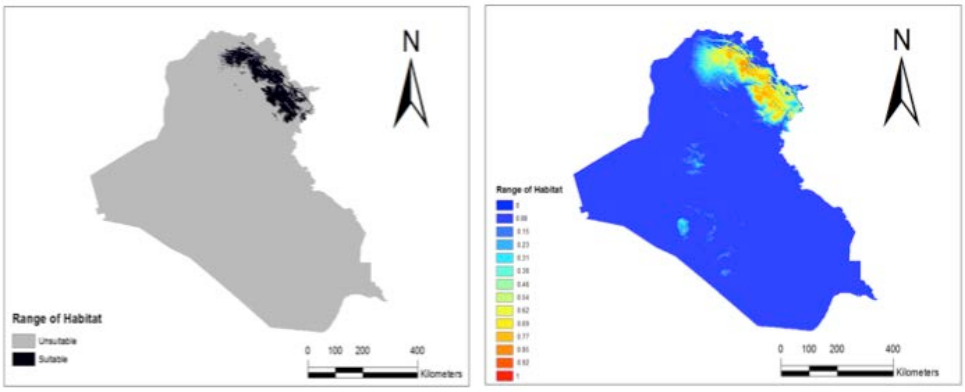

Figure 1: Result from Maxent, right figure before reclassified of predicted suitable habitat for wild goat in Iraq with value range from Maxent between 0-1, left figure after reclassified of values with 10 percentile training presence, predicted suitable habitat (black) and unsuitable habitat (grey).

Therefore the distribution of wild goat is more presence in Kurdistan Region than other parts of Iraq [10]. Moreover, the minimum temperature of the coldest month _BIO6 (January is the coldest month in Iraq) [9] Has impact on the presence of wild goad and it rose from -50°C until it reaches the maximum value in the 0°C then it declined to the 50°C afterwards its stable (Figure 2c). Additionally, the Altitude has influence on distribution of wild goat. The presence of wild goat prediction is high in height altitude while in low altitude is low; according to the Maxent prediction; the maximum distribution of wild goat is between 1500-2500 meters at sea level (Figure 2d). According to Morovati [7] In Iran they are distributed at height between 100-2600 meters at sea level.

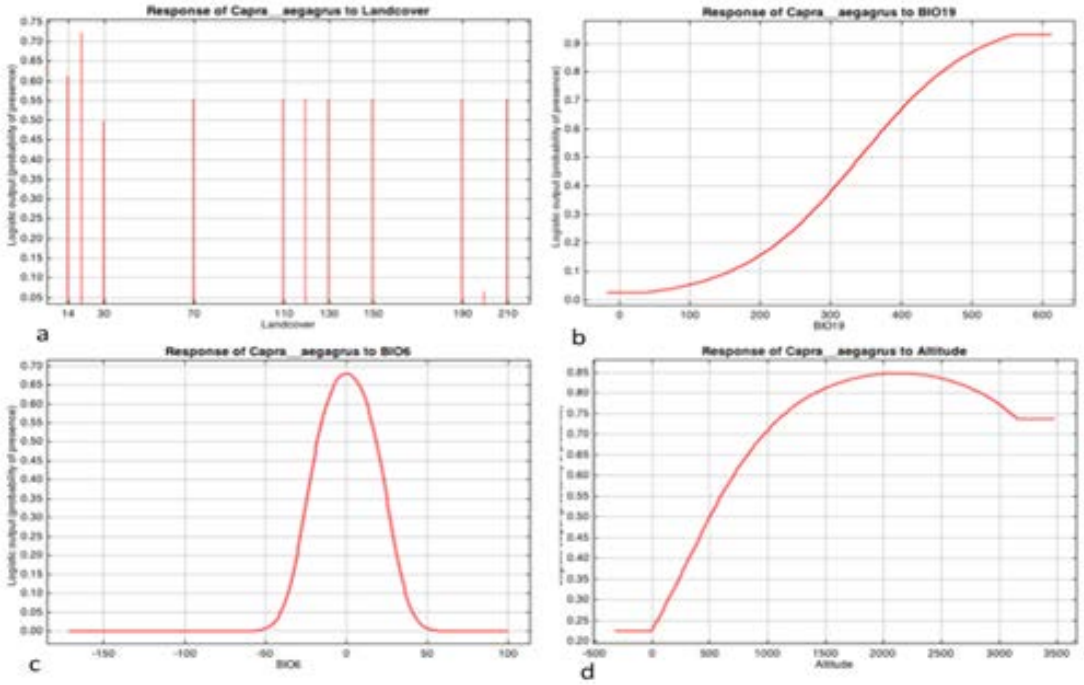

Figure 2: (a) Response curve for Land cover, (b) Precipitation of the coldest quarter _BIO19, (c) Minimum temperature of the coldest month _BIO6 and (d) Altitude with probability of presence of Wild goat.

The environmental variables have estimate relative percentage contribution to the Maxent model. Such as land cover, Precipitation of the coldest quarter_ BIO19, Minimum temperature of the coldest month _BIO6, Precipitation of the wettest quarter_BIO16, Precipitation seasonality (coefficient of variation) _BIO15, Temperature annual range (Max temp of the warmest month - Min temp of the coldest month) _BIO7, Precipitation of the driest quarter _BIO17 and so on with the percentage contribution of 32.1%, 20.3%, 12.4%, 9.9%, 9.2%, 6.1% and 4.2% consequently (Table 3). The following picture shows the results of the jackknife test of variable importance. The environmental variable with highest gain when used in isolation is Precipitation of the coldest quarter _BIO19, which therefore appears to have the most useful information by itself. The environmental variable that decreases the gain the most when it is omitted is Minimum temperature of the coldest month _BIO6, which therefore appears to have the most information that isn't present in the other variables (Figure 3).

Table 3: Relative contributions of the environmental variables to the Maxent model

Variable	Percent contribution	Permutation importance
Land cover	32.1	0
BIO19	20.3	0
BIO6	12.4	68.2
BIO16	9.9	0
BIO15	9.2	18.2
BIO7	6.1	11.3
BIO17	4.2	0
BIO13	1.9	1
BIO3	1.9	0
BIO2	0.9	1.2
BIO4	0.7	0
BIO8	0.4	0
BIO18	0	0
BIO5	0	0
BIO14	0	0
BIO9	0	0
BIO12	0	0
BIO11	0	0
BIO10	0	0
BIO1	0	0
Altitude	0	0

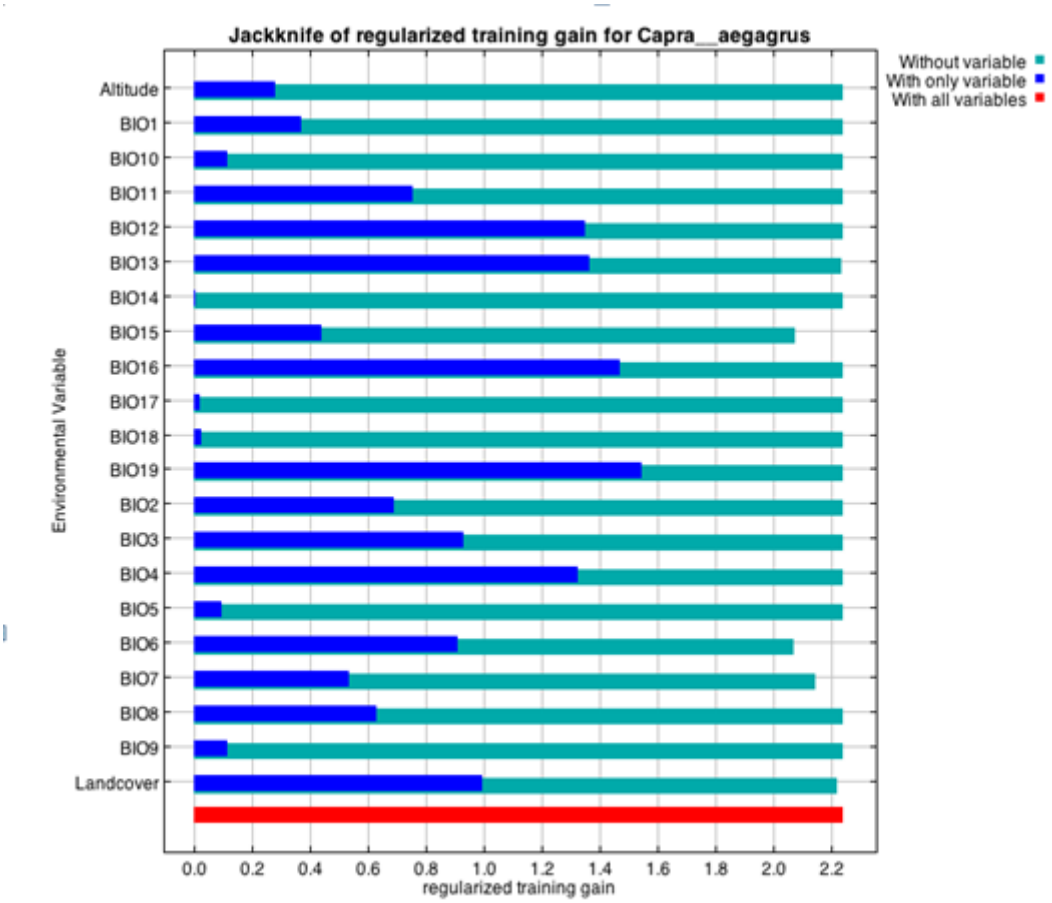

Figure 3: Gains of the variables in the Maxent model (jackknife test). Torques bars: model gain without the corresponding variables; blue bars: model gain with only the corresponding variables; red bars: total gain using all the features.

4. Conclusion

Wild goat is one of the vulnerable species of the world. They are disperses across the Zagros Mountains range in the Kurdistan Region of Iraq. Excessive hunting, habitat loss, declines the populations and logging based on Nature Iraq's field survey were conducted in Barzan area, Qara Dagh Mountain, and Piramagron Mountain between 2007-2013 [2]. To find the impacts of environmental variables on wild goat distribution in Iraq; we used the Maxent model which is a presence model method used to predict species distribution [3, 4].

The result of Maxent prediction to presence of wild goat in Iraq is located in the mountainous region of the country. Its shows very good in prediction and the environmental variables such as land cover; Mosaic cropland (50-70%) / vegetation (grassland/shrub land/forest (20-50%) particularly, altitude, precipitation of winter season and minimum temperature of coldest month have influences on distribution of wild goat. These results can be used in the future conservation project and environment management.

I believe that the temperature, rain fall, altitude, land cover have impact on the distribution of wild goat because of it is a herbivores, rain and temperature have effect on growing the grass and shrub and they have positive

correlation between them. The more growing grass with suitable temperature and rain fall the more wild goat presence in that location regarding the altitude.

5. Recommendation

Wild goat listed as threatened species by IUCN [1] Therefore, protection of them are required by Iraqi Government or Kurdistan Region Government. There are some recommendations that the governments should be considered to implement the conservation of wild goat from declining.

- Establish a powerful role to regulate the hunting and poaching and controlling the hunting of wild goat from hunter by supporting forest police.
- Controlling and prevent their habitats from disturbance by preventing visiting picnicker to the sites, which is common by local people and controlling logging.
- Controlling diseases when spread it especially Peste Des Petits Ruminants Virus (PPRV) as happened as in 2010 and 2011 when 750 death found at Barzan area [25].

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