RESEARCH ARTICLE OPEN ACCESS

Identification of Priority Areas for the Conservation of Tlalcoyote (*Taxidea taxus*) Habitat in Mexico

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Abstract:

The present work proposes to model the ideal habitat of *T. taxus* throughout the Mexican territory, for which 131 georeferenced records of the presence of the species were obtained. 19 climatic variables updated for Mexico were used in addition to environmental variables such as vegetation, altitude and soil (pH and texture). 1,000 iterations were applied with Clog-log type regressions. Statistical validation was performed with 25% of the data with the Cross-validate technique. The Area Under the Curve (AUC) values for the estimated and validated data were 0.811. The variables that most influenced the presence or absence of the taxon were the use of soil and vegetation with 25.6%, the average temperature of the coldest quarter with 16.7%, the Precipitation of the wettest quarter with 12.8% and the minimum temperature of the coldest month with 10.2% the sum of these three variables represents 65.3% of the total contribution to the model. The potential distribution obtained by modeling with MaxEnt allows generating spatial information of the ideal habitat in which *T. taxus* develops. This information provides essential elements for the identification and possible establishment of areas for the conservation of the species.

Keywords **—*Taxidea taxus*, MaxEnt, Habitat, Potential distribution**.

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I. INTRODUCTION

The biological diversity of species present in our country is the result of its favoured geographical position where the biogeographic provinces known as Nearctic and Neotropical converge and interact (Ceballos *et al*., 2009), in addition, the physical and biological characteristics has been divided in19 biogeographic regions with particular characteristics (Morrone, 2019). This complex topography, the variety of climates and various abiotic factors make up a diverse mosaic of environmental conditions thatpromote the development of a rich diversity of plant and animal species of different origins (Sarukhan *et al*., 2009).

In Mexico there is an interest in knowing the state of wildlife,in particular of those species that has great importance for conservation (Hernández-Silva *et al*., 2018). In this sense, this type of studies focused in identification of habitat and species distribution.Those studies offer geographic scenarios with greater location certainty in order to meet the objective of long-term biological conservation with the optimization of human and economic resources (Cuervo and Monroy, 2012).

The Tlalcoyote (*Taxidea taxis*) is medium to large in size, plump and strong body, flattened head with a short neck and almost as wide as this, short and rounded ears, small eyes covered by a nictitating membrane; tail short and stiff with a white tip; like all mustelids they present anal glands; the limbs are short with long curved claws in the forefoot and short shovel-shaped claws in the hindquarters which have the fingers partially joined with a membrane and are black. The skin is projected laterally, making the animal see wider than it is (Alzate, 2013; Jiménez-Guzmán and List, 2005). The hair on the back has three colors, yellow at the base, black in the middle and white at the ends, which gives it a greyish tone; the ventral region is yellowish; the neck, the lower jaw, the throat, the cheeks and the flanks are whitish; they have a black patch with a triangular shape between the eye and the ear and two parallel black bands from the nose to the base of the skull (Gómez-Nísino, 2006).

The Tlalcoyoteis the only truly burrowing carnivore in North America, they use burrows year-round, either as a resting place during the day, a food store, foraging and calving sites. Burrows are dug by themselves or modified from other animals. Mating occurs in the summer and early fall. They give birth from one to five young between March and April, they are solitary and mainly nocturnal, but they can be active at any time of the day. This species does not hibernate, but they do significantly reduce their activity, remaining in their burrows during the winter and in response to the availability of prey. They are adapted to capture burrowing prey, so their main food is made up of rodents such as ground squirrels (*Spermophilus*spp), prairie dogs (*Cynomys*spp) and gophers (*Geomys*spp), as well as other mammals, birds, reptiles, insects and carrion opportunistically. (Oliva, 2005).

In Mexico it lives in semi-arid open areas such as grasslands, mesquite and mesquite-grassland scrub, and pine oak forest, it is found from sea level to elevations above 3,660 meters above sea level. It is an efficient regulator of the rodent populations on which it feeds and its burrows serve as a refuge for many other animals when they are abandoned (Ceballos and Oliva, 2005; Jiménez-Guzmán and List, 2005).

Currently, there are few studies focused on the identification of species habitat under any category of conservation risk, such is the case of *T. taxus* that is under the protection status with the category of Threatened by Mexican laws (NOM-059 - SEMARNAT, 2010). Therefore, this work aims to identify the areas with the greatest potential to provide the ideal habitat for *T. taxus* throughout the Mexican territory, taking climatic and environmental variables, in order to promote actions to promote its conservation.

II. MATERIALS AND METHODS

Species registration

The entire Mexican territory was taken as the basis for the search for records of the species, which is located between parallels 14 ° 33 'N and 32 ° 43' N and between meridians 86 ° 46 'W and 118 ° 20' W, with a territorial extension of 1,964,375 Km^2. An intensive exploration was carried out on the documented records of the presence of *T. taxus*, which generated a database with the location in geographic coordinates (longitude and latitude). The data were obtained from scientific articles (Lavariega*et al*., 2017; González-Christen*et al*., 2006; Barcénas*et al*., 2009), in addition to the Global Biodiversity Information Facility (GBIF, 2021), National Commission for the Knowledge and Use of Biodiversity (CONABIO, 2021), Institute of Biology of the National Autonomous University of Mexico (IBUNAM, 2021), Distributed Databases withBackbone (VERTNET,2021).

Data processing

The information collected was stored in a database and through the help of the geographic information system (GIS) ArcMap 10 (ESRI, 2013) the spatial location of each of the records obtained was displayed. A total of 131 records were obtained, each record was associated with climatic values obtained from Cuervo-Robayo*et al*.(2013) (https://idrisi.uaemex.mx/) and environmental data obtained from the vectors provided by INEGI. For the soil use and vegetation layer series VI (INEGI, 2017) with scale 1: 250,000 and the edaphological layer series III (INEGI, 2014) with scale 1: 250,000; as well as a digital terrain elevation model (MDE), scale 1: 250,000 (INEGI, 2021).

Data transformation

The vector data was loaded into the GIS for its transformation to a raster type format by means of an interpolation of points, giving it a spatial resolution of 1 Km^2 per pixel to match the resolution present in the climatic variables. Subsequently, the files were converted to ASCII format to be able to manipulate them in the MaxEnt software, which allows the modeling of the geographic distribution of the species based on the maximum entropy. The model obtained gives a potential probability of suitability with values ranging from 0 to 1, where zero means little or no probability for the occurrence of the species and 1 means the highest probability of detection of the species.

Table 1. Climatic and environmental variables used for modeling the habitat of T. taxus.

Variable	Description
BIO1	Average annual temperature
BIO2	Daytime mean range (monthly average (maximum and minimum temperature))
BIO3	Isotherms (P2 / P7) (* 100)
BIO4	Seasonal temperature (δ * 100)
BIO5	Maximum temperature of the coldest month
BIO6	Minimum temperature of the coldest month
BIO7	Annual temperature range (P5-P6)
BIO8	Temperature of the wettest quarter
BIO9	Average temperature of the driest quarter
BIO10	Average temperature of the hottest quarter
BIO11	Average temperature of the coldest quarter
BIO12	Annual rainfall
BIO13	Rainfall of the wettest month
BIO14	Precipitation of the driest month
BIO15	Seasonal Precipitation (Coefficient of Variation)
BIO16	Rainfall of the wettest quarter
BIO17	Precipitation of the driest quarter
BIO18	Warmest Quarter Precipitation
BIO19	Coldest Quarter Precipitation
USV.	Land use and vegetation
Texture	Soil texture
pH	Soil pH
Altitude	Height above sea level

Modelling in MaxEnt software

To determine the potential habitat of *T. taxus*, the MaxEnt program (Phillips *et al.* 2006) was used, which generates a probability distribution of the pixels in a grid, starting from the uniform distribution, repeatedly improving the fit of the data. The gain is defined as the average log probability of the presence samples, minus a constant that makes the uniform distribution have zero gain. At the end of the run, the gain indicates how concentrated the model is around the presence samples (Phillips *et al.* 2004 and Phillips *et al.* 2006). For the simulation, 1,000 iterations with Cloglog-type regression were applied, and statistical validation was performed with 25% of the data with the Cross-validate technique and 50 replications. In order to estimate which are the most important variables in the model, a jackknife test was run (Phillips *et al.* 2004).

III. RESULTS AND DISCUSSION

Identified records

131 records were obtained from the consulted literature of which, the largest records are found in the northwest of the country, mainly in the states of Baja California, Baja California Sur, Sonora, Chihuahua and Durango, it was also observed that there are several states that do not count with no records mainly in Mexico western and south-eastern.

Figure 1. Registry of the presence of *T. taxus* in the Mexican Republic.

Priority areas for T. taxus conservation

The model obtained by MaxEnt yielded a potential probability of habitat suitability for the Tlalcoyote that was classified in 4 ranges from 0 to 0.25, it is considered a low or null probability of occurrence, from 0.25 to 0.50 a medium probability, from 0.50 to 0.75 a probability high and 0.75 to 1 the highest probability of occurrence of the species (Figure 2).

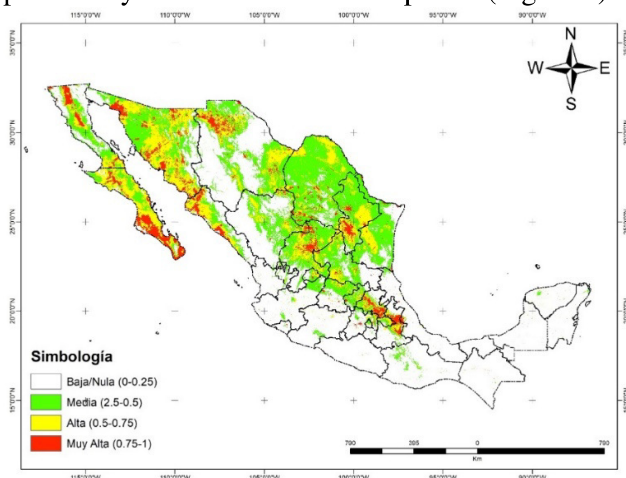

Figure 2. Potential habitat distribution of *T. taxus* by probability ranges.

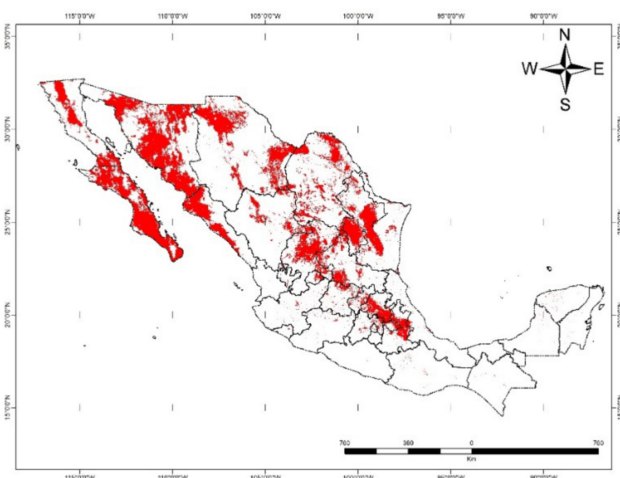

Figure 3. Priority areas for the conservation of the habitat of *T. taxus* in the Mexican Republic.

A probability greater than 0.5 was taken to determine the priority areas for the conservation of the habitat of *T. taxus* (Figure 3) as other authors have done (ManzanillaQuiñones*et al*., 2019, Méndez *et al*., 2020 and Palma-Cancino, 2020). Where the largest surface area is located in the states of Baja California Sur, Sonora, Hidalgo, Sinaloa, Zacatecas and Nuevo León, but in general the center and north of the country are the surfaces with the best characteristics for the establishment of conservation areas of the species.

Presence or absence of the taxon

The values of the Area Under the Curve (AUC) for the estimated and validated data were 0.811, which are considered good, considering what Araujo and Guisan (2006) establish in their classification of precision of the models. The variables that most influenced the presence or absence of the taxon were: the use of soil and vegetation with 25.6%, the average temperature of the coldest quarter with 16.7%, the Precipitation of the wettest quarter with 12.8% and the minimum temperature of the coldest month with 10.2%, the sum of these three variables represents 65.3% of the total contribution to the model.

Potential habitat model for T. taxus

In general, the potential habitat model for *T. taxus* shows that variables such as the type of vegetation considerably influence the presence / absence of it, according to Oliva, 2005 the vegetation of open semi-arid areas such as grasslands, shrubs of Mesquite and mesquite-grassland, in addition to pine and oak forests are preferred by the species, which are also distributed in the areas identified by the model, on the other hand, low temperatures and little precipitation strongly determine the increase or decrease in area potentially occupied by the species. *T. taxus* is a burrowing species and burrows below the surface of the earth (Alzate, 2013), so it was expected that variables such as pH (0.8%) and soil texture (1.0%), would have a strong influence on its distribution, but it was not. The variable that most contributes to the model was the use of land and vegetation (25.6%), it should be noted that vegetation is one of the variables most continuously affected by various anthropogenic activities, among which changes in land use stand out.

Habitat modeling turns out to be an effective tool to identify potential sites for the conservation of species under some risk status in NOM-059, but particular information still needs to be generated to obtain more accurate models, since the variables that define the distribution of some species can vary over time. It is worth mentioning that within the variables used, no variable that presented any interspecific interaction was included, in this sense Messick, (1981) mentions that the distribution of *T. taxus* and its activity depends on the presence of underground rodents. Therefore, to improve the model, it is desirable to feed it with the potential distribution variables of its main prey, in this case the genera *Cynomys* (rairie dogs) and *Spermophilus*(ground squirrels).

IV. CONCLUSIONS

Research on the species habitat modeling is being increasingly popular by the scientific community in Mexico, MaxEnt continues to be one of the most used tools for the spatial representation of species and their habitat, in this sense the potential distribution obtained in this study for the Tlalcoyote (*T. taxus*), provides essential information for the identification and the possible establishment and management of conservation areas of the species. However, field work in the identified areas is essential since this represents a first, large-scale approach that facilitates decision-making for the management of the species.

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