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Use of SNIB data for analysis of floral and faunal richness of the Marismas Nacionales Biosphere Reserve

Uso de datos SNIB para el análisis de la riqueza de flora y fauna en la Reserva de la Biósfera Marismas Nacionales

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ABSTRACT

The objective of this work was to evaluate the association between faunal and floral richness and the different vegetation types present in the Marismas Nacionales Biosphere Reserve, using INEGI Series VII land use and vegetation spatial data and georeferenced species records from the National Biodiversity Information System. The Shannon index was calculated, and the results showed that mangrove swamps and bodies of water presented the highest richness. The highest values of the Shannon index corresponded to hydrophilic halophilic vegetation and mangrove swamps.

KEY WORDS: Marismas Nacionales Biosphere Reserve, species richness, conservation.

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RESUMEN

El objetivo de este trabajo fue evaluar la riqueza faunística y florística asociada a los distintos tipos de vegetación presentes en la Reserva de la Biosfera Marismas Nacionales, utilizando datos espaciales de la serie VII de uso de suelo y vegetación de INEGI y registros georreferenciados de especies del Sistema Nacional de Información Sobre Biodiversidad de la Comisión Nacional para el Conocimiento y Uso de la Biodiversidad. Se calculó el índice de Shannon y los resultados mostraron que el manglar y los cuerpos de agua presentaron la mayor riqueza, la vegetación halófila hidrófila y el manglar obtuvieron los valores más altos del índice de Shannonel.

PALABRAS CLAVE: Reserva de la Biósfera Marismas Nacionales, riqueza de especies, conservación.

Introduction

In Mexico, the Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (National Commission for the Knowledge and Use of Biodiversity) has designed a biodiversity information program employing the National Biodiversity Information System (SNIB) and the Geographic Information System (GIS) to maintain databases of specimens deposited in Mexican and foreign collections; catalogs of taxonomic authorities; species records listed in NOM-059-SEMARNAT-2010; satellite images; digital cartography; and data on vegetation, climate, precipitation, infrastructure, and populations (Muñoz-López, 2009).

The georeferenced records in the SNIB are useful since they enable users to conveniently look up the biodiversity composition in strategic places such as the Marismas Nacionales Biosphere Reserve (RBMN). A wetland classified nationally and internationally as an important area for bird and mangrove swamp conservation, it is considered one of the most productive in northwestern Mexico. In addition to hosting an enormous diversity of resident flora and fauna, including 44 species in some risk category within the NOM-059-SEMARNAT-2010 (DOF, 2010), this region is notable for its high fishing productivity, accounting for nearly 45% of the Mexican catch (CONANP, 2013). It was established as a Protected Natural Area in 2010 (Valderrama-Landeros *et al.*, 2017) and declared a Ramsar site in 1995.

Wetlands carry out key ecological functions such as maintaining water quality, flood control, protection of coasts, aquifer recharge, and biodiversity conservation (Zedler & Kercher, 2005).

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However, more than half of the world's wetlands have been lost, due mainly to human activities such as conversion to agriculture, urban development, pollution, and overexploitation of resources (Gardner & Finlayson, 2018).

The objective of this study was to use georeferenced records of flora and fauna from the National Biodiversity Information System of the Marismas Nacionales Biosphere Reserve to explore the relationship of plants and animals with vegetation cover types and land uses from series VII proposed by INEGI.

Material and Methods

The Marismas Nacionales Biosphere Reserve is part of the Teacapán–Agua Brava lagoon system, located on the coasts of the states of Sinaloa and Nayarit, with an area of 220,000 ha (24º 10′ N, 107º 20′ W; 23º 54′ N, 106º 57′ W) (Valdez-Hernández, 2002). The climate is subhumid, with an average annual temperature ranging between 26 and 28 ºC (average maximum 30 to 34 ºC). Receiving 800 to 1,200 mm year^{-1} annual precipitation (CONANP, 2013), it includes a network of brackish coastal lagoons, flood plains, tidelands, estuaries, ancient sandy barriers, semi-parallel lagoons, deltas, swamps, marshes, and mangrove swamps (Rodríguez-Zuñiga *et al*., 2013; Valderrama-Landeros *et al*., 2017).

Georeferenced records of flora and fauna were obtained from the website of the National Biodiversity Information System (SNIB) of the National Commission for the Knowledge and Use of Biodiversity, 2023, and were processed in a geographic information system using ArcGIS 10.8.1 to obtain all the floristic and faunal groups located within the RBMN polygon. Once these files were produced, the Land Use and Vegetation layers (series VII) were cross-tabulated against the floral and faunal species for each type of land cover and use, to obtain a database of the species present in the area for each one (Figure 1).

Using this database, a chi-square test was carried out with a posteriori test to determine where there are significant differences between the richness of faunal groups versus vegetation types and land use. The chi-square was calculated with the corrected standardized residuals (Z values) using the functions in SPSS. To adjust the *p* value to the number of comparisons made (n = 40), the Bonferroni correction was carried out, which consists of dividing the *p* value = 0.05 by the number of comparisons. It was determined that values lower than the Bonferroni corrected values would be considered significant.

After the floral and faunal species in each vegetation type or land use were identified, the Shannon-Wiener index (H′) was calculated. This is the most commonly used diversity index in ecology because it combines the parameters of specific richness and evenness (Shannon, 1948) and is based not only on the number of species but also on how many individuals per species are present. This index requires that all species be represented in the sample and is very sensitive to abundance (Magurran, 1988). H′ is the value of the index, is the number of species (species richness), is the proportion of individuals of species with respect to the total number of individuals,

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is the number of individuals of species (Eq. 1), and is the evenness index (Eq. 2). These indices were calculated using the PAST (Paleontological Statistics) package, version 4.0.

$$H' = -\sum_{i=1}^{s} p_i Inn_i \quad \text{Ec. 1}$$

$$E = \frac{H'}{InS} \quad \text{Ec. 2}$$

The value of H′ can range between 0 and . When the index is close to zero, the community is not very diverse. The index reaches its maximum value, the logarithm of the specific richness, in communities with maximum evenness those where all species have equal abundance. Species richness was measured as the number of species present in a community.

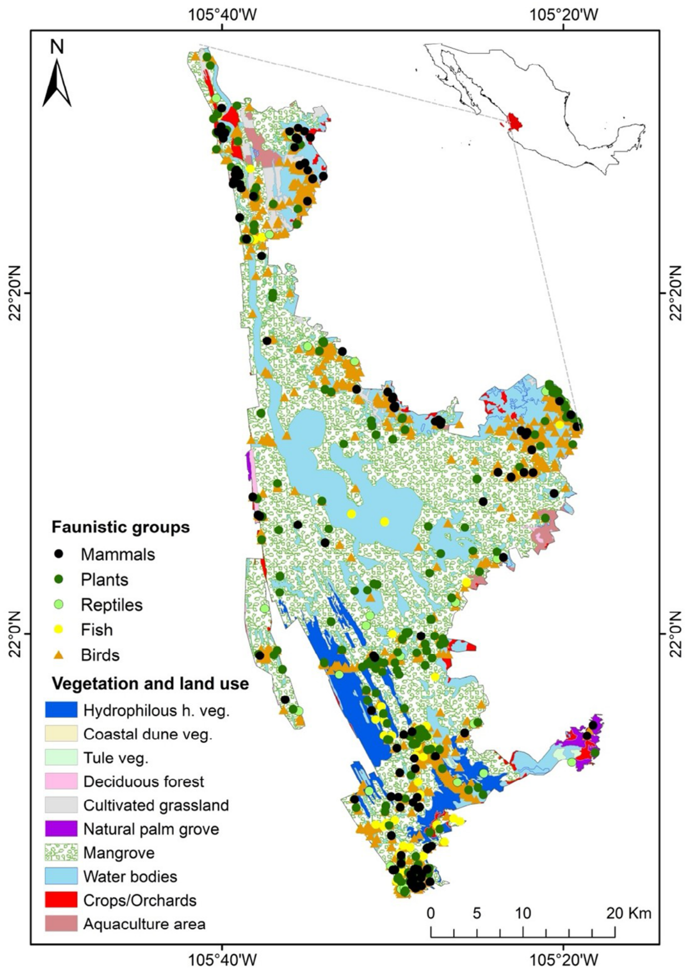

Figure 1. Species distribution map by type of vegetation and land use.

Source: Authors, based on SNIB data.

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Results and Discussion

The vegetation type covering the largest area was mangrove swamp, with 764 km^2, followed by water bodies with 138 $km^{2,}$ and hydrophilous halophilic vegetation with 96 km^2. Birds were the group with the greatest number of species in all vegetation types, followed by plants and fish. 417 bird species were found in mangrove swamps, and 335 in water bodies, while low deciduous forests and areas with aquaculture held fewer than 5 species (Figure 2a). Carmona *et al*. (2017) recorded a total of 954 records of 27 bird species; among the most abundant were the necrophagous birds (*Cathartes aura*, *Coragyps atratus*) and another more migratory bird species (*Pandion haliaetus*) which together accounted for 65 % of all records. This confirms that birds of prey or raptors are an essential group for maintaining balance in these communities, given their top position in the food chain. Mendoza *et al*. (2019) found 27 species of shorebirds, such as the snowy plover and Wilson's plover, the piping plover, the northern jacana, the black-necked stilt, and the Pacific oystercatcher, with a minimum global abundance of 136,236 individuals. They state that the RBMN contains around 10 % of the total abundance of shorebirds in northwestern Mexico, making it a priority conservation site.

The results suggest that aquaculture production areas have a lower species richness compared to natural habitats (Figure 2). This difference could be related to the modification and reduction of these habitats, reducing their capacity to sustain high biological diversity. Recent studies have shown that anthropogenic activities, such as agriculture and aquaculture, can limit the capacity of these areas to support high biological diversity (Newbold *et al*., 2015; Tanentzap *et al*., 2015). Records of fauna that were considered occasional or rare were verified using the SNIB system. These were flamingos (*Phoenicopterus ruber*), reported by Mendoza *et al*., (2013), and the jaguar (*Panthera onca*). Leopold (1959) identified the coast of Nayarit as one of the four areas in Mexico believed to contain the highest density of jaguars in the entire country, while Figel *et al*., (2016) confirmed that Marismas Nacionales is the northernmost semi-aquatic jaguar habitat. Jaguar prey here includes American crocodiles (*Crocodylus acutus*) and freshwater turtles (*Traquemia* spp.) (Brown & López González, 2001). The mangrove swamps and tropical dry forests of Nayarit have suffered extensive deforestation; the opening of the Cuautla Canal in 1972 drastically altered salinity in the study area, resulting in the death of 24 % of the white mangrove (*L. racemosa*) and black mangrove (*A. germinans*) (Flores-Verdugo *et al*., 2001).

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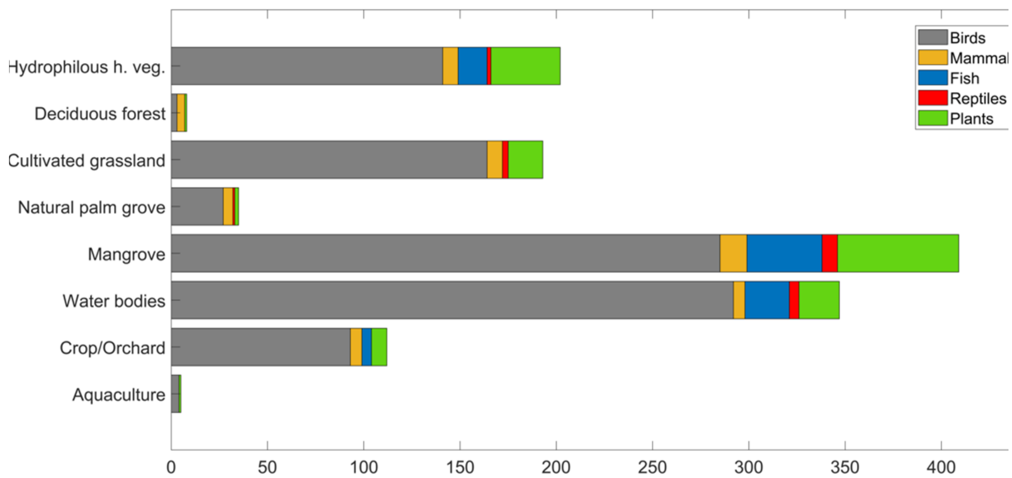

Figure 2. Floral and faunal species and vegetation types in Marismas Nacionales Biosphere Reserve.

Source: Authors, based on SNIB data.

The dominant orders of flora were Gentianales, Poales, Lamiales, Malpighiales, and Myrtales, which occupy extensive areas in the deciduous forest and coastal vegetation in the central, southern, and eastern parts of the RBMN. This is consistent with the results of the project carried out by Valdez-Hernández (2002), who reported 64 species of vascular plants from Marismas Nacionales, in 34 families and 55 genera, mainly from the classes Magnoliopsida, Liliopsida, and Polypodiopsida.

The results of comparing richness of floral and faunal groups among land use and vegetation types are significant (chi-square = 120.98; $p < 0.05$). The value of the Bonferroni correction was $p = 0.001$. The vegetation types or land uses that showed significant values were water bodies, where the faunal groups that showed differences were birds ($p = 0.000$), with the greatest number of species (n = 292), followed by halophilic vegetation ($p = 0.000$) with 141 species (Table 1). This finding was expected because the water bodies are where the greatest number of historic records of bird species and halophilic vegetation have been reported in Marismas Nacionales (Nayarit Marismas Nacionales Biosphere Reserve Management Program, 2013). Mangrove swamp was also significant for bird ($p = 0.000$) and fish ($p = 0.001$) groups, which confirms the importance of this vegetation cover as one of the main habitats for fish reproduction and growth, and resting and feeding areas for birds (Srikanth *et al*., 2015). In natural palm grove vegetation only 5 species of mammals were recorded, but the association was significant ($p = 0.001$). In this vegetation cover, the presence of the raccoon (*Procyon lotor*), the white-nosed coati (*Nasua narica*), and the ringtail (*Bassariscus astutus*) are notable. In cultivated pastureland, the fish group was significant, however there are no species records. In the aquaculture and crop field land uses, no significant differences were found (Table 1).

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Table 1. Results of comparisons between land uses and vegetation types in RBMN. *p* values ≤ 0.001 are significant.

Land use and vegetation type	*Group*	*Standardized residual value*	*p-value*
Aquaculture	*Birds*	*0.16*	*0.872*
	Mammals	*−0.45*	*0.652*
	Fish	*−0.58*	*0.563*
	Reptiles	*−0.27*	*0.786*
	Plants	*0.60*	*0.547*
Crop/Orchard	*Birds*	*1.60*	*0.111*
	Mammals	*0.84*	*0.401*
	Fish	*−0.82*	*0.413*
	Reptiles	*−1.34*	*0.180*
	Plants	*−1.49*	*0.135*
Water bodies	*Birds*	*3.71*	*0.000*
	Mammals	*−2.43*	*0.015*
	Fish	*0.34*	*0.738*
	Reptiles	*−0.02*	*0.988*
	Plants	*−3.68*	**0.000**
Mangrove swamp	*Birds*	*−4.22*	*0.000*
	Mammals	*−0.59*	*0.556*
	Fish	*3.30*	**0.001**
	Reptiles	*1.03*	*0.301*
	Plants	*3.03*	*0.002*
Natural palm grove	*Birds*	*0.03*	*0.980*
	Mammals	*3.22*	*0.001*
	Fish	*−1.55*	*0.121*
	Reptiles	*0.71*	*0.480*
	Plants	*−1.08*	*0.281*
Cultivated grassland	*Birds*	*2.86*	*0.004*
	Mammals	*0.20*	*0.843*
	Fish	*−3.89*	**0.000**
	Reptiles	*0.13*	*0.895*
	Plants	*−1.00*	*0.317*

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Continuation

Table 1. Results of comparisons between land uses and vegetation types in RBMN. *p* values ≤ 0.001 are significant.

Land use and vegetation type	*Group*	*Standardized residual value*	*p-value*
Deciduous forest	*Birds*	*−2.66*	*0.008*
	Mammals	*6.77*	**0.000**
	Fish	*−0.73*	*0.464*
	Reptiles	*−0.34*	*0.731*
	Plants	*0.09*	*0.925*
Hydrophilous-Halophylic vegetation	*Birds*	*−2.63*	*0.009*
	Mammals	*0.06*	*0.955*
	Fish	*0.75*	*0.455*
	Reptiles	*−0.59*	*0.553*
	Plants	*3.10*	*0.002*

Note: *p* values ≤ 0.001 are considered significant (bolded values indicate significance).

Diversity in the RBMN

Hydrophilous halophilic vegetation (H′ = 0.9303) and mangrove swamp (H′=0.9582) showed the highest values of the Shannon index, indicating a greater diversity of species in these vegetation types, consistent with what was reported by Mendoza *et al*., (2017), who highlight that areas with greater mangrove cover serve as suitable habitats for multiple species. The lowest values were observed in cultivated grassland (H′ = 0.5579), water bodies (H′ = 0.6286), areas devoted to aquaculture (H′ = 0.6004), and crops or orchards (H′ = 0.6436), indicating lower species richness in areas with greater anthropogenic pressure (Figure 3). These findings are similar to those reported by Rojas *et al*., (2015), who state that urbanization and diversity of land use negatively impact biodiversity in coastal wetlands, with the most disturbed areas presenting less diversity than those that are less disturbed. Low deciduous forest (H′ = 0.68) and natural palm grove (H′ = 0.78) registered intermediate values of diversity, lower than those described in studies that report greater richness in areas with less disturbed conditions (Cimé-Pool *et al*., 2010), which suggests that these vegetation types also contribute to the biological diversity of the reserve, although to a lesser degree than mangrove swamp and halophilic vegetation areas.

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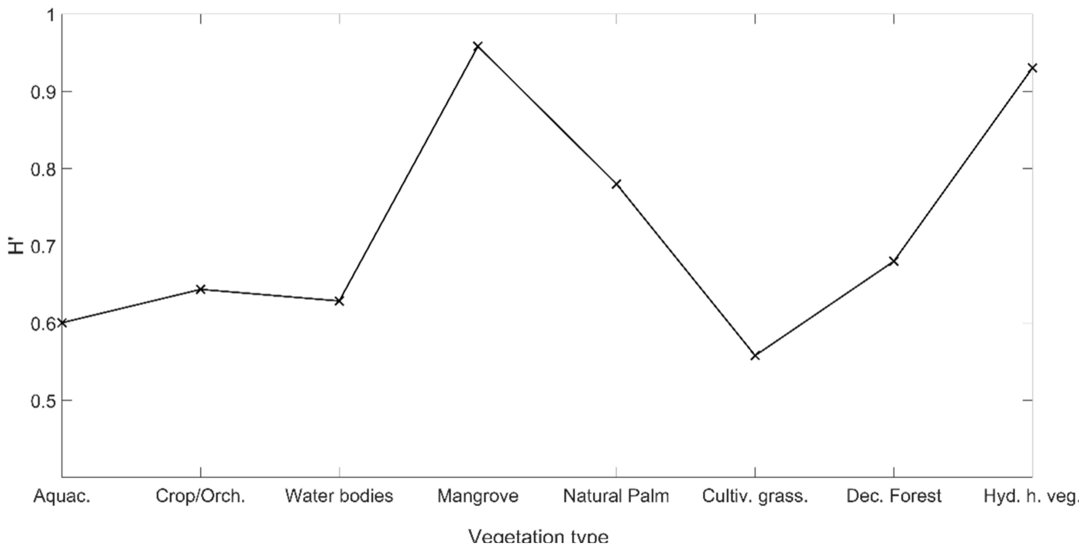

Figure 3. Floral and faunal species by vegetation type in Marismas Nacionales Biosphere Reserve.

Source: Authors, based on SNIB data.

Conclusions

This study confirms the importance of the Marismas Nacionales Biosphere Reserve as a key habitat for regional and global biodiversity, particularly due to the remarkable species richness in mangrove swamps and bodies of water, which support diverse biological communities, including migratory species and species in danger of extinction. Areas with greater anthropogenic influence, such as those devoted to livestock and crops, presented the lowest diversity values, providing evidence of the negative impact of human activities on biodiversity. Given the importance of these ecosystems, the present findings indicate an urgent need to design management and conservation strategies that balance environmental protection with economic development, to ensure the ecological functionality and the services that these ecosystems provide.

The present study used only SNIB species presence data. It is suggested that further research complement these records with field studies and reviews of the scientific literature, to employ more complete and up-to-date data.

Authors' contributions

Conceptualization, review, and editing: SSE, JGEF; writing of the manuscript, preparation of the manuscript, analysis of results, and bibliographic search: AGA, SSE, JGEF.

"All authors of this manuscript have read and accepted the published version."

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Declaration of informed consent

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Conflict of interests

The authors declare no conflicts of interest.

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