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Realized ecological niche of the Mexican Spotted Owl (*Strix occidentalis lucida*) in Mexico

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ABSTRACT

Objective: To characterize the realized niche of the Mexican spotted owl (*Strix occidentalis lucida*) and compare the environmental values it uses within the Mexican physiographic provinces.

Design/methodology/approach: The environmental temperature variables (n=7), precipitation (n=7) and elevation (n=1) were extracted from 79 unique occurrences sites of *S. o. lucida*. These values were grouped by physiographic provinces: Sierra Madre Occidental (n=59), Sierra Madre Oriental (n=13) and Transverse Neovolcanic Belt (n=6). The climate and elevation of these sites were described and compared *via* non-parametric Kruskal-Wallis and Bonferroni-Dunn tests ($P \leq 0.05$).

Results: The presences of the spotted owls were both, dispersed and focally distributed, over the geographic space in Mexico. The temperature and elevation variables have similar characteristics in the assessed physiographic provinces. To be noted, the precipitation variables showed significant differences among sites.

Limitations on study/implications: This study describes the environmental characteristics of the realized niche of the Mexican spotted owl; however, it is necessary to investigate other habitat variables at a smaller scale.

Findings/conclusions: The temperature and elevation environmental characteristics of the ecological niche of the Mexican spotted owl was similar between physiographic provinces.

Keywords: Realized niche, climate, elevation, Mexican Spotted Owl.

INTRODUCTION

Resource availability and environmental conditions vary across a species range (Gaston, 2009), with differences especially marked in widely distributed species (Brown *et al.*, 1996). Under Hutchinson's (1957) concept, these differences can be observed by contrasting realized niche characteristics (N_R).

Image by Jim Kennedy at Pixabay

The N_R is defined as the set of biotic and abiotic factors that allow a specie's presence (Vázquez, 2005). In this sense, studies investigating it are scarce and focus on occupancy predictive models (fundamental ecological niche) derived from climatic, vegetation and elevation variables (Palma-Cancino *et al.*, 2020), in large regions at spatial resolutions of approximately 1 km^2 (Sutton *et al.*, 2020). This misinformation is accentuated in poorly observed species (Pearce and Boyce, 2006) which in turn, limits the available information to establish management and conservation measures for these species (SEMARNAT, 2010; USFWS, 2012).

The N_R characteristics are not clear in elusive birds with wide and discontinuous distributions such as the Mexican Spotted Owl (MSO; *Strix occidentalis lucida*). The MSO inhabits forests, from the southwestern United States to the physiographic provinces: Mexican Sierra Madre Occidental (SMO) Sierra Madre Oriental (SMOR), and the Transverse Neovolcanic Belt (TNB) (USFWS, 2012). This subspecies is listed in Mexico as threatened (SEMARNAT, 2010) and globally as near threatened (BirdLife International, 2020).

For the MSO, forest loss and fragmentation have been the main threats to its populations (Wan *et al.*, 2018), which has led to their habitats being the most studied ecological attribute of this raptor (Salazar-Borunda *et al.*, 2020).

Despite substantial evidence suggesting the wide range of environments used by MSO (Bowden *et al.*, 2015; Hoagland *et al.*, 2018; Silva-Piña *et al.*, 2018), studies explicitly quantifying and comparing the N_R between geographically distant populations are not available. Considering that the description of the environmental characteristics of the sites where this bird inhabit will enrich the available information to those responsible for their management and conservation, the objectives of this work were: i) to characterize the N_R of MSO in Mexico and ii) to compare their used environmental variables between Mexican physiographic provinces.

MATERIALS AND METHODS

Study area

The study area was defined as the range of the MSO distribution area in Mexico and included the physiographic provinces of importance for their conservation: Sierra Madre Occidental (SMO), Sierra Madre Oriental (SMOR) and the Transverse Neovolcanic **Belt** (TNB) (USFWS, 2012). This constitutes a continental surface of 733 131 km^2 and contains diverse climatic groups (De Alba and Reyes, 1998).

Occurrence data

The presences of MSO perch sites in Mexico were obtained from the Global Biodiversity Information Facility platform (GBIF, 2019; 83 points) and field observations collected between 2018 and 2020 (25 points). Repeated coordinates and with georeferencing error were removed from the database, using *spThin* (Aiello-Lammens *et al.*, 2015) and *remove.duplicates* (Pebesma and Bivand, 2005) in the R statistical software (version 4.0.5, R Core Team, 2021).

Environmental characteristics

Climate and elevation variables were obtained from WorldClim (version 2.1, Fick and Hijmans, 2017) at 30 arc-seconds (~1 km^2) of spatial resolution. The climate data represent the annual patterns of temperature (mean annual, maximum of the warmest month, minimum of the coldest month, the mean temperature of the wettest, driest, warmest, and coldest quarters) and precipitation (annual and of the wettest, driest, warmest, and coldest months).

Characterization of the ecological niche

The environmental (climatic and elevation) and presence variables were projected to the geographic space in QGIS (version 3.4.15, QGIS, 2018). To extract the environmental values for each presence point, the *Point Sampling Tool* add-on was used. These values were grouped by province into three groups: a) SMO, b) SMOR and c) TNB.

Statistical analysis

Descriptive and dispersion statistics were calculated for the environmental variables. All statistical analyses were performed in the R statistical software (version 4.0.5, R Core Team, 2021) with an $\alpha=0.05$ significance level. In this phase, the normality of the data series was tested with the Kolmogorov-Smirnov test and the homogeneity of variance with the Levene test. To compare the environmental variables between groups, the Kruskal-Wallis and Bonferroni-Dunn nonparametric tests were used.

RESULTS AND DISCUSSION

Occurrence data

Seventy-nine records of the MSO presence were obtained (Figure 1).

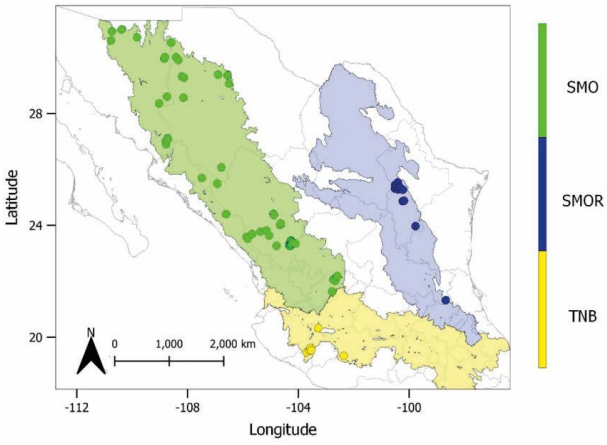

Figure 1. Occurrences of the Mexican spotted owl (points) in the Sierra Madre Occidental (SMO), Sierra Madre Oriental (SMOR) and Transverse Neovolcanic Belt (TNB) provinces.

The physiographic province with the most spotted owl records in Mexico was the SMO (n=59), followed by the SMOR (n=13) and TNB (n=6). It appears that the observations

are distributed in a dispersed manner over the geographic space of the province with the most records and in a focal manner in the other two (in which there are probably poorly explored areas).

Realized ecological niche (N_R)

The N_R of MSO was characterized from environmental variables derived from temperature (n=7), precipitation (n=7) and elevation (n=1) in the physiographic provinces of importance in owl conservation (Table 1).

Table 1. Environmental ranges used by *Strix occidentalis lucida* in Mexico. All temperature variables are expressed in °C, precipitation in mm and elevation in masl.

Environmental variables	Physiographic provinces		
	SMO	SMOR	TNB
Annual mean temperature	10.50 - 24.11	10.35 - 24.00	10.45 - 20.78
Maximum temperature of warmest month*	23.00 - 38.90^{ac}	20.00 - 34.10^{b}	19.20 - 31.30^{ab}
Minimum temperature of the coldest month**	−4.9 - 12.10^{bc}	0.6 - 12.3^{ab}	1.0 - 8.4^{ac}
Mean temperature of wettest quarter	14.15 - 28.15	12.21 - 16.80	11.85 - 22.45
Mean temperature of driest quarter	8.0 - 24.27	7.90 - 19.08	9.75 - 19.51
Mean temperature of warmest quarter	15.06 - 29.31	12.64 - 27.60	12.30 - 22.81
Mean temperature of coldest quarter**	3.81 - 20.21^{a}	7.43-19.08	7.96-18.00
Annual Precipitation**	406 - 1247^{a}	462 - 1805^{b}	924 - 1342^{c}
Precipitation of wettest month **	101 - 289^{a}	75 - 335^{b}	207 - 282^{c}
Precipitation of driest month**	2 - 15^{a}	12 - 49^{bc}	1 - 10^{ac}
Precipitation of wettest quarter**	271 - 763^{a}	206 - 764^{b}	556 - 774^{c}
Precipitation of driest quarter**	11 - 55^{a}	45 - 152^{b}	12 - 38^{c}
Precipitation of warmest quarter**	206 - 673^{a}	169 - 681^{b}	403 - 542^{a}
Precipitation of coldest quarter	24 - 185	47 - 152	24 - 85
Elevation	353 - 2835	270 - 3555	1255 – 3300

Environmental variables (minimum value - maximum value) of the ecological niche of the Mexican Spotted Owl in the Mexican physiographic provinces: Sierra Madre Occidental (SMO), Sierra Madre Oriental (SMOR) and Transverse Neovolcanic Belt (TNB). **P≤0.01; *P≤0.05 (Kruskal-Wallis). Different literals indicate significant differences between sites (Bonferroni-Dunn, P<0.05).

The results suggest that MSO distributes in diverse environments. Some N_R variables are different among provinces (Figure 2); apparently, temperature extremes in short periods (maximums at the hottest and coldest months) and precipitation variables are characteristics that differ among realized niches.

Precipitation has been positively associated with the availability of trophic resources and, in turn, with the reproductive efficiency and survival of this raptor (Seamans *et al*., 2002). In this study, the precipitation variables differed among sites, reflecting that the Mexican spotted owl may be more tolerant to this variable's fluctuation.

On other hand, the mean annual temperature and elevation are characteristics in common among N_R and probably determinant for site occupancy by the MSO. In this sense, the predictive importance of the temperature and elevation variables on this

subspecies potential distribution was reported by Palma-Cancino *et al.* (2020), these, in turn, are associated with the MSO's thermoregulatory mechanisms (Ganey, 2004). Although the average elevation (2160 masl) of the sites coincides with the rugged topography described for the subspecies (Tarango *et al.*, 1997; Tarango *et al.*, 2001; May *et al.*, 2004), it seems that this owl is distributed in areas with a lower altitude than the reported minimum (2072 masl; Young *et al.*, 1997).

This research demonstrates that N_R analysis is an important tool to understand the environmental conditions in which widely distributed birds of prey inhabit and, at the same time, strengthen the knowledge of sensitive and understudied species. Therefore, this research provides a framework to explore other variables of the environment occupied by the MSO, *i.e.*, the description of the biotic and abiotic interactions and their impact on the population dynamics of the subspecies.

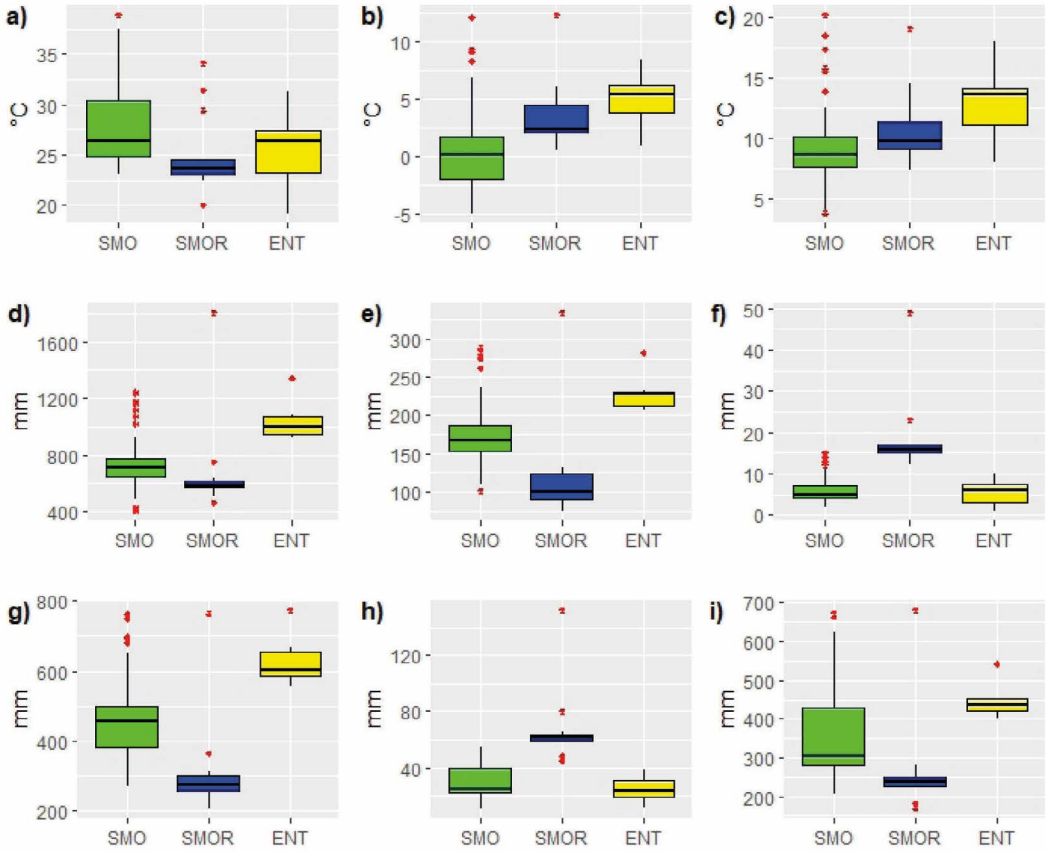

Figure 2. Environmental variables of Mexican Spotted Owl occurrences in the phisiographic provinces: Sierra Madre Occidental (SMO), Sierra Madre Oriental (SMOR) and Transverse Neovolcanic Belt (TNB). Variables derived from temperature (°C): a) maximum of the warmest month, b) of the coldest month, c) mean of the coldest quarter, and variables derived from precipitation (mm) d) annual e) mean of the wettest month, f) driest month, g) the wettest quarter, h) driest and i) warmest quarter.

CONCLUSIONS

The climatic and elevational characteristics of the N_R of the Mexican spotted owl (*Strix occidentalis lucida*) in Mexico were described. The Mexican physiographic

provinces of importance for the conservation of this raptor have similar temperature and elevation ranges. However, the relation between this bird's presence and the environment is undoubtedly more complex. The generated data provide a general description of the thermal, elevational and precipitation regimes of this subspecies. They also provide a framework for exploring other N_R variables of this subspecies at a smaller scale.

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