AGENDA DA SUSTENTABILIDADE NO BRASIL:

Conhecimentos teóricos, metodológicos e empíricos

Adilson Tadeu Basquerote
(Organizador)

Atena Editora
Ano 2021

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Agenda da sustentabilidade no Brasil: conhecimentos teóricos, metodológicos e empíricos 2

Diagramação: Daphynny Pamplona
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Dados Internacionais de Catalogação na Publicação (CIP)

A265 Agenda da sustentabilidade no Brasil: conhecimentos teóricos, metodológicos e empíricos 2 / Organizador Adilson Tadeu Basquerote. – Ponta Grossa - PR: Atena, 2021.

Formato: PDF
Requisitos de sistema: Adobe Acrobat Reader
Modo de acesso: World Wide Web
Inclui bibliografia
ISBN 978-65-5983-746-5
DOI: https://doi.org/10.22533/at.ed.465210212

1. Sustentabilidade. 2. Conservação. I. Basquerote, Adilson Tadeu (Organizador). II. Título.

CDD 333.72

Elaborado por Bibliotecária Janaina Ramos – CRB-8/9166

Atena Editora
Ponta Grossa – Paraná – Brasil
Telefone: +55 (42) 3323-5493
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APRESENTAÇÃO

A obra: **“Agenda da sustentabilidade no Brasil: Conhecimentos teóricos, metodológicos e empíricos 2”**, da mesma forma que no primeiro livro, reúne estudos que centram-se na temática da sustentabilidade em diferentes contextos e perspectivas.

Evidenciando a relação ética e responsável na perspectiva das ações humanas sobre o espaço, a obra apresenta estudos transdisciplinares que abordam interesses conflitantes sobre desenvolvimento social, econômico, ecológico, cultural, territorial, entre outros. Para mais, destaca a importância de práticas sustentáveis como imprescindíveis para a manutenção das características naturais do espaço. Bem como compreender as modificações que ocorrem na paisagem, com a finalidade de propor ações mitigadoras e de menor impacto no/sobre o meio.

Resultado de esforços de pesquisadores de diferentes regiões e instituições brasileiras e mexicanas, o livro é composto por cinco capítulos, resultantes de pesquisas empíricas e teóricas, cujo fio condutor é a relação sociedade natureza por meio da sustentabilidade. Aborda estudos que abrangem impactos ambientais, saúde, problemas urbanos, gestão ambiental, o território, saneamento básico, entre outros. A obra reflete um panorama de realidades socioculturais variadas e distintas entre si, proporcionado maior abrangência e análise espacial, riqueza cultural e diversidade de sujeitos.

Por fim, destaca-se que a obra apresenta pluralidade de ideias acerca dos elementos constitutivos da sustentabilidade na atualidade. Para mais acredita-se que ela possa conduzir a reflexões na busca de ações que envolvam a construção de uma sociedade socio- ambientalmente mais harmônica e cidadã, respeitando as diversidades humanas e naturais.

Que a leitura seja convidativa!

Dr. Adilson Tadeu Basquerote

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https://doi.org/10.22533/at.ed.4652102121

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https://doi.org/10.22533/at.ed.4652102125

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WATERFOWL TEMPORARY DISTRIBUTION IN A SECTION OF THE SAN PEDRO RIVER, MEOQUI, CHIHUAHUA, MEXICO

Data de aceite: 01/12/2021

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ABSTRACT: Knowledge of the temporal distribution of waterfowl species is essential to take measures for its conservation and preserving their habitat. The present study was carried out in the section called “Vado” at San Pedro River in Meoqui town; this river was included in the Ramsar List of Wetlands of International Importance. The objective was to analyze the temporal distribution of waterfowl in Meoqui, as well as the effect of environmental variables. A multivariate analysis was carried out to determine the association between environmental variables and the frequency of distribution of species, analyzing the variability in the distribution of birds and environmental conditions of preference. As a result, 30 species were observed, belonging to 19 genus, it was observed that the month with the highest abundance was january due to the presence of winter migratory birds. It was identified that *Agelaius phoeniceus, Anas acuta and Butorides virescens* are birds with differentiated behavior, because they are species that prefer warm temperatures with high precipitation. Temperature, wind speed and precipitation are the main environmental variables which determine the temporal distribution of waterfowl. The results indicate that there is an association between the frequency of sightings of waterfowl with the months of the year, according to environmental variables.
KEYWORDS: *species, winter, wetland, migration, birds.*

DISTRIBUIÇÃO TEMPORÁRIA DO AVES AQUÁTICAS EM UMA SEÇÃO DO RÍO SAN PEDRO MEOQUI, CHIHUAUA, MÉXICO

RESUMO: Conhecimento da distribucão temporaria do aves aquáticas é essencial para a conservacão e preservacão de seu hábitat. O presente estudo foi realizado na secão denominada “vado” do rio San Pedro, Meoqui, Chihuahua, no norte do México; este rio está na lista Ramsar do zonas úmidas do importância internacional. O objetivo foi analizar a distribucão temporal das aves aquáticas no “vado”, bem como o efeito das variáveis ambientais. Para determinar associacão entre variáveis ambientais e a frêquencia de distribucão das espécies, uma análise multivariada foi realizada, comparando a variabilidade na distribucão do aves e condicões

ambientais de preferencia. Como resultado, 30 espécies foram observadas pertencendo a 19 gêneros. Se observou que o mês com maior abundancia foi janeiro, como consequência da presenca de aves migratórias de inverno. Foi identificado que *Agelaius phoeniceus, Anas acuta* e *Butorides virescens* são aves com comportamiento diferenciado, ja que são espécies que preferem temperaturas quentes com alta precipitacão. Temperatura, velocidade do vento e precipitacão são as principais variáveis ambientais que determinam a distribucão temporal das aves aquáticas. Os resultados indican que existe uma associacão entre a frequência de avistamentos de aves aquáticas com os meses do ano dependiendo das varáveis ambientais.
PALAVRAS CHAVE*: espécies, inverno, pantanal, migracão, aves.*

DISTRIBUCIÓN TEMPORAL DE AVES ACUÁTICAS EN LA SECCIÓN VADO DE MEOQUI DEL RÍO SAN PEDRO, CHIHUAHUA, MÉXICO

RESUMEN: El conocimiento de la distribución temporal de las especies de aves acuáticas es fundamental para tomar medidas en materia de conservación y preservación de su hábitat. El presente estudio se llevó a cabo en la sección llamada "vado" del Río San Pedro en el municipio de Meoqui, Chihuahua al norte de México; este rio se encuentra en el Listado Ramsar de humedales de importancia internacional. El objetivo fue analizar la distribución temporal de aves acuáticas en el vado de Meoqui, así como el efecto de las variables ambientales. Para determinar la asociación entre variables ambientales y la frecuencia de la distribución de las especies, se realizó un análisis multivariado, comparando la variabilidad en la distribución de las aves y las condiciones ambientales de preferencia, además se realizaron agrupamientos potenciales de especies de aves. Como resultado, se observaron 30 especies pertenecientes a 19 géneros. Se observó que el mes con mayor abundancia fue enero, como consecuencia de la presencia de aves migratorias invernales. Se identificó que *Agelaius phoeniceus, Anas acuta y Butorides virescens* son aves con comportamiento diferenciado, ya que son especies que prefieren las temperaturas cálidas con alta precipitación. La temperatura, velocidad del viento y precipitación son las principales variables ambientales que condicionan la distribución temporal de las aves acuáticas. Los resultados indican que existe asociación entre la frecuencia de avistamientos de aves acuáticas con los meses del año, dependiendo de las variables ambientales.
PALABRAS CLAVE: *especies, invierno, humedal, migración, aves.*

INTRODUCTION

Some birds follow a type of dispersal pattern called migration, by which they travel long distances in search of suitable conditions to develop their life. The rivers, lagoons, lakes, among others, are places used by these species in search of food and to take a rest before resuming their flight. The "vado" of Meoqui is an urbanized section of San Pedro River, home of many species of aquatic, local and migratory birds. Numerous species arrive during winter to this wetland, standing out: *Aythya americana*, *Ardea alba* and *Pelecanus erythrorhynchos.* San Pedro River is essential for the sustenance of species that cross through desert areas of Chihuahua state because there are a few wetlands in which they

take refuge.

Worldwide in the last century, more than 50% of wetlands were lost due to anthropogenic activities (Maltchik *et al*., 2011). In 2012, San Pedro River was included in the Ramsar List of wetlands of international importance (WWF, 2012). Analyzing the temporal distribution of waterfowl at the "vado" in San Pedro River, Meoqui, Chihuahua was the purpose of this research, as well as the effect of environmental variables. This information is basic for future research related to waterfowl in this wetland or similar ecosystems, contributing to the preservation of bird species and aquatic ecosystems.

MIGRATION, ROUTES AND ENVIRONMENTAL IMPACT

Long distance animal journeys are classified as migrations when they have a duration of days, weeks and even months, in addition to being a direct movement, unlike the usual movements that last hours and in which they frequently change direction (Ministro de Ambiente, Vivienda y Desarrollo Territorial & WWF, 2009). Migration is an adaptive response to the seasonal environment, allowing animals to benefit from the variation of resources in different seasons. Factors that contribute to migration are; interspecific and intraspecific competition in saturated habitats, predation and parasitism (Pulido, 2007), the search for a less severe climate with more sunlight (Shackelford *et al*., 2005) and food availability, so diversity in migration patterns depends on their nutritional requirements (Boyle, 2008).

The evolution of animal migration involves a set of physiological and morphological characteristics and neurological adaptations that allow resistance and orientation during the journey (Winger *et al.,* 2014). For instance, the ability to store fat for the entire travel (Manoment, 2015). Birds generally follow specific routes determined by guiding factors from topographic reference, for instance, mountains and rivers; ecological factors, such as vegetation zones; and climatic changes, such as direction and strength of the wind (Shackelford *et al*., 2005). The importance of migration lies in the fact that it can potentially induce speciation, because populations within the same species have different migratory routes which can generate genetic divergence as there is no exchange of genes through reproduction. There are studies supporting this hypothesis, such as Rolland *et al*. (2014) this world scale phylogeny work revealed a significant association between migratory behavior and speciation, therefore reducing extinction.

The migration paths follow a north-south predominant line, where they link nests in the arctic and temperate regions with non-nesting sites in temperate and tropical zones. Eight migration routes have been identified: Mid-Atlantic, Mediterranean/Black Sea, Asia/Middle East Africa, Central Asia, East Asia/Oceania and three migratory routes in the Americas and the Neotropics (Spatula, 2015). The three American routes are: the Pacific, the Atlantic and the Central American (Manoment, 2015), the latter crosses through the center of Mexico where San Pedro River is located. The main wintering area for Neotropical

migratory birds extends through Mexico to Panama; having the worlds highest density from winter residents of birds (Shackelford *et al*., 2005).

Many bird species are sensitive to minimal changes, whence their presence is closely related to the habitats condition (Navarro-Sigüenza *et al*., 2014). Climate change has induced one of the recorded effects on the geographic distribution of birds, 177 bird species out of 305 tracked in North America, changed their distribution during winter. This can lead to structural and functional changes in ecological communities, but it is difficult to precisely predict the effect on birds. Extreme weather changes such as floods, droughts and heat waves may exceed their tolerance levels. which would cause changes in habitat and migration habits (National Wildlife Federation, 2015). Stopping places during migration are of vital importance for the survival and reproductive success of birds, if a habitual stopping place is lost, birds do not have the energy or time to search for another place, making them vulnerable (Manoment, 2015).

Changes have been recorded in the migratory routes of some species, including *Anas platyrhynchos*, *Chrysomantis tristis, Mergus serrator*, *Anas rubripes, Anas crecca*, *Pluvialis squatarola,* among others (National Wildlife Federation, 2105). Some changes have been registered in Chihuahua, for example, the Argentine parrot was spotted for the first time (*Myiopsitta monachus*) (Soto- Cruz *et al*., 2014), the first records of local reproduction of *Recurvirosta americana*, (Venegas *et al*., 2015) and the first sightings of *Pelecanus occidentalis* in the study area, which only inhabited coasts in the past (Sáenz, 2015).

METHOD

Study area

The study was carried out in San Pedro River at the section called “vado”, in the municipality of Meoqui, Chihuahua, Mexico (Figure 1). This municipality is in the coordinate system 27° 77’ nortth latitude and 105° 19’ west longitude, with an average altitude of 1165 meters above sea level, the climate of the area is arid semi-warm, with high temperatures in the summer and moderate cold in the winter (Espino-Valdés, 2009). With average annual temperature between 18 °C and 22 ºC, with summer rains (CONAGUA, 2015).

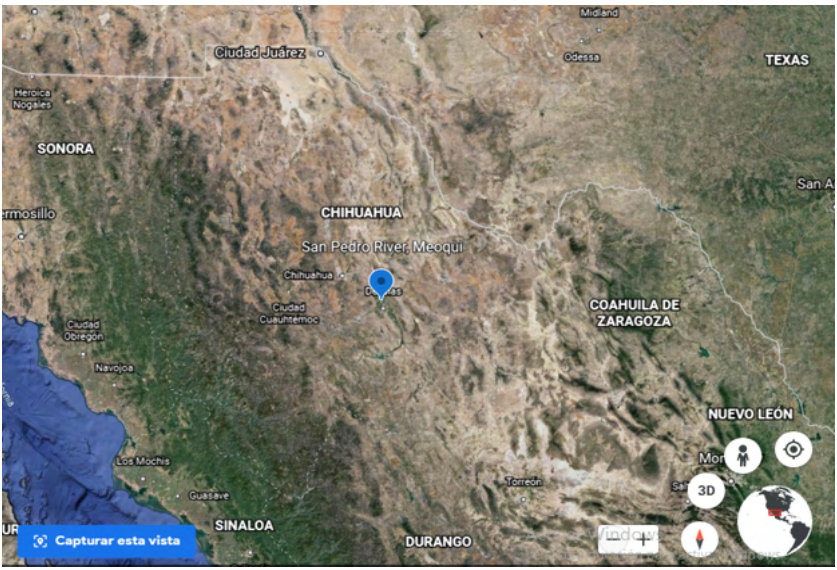

Figure 1. *Location of the study area, section of "vado" at the San Pedro River, Meoqui.*

Source: Google earth, 2021.

Censuses

One visit per month was carried out during the period from June 2013 to June 2014, observations were made in the morning, from 7:00 a.m. at 12:00 p.m., data were collected on a line with a two km length of the river. Bird identification guides of Kaufman (2005) and Allen (2000) were used. The bird observations were registered in a format established in the method proposed by Kepler & Scott (1981); this method indicates that the counting point should be accessed with minimal disturbance to the birds.

Collection of environmental variables

The environmental variables were collected during the sampling period, considering the closest meteorological station (*Lomas del Consuelo*, municipality of Meoquí) in order to know the influence of weather conditions on the frequencies of the temporal distribution of birds. The environmental variables used were: precipitation (mm), maximum temperature (°C), mean temperature (°C), minimum temperature (°C), maximum wind speed (km/h), direction of maximum wind speed (degrees azimut), mean wind speed (km/h), mean wind direction (degrees azimuth), global radiation (w/m^2), relative humidity (%), reference evapotranspiration (mm) and potential evaporation (mm).

Statistical analysis

Statistical analyzes were executed using different procedures of the package SAS

9.1.3 (SAS, 2006). A correlation analysis was carried out to determine the association between environmental variables and the frequency of species distribution, using the procedure CORR.In addition, a cluster analysis was executed to determine potential groupings of bird species based on its temporal distribution, using the procedure CLUSTER, and finally a Chi square test and correspondence analysis to study the correspondence between the species and/or potential group with the month of the year, using the procedures FREQ y CORRESP by SAS, respectively.

RESULTS AND DISCUSSION

As a result, 30 species of aquatic birds were registered in the “Vado” area of Meoqui, which are grouped into 7 orders and 21 genera. The status of each species was determined using the NOM-059-SEMARNART-2010 (mexican norm) and the listing of the IUCN (International Union for Conservation of Nature). The IUCN reports 12 species with declining population; *A. phoeniceus* (BirdLife International, 2021), *A. acuta*, *S. clypeata, S. cyanoptera*, *S. discors*, *B. virescens, C. minutilla*, *C. vociferous, E. caerulea, F. americana*, *N. nycticorax, T. flavipes* (BirdLife International, 2016). The endemic species of Mexico *Anas diazi, not found in the data of the* IUCN (BirdLife International, 2021).

NOM-059-SEMARNAT

Species *A. diazi* is located in San Pedro River, which is listed in the NOM-059-SEMARNAT-2010 under the category of threatened, in addition to being a Mexicos endemic duck, making it a key species.

PRESENCE AND ABSENCE

The presence of the species was recorded monthly for one year, with a total of 30 species identified (Figure 2). It’s important to mention that only aquatic birds were counted, since there are many types of birds in that area. Some birds were observed throughout the year, such as *A. diazi* for being a resident of the place, other species were observed only in winter, such as *P. erythrorhynchos* since it is a winter migratory bird, and some other species, although in smaller quantities, were observed only in summer as *A. phoeniceus* which is a summer migratory species.

Species	jun-13	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	jun-14
Agelaius phoeniceus			*								*		
Anas acuta													
Anas crecca													
Anas diazi													
Anas platyrhynchos													
Ardea alba												*	
Ardea herodias													
Butorides virescens				*									
Calidris minutilla											*		
Charadrius vociferus													
Dendrocygna autumnalis					*						*		
Egretta caerulea													
Egretta thula													
Fulica americana			*										
Gallinula chloropus													
Himantopus mexicanus			*										
Larus delawarensis					*								
Limnodromus scolopaceus					*		*		*				
Mareca strepera					*								
Nycticorax nycticorax													
Pelecanus erythrorhynchos							*						
Plegadis chihi				*									
Podilymbus podiceps													
Recurvirostra americana		*											
Spatula americana			*		*								
Spatula clypeata					*								
Spatula cyanoptera					*								
Spatula discors					*								
Steganopus tricolor													
Tringa flavipes													

Figure 2. *Presence and absence of aquatic birds in a section of San Pedro River, Meoqui Chihuahua, Mexico.*

Note: Asterisks (*) represent the expected presence of the species, however, due to environmental events such as rain or anthropogenic events, could affect their presence.

Source: own elaboration

Frecuency

The frequency varied for the different species throughout the year, Figure 3 indicates the frequency of all species in one year period, two main increases were observed in the community, the first one in September and corresponds to the water increase level due to rain, the second and most significant increase corresponds to the month of January, due to the presence of winter migratory birds.

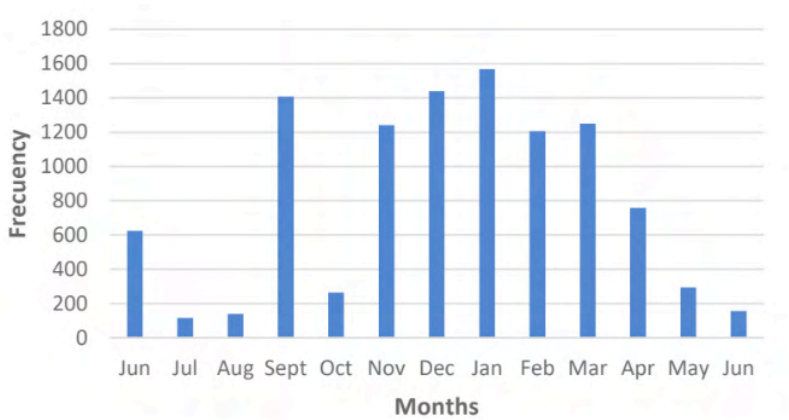

Figure 3. *Temporal frequency of the total birds registered in a section of San Pedro River, Meoqui, Chihuahua, Mexico.*

Source: own elaboration.

This is consistent with data reported by Fonseca *et al*. (2012), who mentioned that bird´s wealth and abundance increased by September, due to the decrease in the size of the lagoon after reaching its maximum extension and the arrival of migratory species, because after rain the availability of the resources of the aquatic system is larger. The temporary frequency of *A. diazi,* an endemic species, is presented (Figure 4). This bird was present throughout the year, although in different quantities, having a greater presence in September.

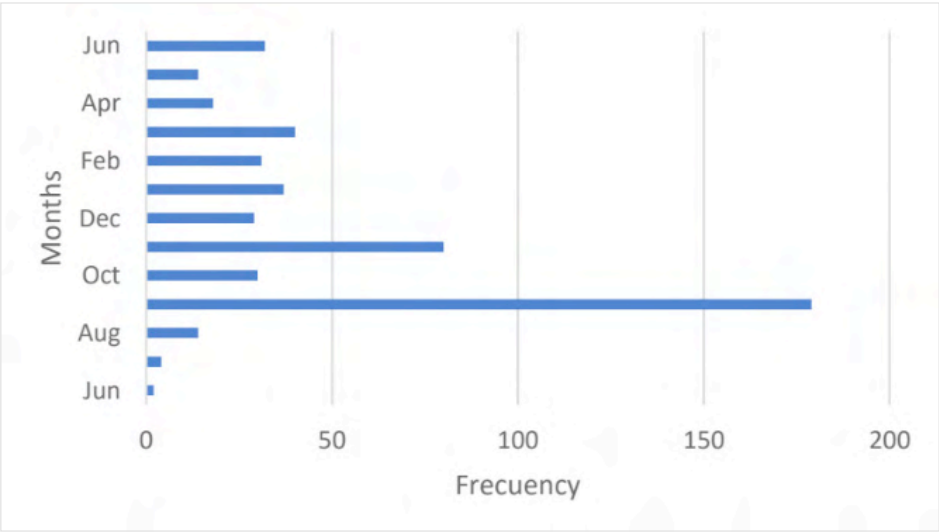

Figure 4. *Temporal frequency of A. diazi registered in a section of San Pedro River, Meoqui, Chihuahua, Mexico.*

Source: own elaboration.

Association between environmental variables and species

The correlation analysis between the environmental variables and the frequencies of waterfowl´s distribution throughout the year, indicates that the climatic variables that are the most associated ($p \leq 0.05$) with the variation in the distribution of birds were average, minimum and maximum temperature, as well as the speed of the wind; the type of association was direct or indirect according to the seasonal behavior of some species. The association between species was measured as well.

There were some species whose distribution was independent of most of the variables, such is the case of *A. platyrhynchos, C. vociferus* e *H. mexicanus,* that were found throughout the year, because they did not manifest a seasonal behavior. For instance, *A. acuta* correlates with relative humidity with a ($r= 0.587$, $p= 0.034$), so in dry months it is unlikely to find it in the area. *A. diazi* has correlation with the species *A. acuta* (r=

0.805; p=0.000) and with *S. americana*, (r= 0.575; p= 0.039), so they can be found in the same season. *P. erythrorhynchos* has negative correlation with maximum temperature (r= -0.059; p= 0.030), therefore it is more akin to low temperatures. Moreover, it has a negative correlation with *A. alba* (r= 0.672; p= 0.011) and *G. galeata (*r= 0.587; p= 0 .034), so it is unlikely to find them together.

Finally *S. tricolor* has a negative correlation with the direction of speed maximum of wind (r= 0.573; p= 0 .040), since it prefers low speed wind, in addition has a correlation with *A. platyrynchos* (r= 0.709; p= 0 .006), *A. alba* (r= 0.891; p= <.000) and *E. thula* (r= 0.835; p= .000).

Potential Clusters

The cluster analysis grouped the species of waterfowl observed, it was chosen to work with four groups according to the suggestion of the Pseudostatistics T^2, which indicates that in this level there is a separation between groups (r^2=0.746); as well as being a practical number for analysis. It is important to emphasize that the *S. tricolor* remains as a group by itself, given its exclusive sighting in the month of November.

Four large groups were formed according to the correlation between species and environmental variables (Table 1), those groups are; number four represents a single species (*S. tricolor*), observed in the month of November with a precipitation of 46.1 mm and maximum, minimum and mean temperatures of 20.25 °C, 6.6 8°C &12.77 °C, respectively, and a wind speed of 4.07 km/h. Group three is formed of four species seen in a few months, each species was observed at different times of the year, so the environmental characteristics in which they developed are varied. Group two is the largest one, up to 16 species with broader environmental characteristics since most of the them are distributed throughout the year. The group one contains six species, which are distributed from September to April, corresponding to the months with less heat, with precipitation averages of 11.22 mm, maximum temperature of 25.09 °C, mínimum temperatura of 9.89 °C, mean temperature of 17.36 °C and wind speed of 3.65 km/h, respectively.

GROUP 1	GROUP 2	GROUP 3	GROUP 4
S. americana	acuta	phoeniceus	S. tricolor
S. clypeata	S. discors	B. virescens	
Crecca	diazi	C. minutilla	
S. cyanoptera	A. platyrhynchos	E. caerulea	
strepera	alba		
autumnalis.	herodias		
L. delawarensis	C. vociferous		
L. scolopaceus	thula		

P. erythrorhynchos	americana
	chloropus.
	mexicanus
	N. nycticorax
	P. chihi
	P. podiceps
	R. americana
	T. flavipes

Table 1. Characterization of groups of birds according to their main environmental components. Source: own elaboration.

Association and Correspondence Analysis (JiCuadrada and A Correspondence)

The JiCuadrada test identified the existence of an association between the aquatic bird species and their distribution throughout the year ($p<0.0001$). The correspondence analysis signalize that in the months of June, July and August (summer) the species with the most correspondence were the *A. phoeniceus*, *P. chihi* & *B. virescens*; these three species being the most contrasting with respect to the rest. In the month of May, the species that corresponded were *A. acuta*, *E. caerulea*, *A. herodias*, *C. vociferus* and *N. nycticorax*.

CONCLUSIONS

The results revealed an abundance of species that increases by September due to the rise in the water level caused by the rainy season, incrementing as well the availability of resources. Nevertheless, the month with the highest abundance level was January, due to the presence of winter migratory birds. This shows an association between the frequency of sightings of waterfowl and the months of the year. Temperature, precipitation and wind speed are the main environmental variables conditioning the temporal distribution of waterfowl.

It is feasible to generate groupings of waterfowl species based on the frequency of their temporary sightings and the preferred environmental conditions. There is a large group including most of the species that demostrate similar requirements in terms of environmental variables. The species *S. tricolor* behaved very differently from the rest of the bird species, because it was observed only in the month of November, so its preferences are associated with the onset of low temperatures, higher wind speeds and less precipitation. It was possible to observe species that prefer the winter season while others only appear in summer, for instance *A. phoeniceus, A. acuta* and *B. virescens* are species that prefer warm temperatures with high precipitation. Referring to the species listed in the NOM-059-SEMARNAT-2010 in the category of threatened and endemic, *A. diazi* it was registered throughout the year with the largest population in September to March.

SUGGESTIONS

The generation and availability of information is essential for conservation, therefore, it is recommended to continue with studies related to biological diversity, pollution, as well as the impact caused by urbanization, livestock and agricultural activities. It is essential to continue monitoring waterfowl in the area, since the migration patterns and habits are presenting changes in recent years as a result of climate change and other environmental impacts. Numerous dead fish were observed during the study, large buildup of foam due to use of detergents, garbage, in addition to people riding quad bikes, causing damage to birds and their nests, so it is recommended to promote and comply the environmental laws and regulations to preserve the place that nowadays is in spoilage despite being a RAMSAR site.

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ANNEXES

Figure 5. *Charadrius vociferus, observed in the month of August.*

Figure 6. *Ardea alba, observed in the month of August.*

Figure 7. *Ardea herodias, observed in the month of August.*

Figure 8. *Nyctycorax nyctycorax, observed in the month of August.*

Figure 9. *Fulica americana, observed in the month of February.*

Figure 10. *Spatula clypeata,* observed in the month of February.

Figure 11. *Pelecanus erythrorhynchos, observed in the month of February.*

Figure 12. Picture *of Anas diazi,* male and famale (Becerril, (Becerril, 2018).

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