Habitat characteristics of the Montezuma quail (*Cyrtonyx montezumae* Vigors 1830) in Durango, Mexico

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ABSTRACT
Objective. To characterize the habitat of the Montezuma quail (*Cyrtonyx montezumae*) in Rancho Chapultepec, Durango, Mexico.
Design/Methodology/Approach. From February to October 2020, fieldwork was carried out to search for Montezuma quail sites using transects and sounds. Subsequently each site-of-use was characterized; for each of them three random sites were located. Intercept lines (or Canfield), embedded frames, and nearest neighbour techniques were used. Recorded data were analysed using Principal component analysis (PCA); Frequency of observation (FO); Kruskal-Wallis; and Poisson regression (PR).
Results. The PCA showed values for sites of use=48, non-use=43, and both=36 of the present variability in vegetation-habitat variables. FO showed values per site of use=6.25%; non-use=2.08% and both=1.56%; and per species in sites of use=3.57, non-use=3.85 and both=3.33%. Kruskal-Wallis exhibited significant differences in richness and abundance and similarity in diversity. Poisson regression (PR) showed the effect of some vegetation-habitat variables on the Montezuma quail.
Limitations /Implications of the study. The monitoring period evaluated only comprised a short space of time. It is suggested to extend the sampling time, allowing to visualize the population fluctuation regarding this variable.
Findings/Conclusions: It was possible to determine that there is an association between the variables of the vegetation-habitat with the presence of *C. montezumae*. Vegetation type is the variable that determines the incidence of this species.

Keywords: birds, quail, scrubland, herbaceous vegetation, grassland.

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INTRODUCTION

The grasslands of arid and semi-arid areas of Mexico comprise approximately 128.3 million ha; they are sustenance for domestic livestock and wildlife (Jurado-Guerra *et al.*, 2004). However, this type of vegetation faces varying degrees of deterioration, affecting bird communities, modifying their richness, diversity and reducing their population size.

The Montezuma quail (*Cyrtonyx montezumae* Vigors 1830) has ecological importance in forest, arid and semi-arid environments (Sánchez *et al.*, 2011). These environments are

found in the state of Durango, where 28.73% of its land extension is occupied by the Valley Region with the presence of natural grasslands (González *et al.*, 2007). Rancho Chapultepec is located in those valleys, an arid region where there is evidence of the natural distribution of this quail.

This study characterizes the habitat of the Montezuma quail in a representative area of the Valles de Durango region, within the Rancho Chapultepec, through the following objectives: to characterize the habitat of the Montezuma quail in terms of Beta diversity by types of use and non-use in Rancho Chapultepec, Durango Mexico; and to determine the level of association for variables of vegetation–habitat with the presence of C. montezumae at sites of use and non-use in Rancho Chapultepec, Durango Mexico.

MATERIALS AND METHODS

This study was conducted in Rancho Chapultepec, a small property (category of private land tenure) located in the municipality of Durango, Mexico, whose main building is at the geographical coordinates 24° 14' 37" N and 104° 25' 56.75" W. This small property has an area of 5034 ha, mainly intended for extensive livestock.

Search for the Montezuma quail

The fieldwork began in February and ended in October 2020; paddocks were surveyed to know where there could be quail Moctezuma (Hernández *et al.*, 2006). For the location of the quail, quail sounds were reproduced (playback) from both sides of the transect, at 50 m taking the path as the center. The vocalizations of the species were reproduced (Vázquez-Pérez *et al.*, 2009) from both female and male; obtained from the library specialized in bird sounds (https://www.xeno-canto.org/). When the song was answered, coordinates were recorded (altitude, length, and altitude) with a GARMIN MAP 64s GPS (Bristow and Ockenfels, 2004). The site was marked for later location and characterization.

Characterization of quail sighting sites

Each site of use was characterized; for each one three points were located at random. In each site the habitat was characterized; four sampling methods were used: a) intercept line or Canfield, b) 4×4 m plots, c) 1×1 m plots, and d) nearest neighbor.

a) Intercept or Canfield lines; to know the coverage of each component considered (Canfield, 1941; Bristow and Ockenfels, 2004).
b) On the 4×4 m plot, data on scrubland species were recorded.
c) A plot of 1×1 m was sampled. In this plot, information on herbaceous plant species was collected.
d) Nearest neighbor. It was used to obtain data on tree species that quails use as an escape option.

Richness, abundance and diversity of plant species

In order to know the variables of vegetation and habitat, that explained the greater variance in the characterization of the sites, a principal component analysis (PCA) was applied in three axes. This analysis was performed with R version 3.6.1 (Fox, 2005).

The frequency of observation (FO) and relative abundance index (RAI) at sites and species levels were determined. To evaluate the possible association between vegetation-habitat variables and the frequency of quails recorded in sites, a Poisson regression analysis (ARP) was applied, using the Stepwise polynomial-variable selection procedure, the fit of the models was assessed by the minimum Akaike criterion (AIC; Akaike, 1969) in R-version 3.6.1.

In order to establish possible statistically significant differences, the results of the estimators Jacknife 1 (Richness), relative abundance index (RAI) and Shannon-Wiener (Diversity) obtained for sites of use vs. non-use, were analyzed by the non-parametric Kruskal-wallis test. This due to not fulfilling the assumptions for parametric statistics; such analyses were carried out in Xlstat v. 2021.4.

RESULTS AND DISCUSSION

It was observed that the first three axes (components) explained in use=48; non-use=43 and both=36 of the total present variation. Six important variables were recorded, which compose and describe the variability of vegetation-habitat (Table 1).

FO: indicates average values per site for use=6.25%; non-use=2.08% and both=1.56%; and per species in sites of use=3.57, non-use=3.85; and both 3.33%. The relative abundance index suggests mean values of RAI=0.06; 0.02 and; 0.02, respectively (Figure 1).

Poisson regression indicated that the best-fitted model has values of AIC=54.48; AIC=77.37 and; AIC=144.22, which determined the best adjusted models for each case of analysis, exhibiting 1; 11 and; 18 variables (vegetation-habitat), respectively (Table 2).

Kruskal-Wallis results for the estimators Jacknife 1 (Richness); Relative abundance index (RAI) and; Shannon-Wiener (Diversity) obtained for sites in condition of use *vs*. non-use, allowed to show that there are significant differences ($p=-0.007$; $p\leq 0.0001$) in richness and abundance; however, diversity appears to be similar ($p=-0.21$) (Figure 2).

The trends showed by this study (richness) are consistent with those reported by Bristow and Ockenfels (2002; 2004; 2006) and Hernández *et al.* (2006) who evaluated the habitat of

Table 1. Main components that explain in three axes the proportion of the accumulated variance out of 100% of the total present variation that compose and determine the presence of the Montezuma quail.

Variables studied	Component 1	Component 2	Component 3
Grasses	−0.04269102	−0.30848731	0.17848068
Herbaceous (%)	0.31925713	−0.05725741	−0.04342608
Grasses (%)	0.10888704	−0.18769812	−0.16302592
Frangula microphylla	−0.09201525	−0.30588082	0.09435311
Prosopis sp.	−0.2898917	0.0983107	−0.12683786
Tree height	−0.29929015	−0.05612058	−0.00141829

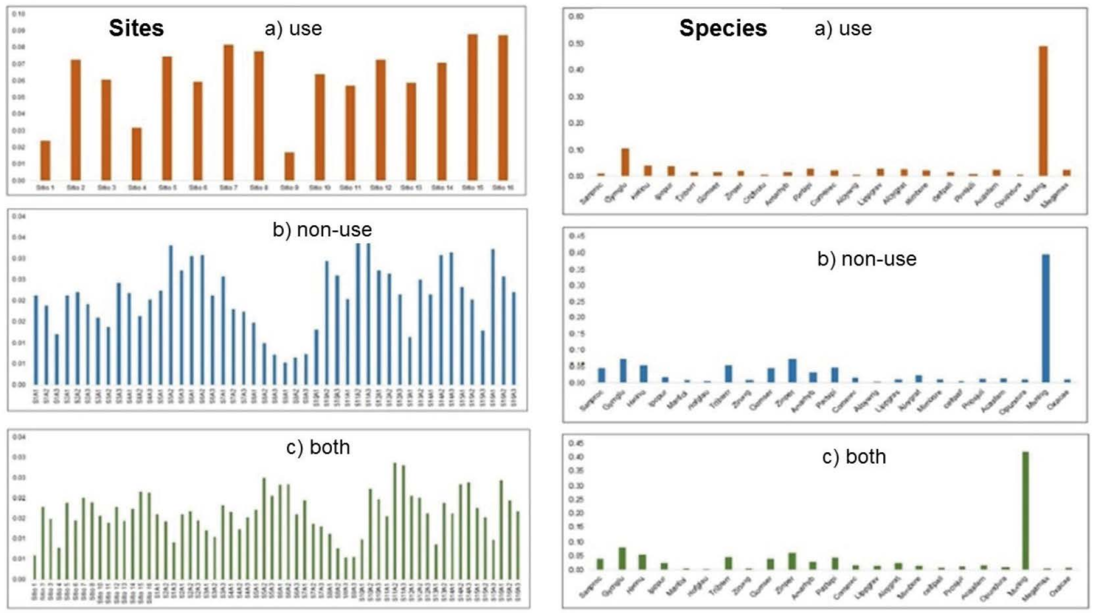

Figure 1. Relative abundance index (RAI) for sites and by species for sites in A) use; B) non-use; C) both conditions, in Rancho Chapultec, Durango, Mexico.

the Montezuma and Scaly quails in the Chihuahuan Desert, evergreen forest and desertic grassland, respectively. Those authors analyzed the macrohabitats at feeding sites and random sites, finding richness values of 23% and 29% using the Simpson estimator; the diversity and uniformity using the sum test were 6.5, 0.3 and 7.6, 0.3, respectively; thus, they found a similar richness between sites.

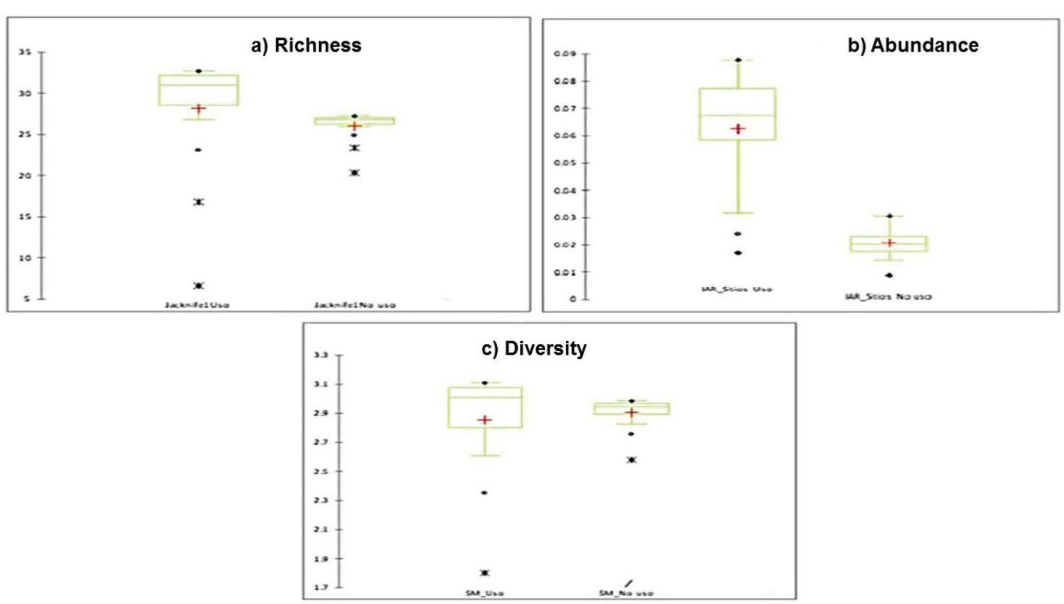

Figure 2. Kruskal-Wallis Box plots for Jacknife 1 estimator (richness); estimated for sites in condition of use vs. non-use, in Rancho Chapultec, Durango, Mexico.

Table 2. Poisson regression analyses using GLM models to determine the degree of association between vegetation-habitat variables and quail frequency recorded at sites of use; non-use and both conditions, in Rancho Chapultec, Durango, Mexico.

	Estimate	Std. Error	z value	Pr(>|z|)
Sites of use				
Intercept	0.70825	0.19607	3.612	0.000304 ***
Tree coverage	0.10173	0.05024	2.025	0.042855 *
Non-Use Sites				
Intercept	−3.7592	1.1788	−3.189	0.00143 **
Shrub cover	−1.6545	0.2614	−6.329	2.47e-10 ***
Grass coverage	8.3511	1.4616	5.714	1.11e-08 ***
Herbaceous coverage	−21.7551	4.2393	−5.132	2.87e-07 ***
Tree height	3.9074	0.759	5.148	2.63e-07 ***
Herbaceous height	29.772	4.7813	6.227	4.76e-10 ***
Shade	7.6237	1.5497	4.919	8.68e-07 ***
Grasses	−1.4625	0.2743	−5.331	9.77e-08 ***
Tree coverage	−0.7872	0.1682	−4.679	2.88e-06 ***
Tree distance	−2.9307	0.5422	−5.405	6.47e-08 ***
Distance to the *Frangula microphylla*	15.5066	3.0894	5.019	5.19e-07 ***
Both conditions				
Intercept	−0.23099	0.55686	−0.415	0.678279
Shrub cover	−0.43953	0.08602	−5.11	3.23E-07***
Grass coverage	0.48209	0.14786	3.26	0.001112 **
Herbaceous coverage	3.23777	0.74715	4.334	1.468E-05 ***
Tree height	0.7023	0.3091	2.272	0.023083 *
Gramineous height	−4.40945	1.0647	−4.141	3.451E-05 ***
Shrubbery	0.81744	0.17783	4.597	4.292E-06 ***
Shade	−1.19331	0.23928	−4.987	6.13E-07 ***
Basal area	−3.54666	1.73088	−2.049	0.040457 *
Tree coverage	0.20334	0.0787	2.584	0.009777 **
Shadow / Dalea bicolor	4.86159	1.18131	4.115	3.865E-05 ***
Frangula microphylla	3.10164	0.81646	3.799	0.000145 ***
Herbaceous	−0.03723	0.0096	−3.878	0.000105 ***
Coverage area	0.08506	0.02331	3.649	0.000264 ***
Tree distance	1.05221	0.26991	3.898	9.684E-05 ***
Distance to the *Frangula microphylla*	−3.1632	0.63032	−5.018	5.21E-07 ***
Distance to the *Vachellia* sp.	1.02205	0.23052	4.434	9.262E-06 ***
Distance to the *Prosopis* sp.	−1.76188	0.37391	−4.712	2.452E-06 ***
Distance to the *Opuntia* sp.	−0.48184	0.22017	−2.188	0.028635 *

Significant at *** $p \leq 0.001$; ** $p \leq 0.01$; * $p \leq 0.05$.

However, the index used herein (this study) differs from that used in those other studies; which agree in reporting a similar richness between conditions, especially in grassland. This assumes that *Cyrtonyx montezumae* seems to use similar ecological conditions in the composition of plant species, particularly those that compose the lower stratum (grasses and grains) in this region of Mexico.

Thus, this research supports the idea that the Montezuma quail behaves similarly at the stratum level in the use of habitat in this type of systems. It is imperative to note that this study was carried out in a scrubland, which should be noted included sites that sustain diverse plant communities such as Spiny hackberry (*Celtis pallida*), prickly pear cactus (*Opuntia durangensis*), the twisted or Schaffner's acacia (*Vachellia shaffneri*) and smooth mesquite (*Prosopis laevigata*). Within this vegetation type, the herbaceous stratum dominant in cover was an association of Deer grass (*Muhlenbergia rigens*). All these species are within their natural distribution in the study area.

This does not agree with what was reported by Leopold and McCabe (1957) who described the Montezuma quail as a species of bird that preferentially inhabits pine-oak forests. Those authors indicated tough, that quails also tend to use the understory; particularly in forests with secondary succession, which turn out to be a more favorable habitat for this bird species. However, these assertions are notably in contrast with Tapia *et al*. (2002) and Garza (2007) who mentioned that this species is associated, in the vertical vegetation profile, with the community structure of pine, oak, juniper and oak forests. Cork (2017) partially supported this, after evaluating the habitat selection and spatial ecology of the Montezuma quail in the mountains of New Mexico, indicating that the selection of feeding sites is a function of the height and average distance of the nearest trees.

This latter statement supports part of the trends recorded in this study, where we recorded such a phenomenon, tough it was associated to a greater extent with herbaceous communities (grassland), which suggests the relevance of trees closer to grassland areas as cover spots for escape and refuge from possible predators. Nevertheless, the activity recorded in this research, especially on the sites in codition of use, seems to be more related to the lower stratum of the evaluated plant structure.

CONCLUSIONS

Habitat characterization by sites in condition of use and non-use was achieved in regard to Betha diversity; through interpreting richness, abundance and diversity as complementary parameters in the contrast between sites.

It was possible to determine that there is an association between variables of the vegetation-habitat with the presence of *Cyrtonyx montezumae*; we accomplished identifying that such an association occurs in greater proportion with the vegetation variables.

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