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ARTÍCULO ORIGINAL

Waterfowl community from a protected artificial wetland in Mexico State, Mexico

Comunidad de aves acuáticas de un humedal protegido en el Estado de México, México

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Abstract
Wetlands are one of the most important ecosystems worldwide due to the great biologic diversity that they harbor and the resources and ecosystem services that they provide; however, their conservation is seriously threatened. Waterfowl are one of the most representative components of wetland biodiversity and the study of their communities is necessary to establish protection priorities appropriately. In this study, we describe the species richness and relative abundance of the waterfowl community of an artificial wetland in Mexico State which we visited from August 2010 to August 2011. We found 23 species, most of which belong to the *Anatidae* (ducks) and *Ardeidae* (herons) families and we recorded an accumulated abundance of 25,220 individuals. We performed an accumulation curve and we used Clench's model which estimated 24 species; thus, we observed 95% of the predicted species. The arrival of migratory species contributed substantially to the increase of the species richness and the abundance of individuals, especially from October to March. We consider that the species richness and the abundance that we recorded, including observations of rare species, species reproducing, and species under a conservation category, are indicative of the great ecological value of this wetland despite its limited size. Therefore, it is relevant to assess ecological features of natural and artificial wetlands, including waterfowl communities, in order to improve the conservation actions in this region.

Keywords: Abundance, Anatidae, Ardeidae, conservation, distribution, diversity, species richness.

Resumen
Los humedales son de los ecosistemas más importantes en el mundo por la gran diversidad biológica que albergan y los recursos y servicios ecosistémicos que proporcionan; sin embargo, su conservación está severamente amenazada. Las aves acuáticas son uno de los componentes más representativos de la biodiversidad de los humedales y es necesario estudiar sus comunidades para establecer prioridades de protección adecuadamente. En este estudio describimos la riqueza de especies y abundancia relativa de la comunidad de aves acuáticas de un humedal del Estado de México que visitamos desde agosto de 2010 al mes de agosto de 2011. Encontramos 23 especies de aves acuáticas, la mayoría pertenecen a las familias *Anatidae* (patos) y *Ardeidae* (garzas) y registramos una abundancia acumulada de 25,220 individuos. Realizamos una curva de acumulación de especies y empleamos el modelo de Clench, cuya estimación fue de 24 especies; por lo tanto, observamos al 95% de las especies predichas. La llegada de especies migratorias contribuyó evidentemente al incremento de la riqueza de especies y la abundancia de individuos, especialmente de octubre a marzo. Consideramos que la riqueza de especies y la abundancia que registramos, así como la observación de especies poco comunes, especies reproduciéndose y especies sujetas a una categoría de conservación, indican el gran valor ecológico de este humedal a pesar de su extensión limitada. Por lo tanto, es relevante evaluar las características ecológicas de los humedales naturales y artificiales, incluyendo a las comunidades de aves acuáticas, para mejorar las acciones de conservación en esta región.

Palabras clave: Abundancia, Anatidae, Ardeidae, conservación, distribución, diversidad, riqueza de especies.

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Introduction

In Mexico, wetlands are examples of the great biodiversity of the country, not only due to their different types, from coastal lagoons and mangrove swamps to inland lakes and marshes, but also because they support a great diversity of species; likewise, they provide the local human societies with valuable natural resources (Wilson and Ryan 1997). Nevertheless, they are also one of the most threatened environments due to anthropogenic pressures (Sebastián-González *et al.* 2013).

Wetlands are essential for many species such as waterfowl, which depend ecologically on them and are one of the most remarkable elements of global biodiversity (Wetlands International 2012). For a considerable proportion of North America's waterfowl and other migratory bird populations, Mexican wetlands are essential stopover and wintering sites and their protection is critical to ensure the long-term survival of these birds (Wilson and Ryan 1997, DGVS 2008). In response to the wetlands and waterfowl protection needs, Mexico has become a member of conservation agreements, participating internationally in the Ramsar Convention on Wetlands (Ramsar 2014), regionally in the North American Wetlands Conservation Act (Wilson and Ryan 1997) and the American Waterfowl Management Plan (Williams *et al.* 1999, Pérez-Arteaga et al. 2005), and at the country level, the National Strategy for the Conservation, Management and Rational Use of Waterfowl and their Habitats in Mexico has been implemented (DGVS 2008).

The study and characterization of wetlands and waterfowl populations are relevant for planning, adapting, and implementing conservation actions against the threats that they face (DGVS 2008). Leading efforts have been achieved for assessing the status of wetlands and waterfowl at international and national levels (Pérez-Arteaga and Gaston 2004, Pérez-Arteaga *et al.* 2005, Wetlands International 2012), but studies about regions or specific locations are still needed, especially in the Neotropical region (Rojas-Soto and Olivares de Ita 2005). Hence, it is necessary to monitor the waterfowl populations to gather information that can be used for the establishment of priority sites and protection strategies at the local and regional levels, especially in relation to the modification of natural habitats and the creation of new ones by human activities, like artificial wetlands which could become alternatives for biodiversity conservation (Carmona *et al.* 2011, Sebastián-González *et al.* 2013). Here, we make the first description of the waterfowl community that inhabits an artificial and protected wetland in the central highlands of Mexico, during a period of one year, and in that way, we provide a reference for further conservation decisions and ecological research.

Methods

Study area

The study area is encompassed in the river basin of Lerma-Chapala-Santiago (Obregón 2011), in the middle of the transvolcanic belt, where intense volcanic activity created several lakes and marshes (Mitsch and Hernández 2013). It is near the Ciénegas de Lerma, a natural protected area which is the biggest wetland in the central zone of Mexico and it is a crucial area for the migration of North American waterfowl (Colón-Quezada 2009, Ramsar 2014). This area is under considerable pressure for agricultural production and due to the loss of the original vegetation, the ground has a high evaporation rate and many natural wetlands have been lost. For that reasons, several artificial water reservoirs were constructed to irrigate the fields. The climate of the region is temperate with summer rains and frosts, the average annual temperature is 12.6 °C and the average precipitation is 878.4 mm (López *et al.* 2007).

The artificial wetland that we studied is called "Bordo las Maravillas", is part of the University Campus El Cerrillo, Piedras Blancas of the Autonomous University of Mexico State, and it is located in the municipality of Toluca in Mexico State, at 2600 m above sea level (19°24'26.71"N; 99°41'30.71'' W) (Figure 1). It was constructed for agricultural purposes, although it is a natural area under the scheme of Unit for the Management and Conservation of Wildlife (UMA for its abbreviation in Spanish) without natural resources extraction. Its surface is 16.59 ha and it has a floodgate and a channel that delivers domestic sewage. The depth is 70 cm on average, but it varies across the year due to the input of rainwater, the evaporation and the extraction of water for agricultural irrigation; the deepest areas are toward the floodgate and the shallowest ones are near the channel (Obregón 2011). The perimeter is 1,577 m, and is secured with cyclonic mesh and surrounded almost entirely by willows (*Salix babilonica*); the aquatic vegetation is composed of species like *Scirpus* sp., *Juncus microcephalus* and *Typha latifolia* (Colón 2004, López *et al.* 2007), which create several islands at the interior of the wetland.

Birds observation

With the aim of generating a census observing most of the water surface, we used the point counts technique (Bibby *et al.* 2000). We established four independent observation points at the edges of the wetland, about 230 m apart from each other on average, and we set visual references for delimitating the

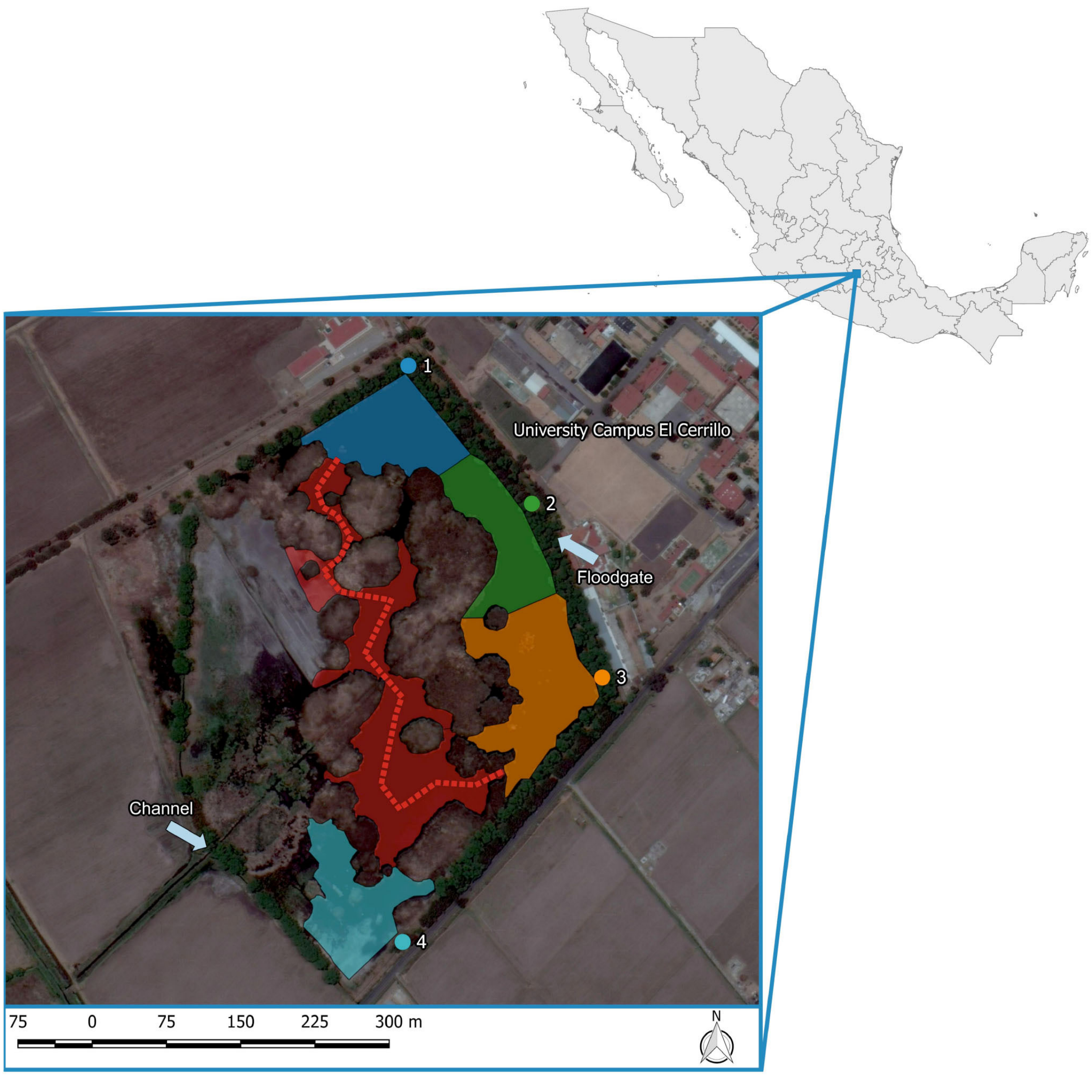

Figure 1. Map of the artificial wetland "Bordo las Maravillas", Mexico State. The numbers indicate the observation points, the dotted line is the route followed in the transcect and the shaded areas are the water surface observed from the observation point and the transect of the corresponding color.

observation area and avoiding sightings duplications. This wetland has an earth wall on its Northeast, East, and Southeast sides and dense vegetation on its edges, so we could move between the observation points behind the wall without disturbing the birds. Because of the aquatic vegetation enclosing parts of the wetland, it is not possible to have a complete view of an inner area from the edges; therefore, we also did a transect by boat on the wetland inside to count and identify the birds that were only in this area (Figure 1). Nevertheless, there are inaccessible areas at the west part of the wetland where some waterfowl could be present, but they were the shallowest and we found them entirely dry in many visits.

We performed 19 visits, from August 2nd, 2010 to August 12th, 2011. The observation period was from 7:00 h to 8:45 h, we spent 15 minutes on each observation point and 5 minutes walking between points; then, we covered the transect in 25 minutes, approximately. Due to the high abundance of individuals during the wintering months, from October to March we performed fortnightly visits and through the reproduction period, when the abundance decreased, we did one visit per month. For reporting the accumulative abundance of the wetland, we considered only the maximum amount of individuals within a month. During the wintering period, the high density of individuals from the *Anatidae* family, in addition to the lack of distinctive marks in females, juveniles, and males in basic plumage, prevented us from achieving the identification at a species level for many of them, creating an important gap in our records.

The observations were completed by two observers, AHC and MY. In the observation points, we watched the birds using 16 x 50 binoculars and a spotting scope (20 x 60) and in the transect, we used binoculars (16 x 50). For the transect route, GGE and AEOA assisted leading the boat so the observers could concentrate exclusively on the birds. We confirmed the birds' identification using the guides of Howell and Webb (1995), Dunn and Alderfer (2006) and Van Perlo (2006), and we followed the scientific nomenclature of The American Ornithologists' Union (AOU 1998). Our classification of bird species as waterfowl is based on the families included in the waterfowl definition from Wetlands International (2012).

We performed the abundance and species richness analysis for the whole wetland after integrating our records per day because most of the species that we found were present in all of the observation points and along the transect. Like Herrera and Salgado (2014), we assigned a relative abundance value of 100% to the species with the highest number of records and we calculated the relative abundance of the other species as a proportion in relation to the first one using the following formula:

$$A_{rel} = (O_z / O_{max})\ 100$$

Where:

A_{rel} = Relative abundance
O_z = Observations of the species Z
O_{max} = Observations of the most abundant species

For assessing the sampling effort and the species richness, we estimated the species accumulation curve using the Clench's model, we calculated the curve using the EstimateS© and Statistica© software, following the procedure proposed by Jiménez-Valverde and Hortal (2003) and we set 200 randomizations, calculated the 95% confidence intervals, and extrapolated the curve to 10 extra sampling units.

Results

We recorded the presence of 23 species, which belong to five orders, six families, and fifteen genera. The most represented family was *Anatidae*, from which we observed ten species, and the second one was *Ardeidae* with six species. From the families *Threskiornithidae* and *Scolopacidae* we observed one species each, thus they were the least represented. By contrast, considering the observed species in relation to the total of species for the country per family, the highest proportion was in the *Ardeidae* family in which we recorded six of the sixteen species (37.5%). Most of the species that we observed (14/23) are considered migratory in the region of our study (Berlanga *et al.* 2008). The complete list of species, their proportions per family and migratory status can be consulted in Table 1.

The species accumulation curve that we recorded had typical growth and on the December 13th observation, reached its maximum value of 23 species. Accordingly, the curve calculated with Clench's model was very similar; its asymptote had a value of 23.98, predicting that the ecosystem may harbor 24 species and shows that we found 95% of them and could only register one additional species (Figure 2). Likewise, the determination coefficient (R^2) is close to one (0.99) showing that the model had a good adjustment to the data, and the curve slope was less than 0.1 (0.04) which let us conclude that the species list is reliable (Jiménez-Valverde and Hortal 2003). Therefore, we had an accurate description of the species richness.

The number of species varied during the observation period but the increase due to the addition of migratory spe-

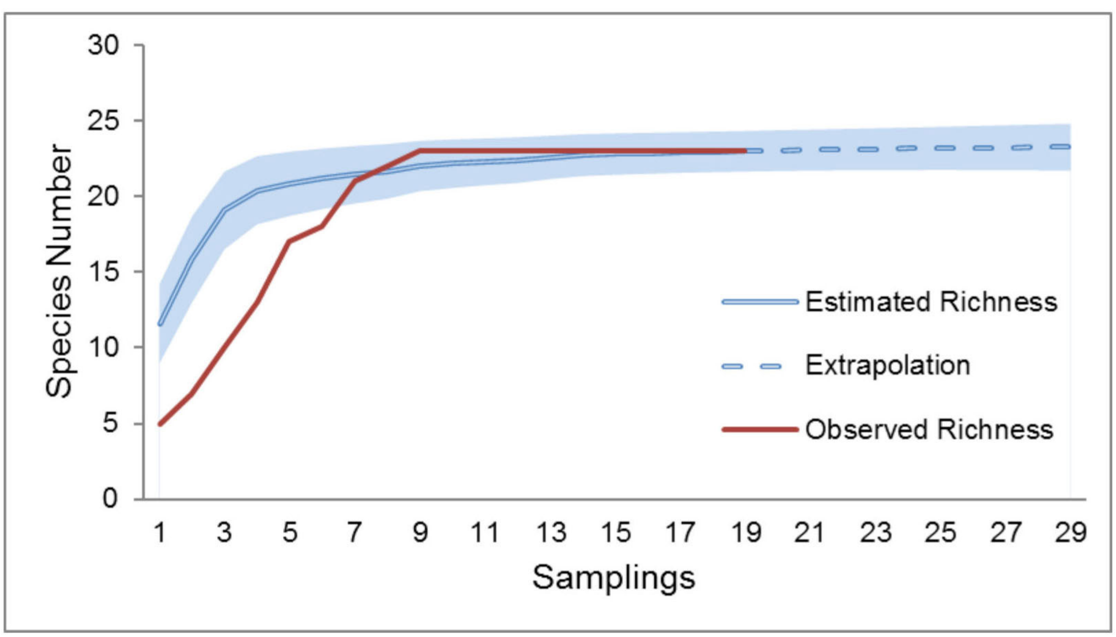

Figure 2. Observed and estimated species accumulation curves. The shadow area indicates the upper and lower 95% confidence intervals.

cies in the wintering months (October-March) was evident. At the beginning, we registered an average of seven species in August; then, from October to April, we registered over ten species. The highest record was during January (n=18), and afterwards, the species richness decreased to eight in August the next year; nevertheless, we recorded four species on November 29th which was the lowest value (Figure 3-A). The most frequent species were the Mexican Duck (*Anas platyrhynchos diazi*) and the American Coot (*Fulica americana*), which we observed in all but one of our visits and both had a relative abundance of 100%; by contrast, the species with the lowest relative abundance (6%) was the Sora (*Porzana carolina*) (Table 1).

The abundance of individuals in the site varied throughout the year, which was expected for the arrival of migratory species. Figure 3-B shows the increase of individuals during the winter period and the subsequent decrease in the summer months. We recorded the maximum abundance during January 24th (n = 8,808) and the minimum, during August 2nd of the first year (n = 79) (Table 2).

Excluding the group of unidentified ducks and teals, the Cattle Egret (*Bubulcus ibis*) was the most abundant species reaching an accumulative abundance of 1,943 individuals; followed by the Green-winged Teal (*Anas crecca*) with 1,141. The least represented species were the Sora (*Porzana carolina*), from which we just saw one individual on one occasion, the Least Grebe (*Tachybaptus dominicus*) (one individual in two visits), and the Great Blue Heron (*Ardea herodias*) (one individual in three visits). The accumulated abundance that we documented at the end of the study, considering only the maximum record per month, was 25,220 individuals. In Table 2 the abundance per visit, species and total is displayed.

Regarding the resident species, we confirmed that some were reproducing in this wetland. We observed Black-crowned Night-Heron (*Nycticorax nycticorax*) younglings and American Coot (*Fulica americana*) chicks. Additionally, we found a Mexi-

Table 1. Taxonomy, scientific and English names, conservation status and migratory status of the observed species in the artificial wetland "Bordo las Maravillas", Mexico State.

Order	Family proportion*	Subfamily	Species	Common Name	Migratory Status	RA %
Anseriformes	*Anatidae* 10/41 (24.3%)	*Dendrocygninae*	*Dendrocygna bicolor*	Fulvous Whistling-Duck	R	28
		Anatinae	*Anas strepera*	Gadwall	M	44
			Anas americana	American Wigeon	M	33
			Anas platyrhynchos diazi	Mexican duck (T)	R	100
			Anas discors	Blue-winged Teal	M	67
			Anas cyanoptera	Cinnamon Teal	M	83
			Anas clypeata	Northern Shoveler	M	72
			Anas acuta	Northern Pintail	M	44
			Anas crecca	Green-winged Teal	M	67
			Oxyura jamaicensis	Ruddy Duck	R	89
Podicipediformes	*Podicipedidae* 2/7 (28.5%)		*Tachybaptus dominicus*	Least Grebe (SP)	R	11
			Podilymbus podiceps	Pied-billed Grebe	R	44
Pelecaniformes	*Ardeidae* 6/16 (37.5%)		*Ardea herodias*	Great Blue Heron	M	17
			Ardea alba	Great Egret	M	72
			Egretta thula	Snowy Egret	M	61
			Bubulcus ibis	Cattle Egret	M	61
			Butorides virescens	Green Heron	M	22
			Nycticorax nycticorax	Black-crowned Night-Heron	R	83
	Threskiornithidae 1/4 (25%)	*Threskiornithinae*	*Plegadis chihi*	White-faced Ibis	R	56
Gruiformes	*Rallidae* 3/18 (16.6%)		*Porzana carolina*	Sora	M	6
			Gallinula chloropus	Common Moorhen	R	78
			Fulica americana	American Coot	R	100
Charadriiformes	*Scolopacidae* 1/42 (2.3%)	*Phalaropodinae*	Phalaropus tricolor	Wilson's Phalarope	M	11

*The family proportion refers to the number of species observed, compared to the amount reported for the country; in parenthesis is the corresponding percentage. The conservation categories "Threatened" and "Special Protection" from the Mexican law for the protection of endangered species are abbreviated as (T) and (SP), respectively (SEMARNAT 2010). Regarding the migratory status in the region, R stands for resident and M for migratory. The relative abundance (RA) is reported in percentage.

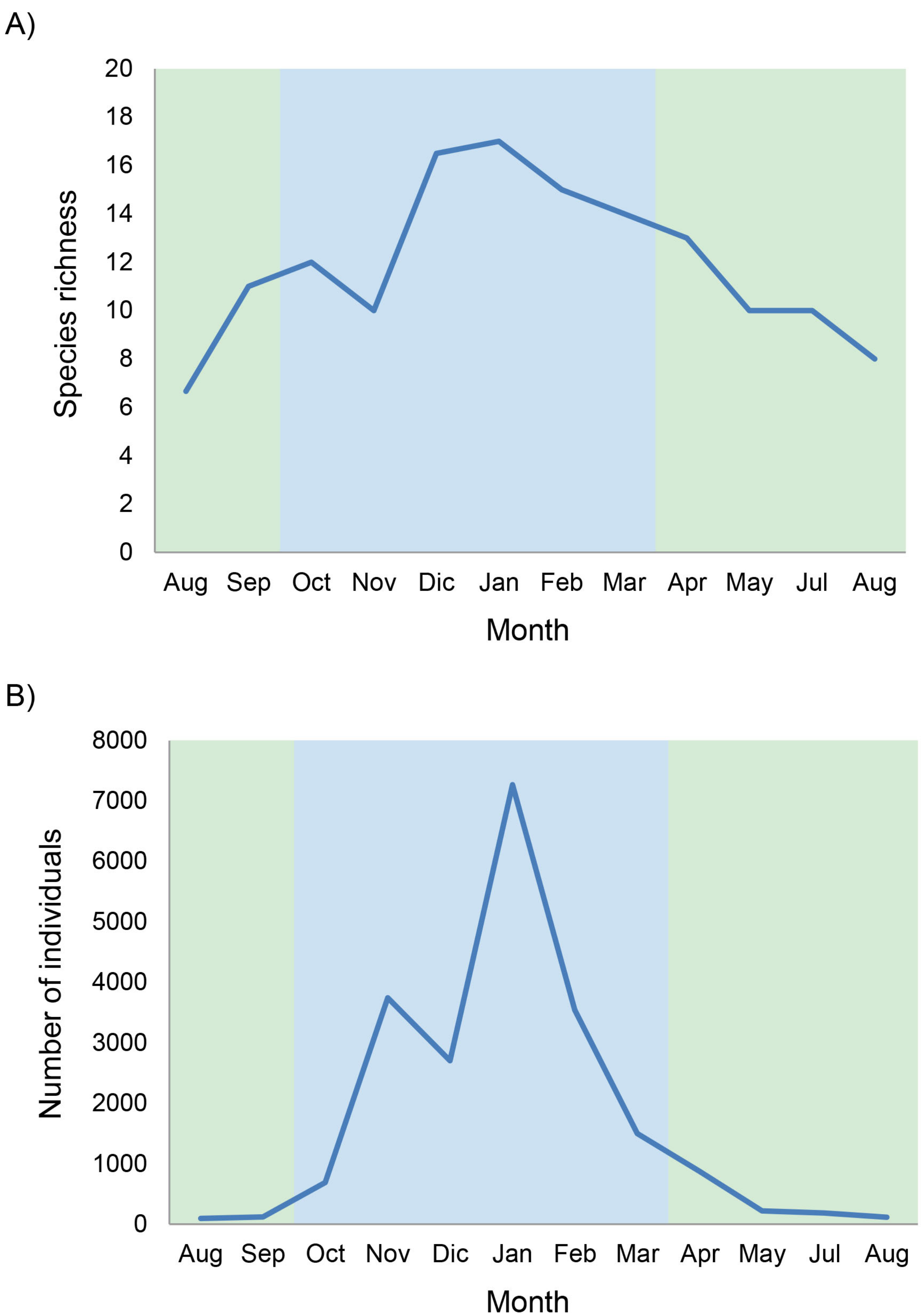

Figure 3. Species richness (A) and abundance of individuals (B) observed in the artificial wetland "Bordo las Maravillas", Mexico State. The green shading indicates the reproductive period and the blue one, the wintering period.

Table 2. Number of observed individuals and abundance in the artificial wetland "Bordo las Maravillas", Mexico State.

Species	Observation 02/08/10	15/08/10	30/08/10	20/09/10	04/10/10	25/10/10	15/11/10	29/11/10	13/12/10	29/12/10	10/01/11	24/01/11	14/02/11	28/02/11	24/03/11	30/04/11	31/05/11	02/07/11	12/08/11	Total
Dendrocygna bicolor	0	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	7	0	2	15
Anas strepera	0	0	0	0	0	0	4	3	0	10	9	14	8	8	2	0	0	0	0	58
Anas americana	0	0	0	0	0	0	3	0	1	3	1	2	0	2	0	0	0	0	0	12
Anas platyrhynchos diazi	16	8	12	8	35	10	53	0	16	30	15	33	11	13	46	14	22	121	19	482
Anas discors	0	0	0	0	1	8	2	0	6	5	8	11	2	7	9	8	0	1	0	68
Anas cyanoptera	0	6	5	10	28	16	20	0	30	4	20	14	14	7	7	1	0	5	0	187
Anas clypeata	0	0	0	0	12	9	35	0	13	56	23	54	42	80	62	5	2	0	5	398
Anas acuta	0	0	0	0	0	0	543	0	3	29	40	22	3	3	1	0	0	0	0	644
Anas crecca	0	0	0	0	3	5	21	0	65	472	236	155	148	27	3	2	2	2	0	1141
Anas spp.	28	72	0	16	218	927	3376	2927	1445	2226	5277	7930	3605	2628	1299	770	127	0	54	32925
Oxyura jamaicensis	1	10	7	0	0	7	11	0	17	6	7	23	1	3	9	4	4	20	5	135
Tachybaptus dominicus	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	2
Podilymbus podiceps	0	0	0	0	0	2	2	0	2	3	2	2	2	3	0	0	0	0	0	18
Ardea herodias	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3
Ardea alba	0	0	0	1	0	3	0	4	2	5	2	5	7	1	2	2	1	1	0	36
Egretta thula	5	4	6	10	2	5	1	0	0	3	0	0	0	0	5	4	10	7	0	62
Bubulcus ibis	0	0	0	0	0	21	150	302	35	504	63	477	360	10	20	1	0	0	0	1943
Butorides virescens	0	0	0	2	1	0	0	0	0	0	0	2	0	1	0	0	0	0	0	6
Nycticorax nycticorax	13	2	2	1	3	0	1	0	7	2	1	1	0	0	2	4	10	6	8	63
Plegadis chihi	0	0	0	11	0	16	21	0	40	348	5	39	11	0	0	10	0	0	6	507
Porzana carolina	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Gallinula chloropus	0	0	0	0	1	3	3	0	1	1	1	3	2	2	1	7	5	4	1	35
Fulica americana	16	13	5	19	11	29	7	0	11	7	19	20	35	37	32	42	28	19	16	366
Phalaropus tricolor	0	0	56	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96
Total	79	117	95	121	316	1061	4253	3237	1695	3714	5729	8808	4252	2832	1500	874	218	186	116	25220*

* We considered only the maximum abundance per month to calculate the total accumulated abundance.

can duck (*Anas platyrhynchos diazi*) nest with two eggs and later on the season we observed the younglings of this species.

Two species that we recorded have a category of protection in the Mexican law for the protection of endangered species. The Least Grebe (*Tachybaptus dominicus*) is included in the "special protection" category and the Mexican Duck (*Anas platyrhynchos diazi*), in the "threatened" category (SEMARNAT 2010).

Discussion

The species richness, distribution and abundance are necessary parameters for making conservation decisions and for the sustainable use of waterfowl (DGVS 2008, Ruelas *et al.* 2009).

Performing a systematic description by covering most of the water surface of the wetland of our study allowed us to obtain a comprehensive description of the waterfowl community. We had an almost complete record of the species richness, given that we registered 23 of the 24 predicted species; likewise, we could estimate the number of birds present and in this way, we observed the changes in the compositions of species and in the abundance of individuals in a year basis.

The particular low species count that we had on November 29th, was associated with an unknown disturbance that made the birds leave at the beginning of our visit before we were able to identify them, although we could count the individuals as they flew over the wetland and therefore that fluctuation is not strictly reflected in the corresponding abundance. Likewise, we also faced a disturbance that scared the birds on December 13th; on that occasion, it happened in the middle of our visit, so we identified many individuals, but we could not count all of them because they flew away from the wetland. To avoid this, digital recording methods like high definition photographs and videos could be used for achieving a better identification; although we did not have access to them during our study. Contrastingly, the outstanding abundance that we observed on January 24th highly exceeded the previous and subsequent records. In this case, there is the possibility that other disturbances had scared the birds in the surrounding wetlands and they took refuge in our study wetland. Despite these peculiar situations, both the species richness and the abundance of individuals in the wetland showed a considerable increase in the wintering months, showing that this wetland can be a refuge for waterfowl during migration, similar to other important resting areas in the country (Ramírez-Bastida *et al.* 2008).

An interesting observation was the presence of the Fulvous Whistling-Duck (*Dendrocygna bicolor*) and the Least Grebe (*Tachybaptus dominicus*), both of which are considered to be infrequent in the central highlands (Colón 2004, Ortega-Álvarez 2013). In a previous study in this wetland, Colón (2004) reported the presence of the Fulvous Whistling-Duck (*Dendrocyna bicolor*) and Black-bellied Whistling-Duck (*Dendrocygna autumnalis*) which are unusual in the region or not present at all (Colón 2004, Ramírez-Bastida *et al.* 2008). Although we confirmed the presence of the Fulvous Whistling-Duck during the summer of both years, we did not observe the Black-bellied Whistling-Duck. Similarly, the sight of the Least Grebe (*Tachybaptus dominicus*) is considered to be uncommon in the region (Ortega-Álvarez 2013). In a similar way, the unique observation that we had of the Sora (*Porzana carolina*) was notable because certain species of waterfowl, like some from the *Rallidae* family, are elusive, cryptic and difficult to watch; therefore the studies of their abundance can be complemented with other techniques like recorded calling playback (Brambilla and Jenkins 2009, Conway and Nadeau 2010). These observations suggest that this wetland offers specific characteristics to rare species, which increase its ecological value.

We confirmed that the Mexican Duck is reproducing here through our observation of a nest with eggs and juveniles. The Mallard (*Anas platyrhynchos*) has a broad distribution and big populations in America, but the Mexican Duck (*Anas platyrhynchos diazi*) is the only member of the genus *Anas* that has adapted as a resident in Mexican highlands, where 98% of its population resides (Pérez-Arteaga and Gaston 2004) and it showed a significant decline in its populations in the Lerma region from 1991 to 2000 (Pérez-Arteaga *et al.* 2002). The lack of suitable vegetation for nesting and refuge has being proposed as one of the limiting factors for its distribution (Pérez-Arteaga *et al.* 2002); therefore, the preservation of wetlands that offer refuge, food sources, and nesting resources, is relevant for the conservation of this threatened duck.

In comparison to other similar descriptions of waterbird communities in the central zone of Mexico, the wetland that we studied has a high abundance of birds and species richness considering its surface (16.59 ha). For instance, Fonseca *et al.* (2012) reported for a one year period, an accumulated abundance of 48,794 individuals and 36 species of waterfowl (ten belonging to the *Anatidae* family) in the Acuitlapilco lagoon in Tlaxcala State, which surface varies from 30 to 70 ha through the year. In Río Grande de Morelia basin in Michoacán State (700 ha surface), during one year, Barragán *et al.* (2002) recorded 23 species of aquatic birds and the *Anatidae* and *Ardeidae* families were the best represented with six and five species respectively. From the 69 species (including others than waterfowl) observed by Pineda-López and Arellano-Sanaphre (2010) during two years in 12 sites with a combined surface of over 1500 ha in the Queretaro State, 18 belong to the *Anatidae* family. Like the mentioned authors, we also found that the most abundant family was *Anatidae* and that its input of migratory species has a strong influence on the composition and size of the waterfowl communities; hence, this family has a constant presence in the region despite the wetlands' differing conditions. In our study and in the cited ones, the proportion of migratory and transient species was elevated; considering the regional residence status described in Berlanga *et al.* (2008), 14 (61%) of the species that we observed, 27 (75%) of the species reported by Fonseca *et al.* (2012), 16 (70%) from Barragán *et al.* (2002), and 51 (74%) listed by Pineda-López and Arellano-Sanaphre (2010) belong to these categories. This confirms that the wetlands of the country are essential as resting and wintering areas during migration as mentioned previously (Ramírez-Bastida *et al.*2008).

Wetlands are highly dynamic ecosystems where resources vary seasonally (Barragán *et al.* 2002) and these variations have a direct influence on waterfowl distribution because it depends on the characteristics, extensiveness, and quality of the wetlands (DGVS 2008). Waterfowl choose sites with good food availability and shelter, especially for nesting and wintering (DGVS 2008) and they use wetlands with high eutrophication levels (Barragán *et al.* 2002); therefore, it is likely that migratory ducks adjust their time of stopover according to the foraging quality of the habitats (O'Neal *et al.* 2012). For instance, Obregón (2011) found that this particular reservoir has a high level of eutrophication, tending to be hyper-eutrophicated. Also, the diet of some waterfowl species is mainly based on plants associated with wetlands and it can be complemented with crops, especially in regions where the wetlands have suffered from continuous degradation, the nearby fields can provide an alternative food resource for waterfowl (DGVS 2008, Colón-Quezada 2009); for example, Colón-Quezada (2009) found that corn was one of the main diet components for the Mexican duck (*Anas platyrhynchos diazi*) in Ciénegas del Lerma. These could be some of the reasons why we observed migratory ducks in all but one of our visits and we recorded high concentrations of them during the wintering period; however, a comprehensive analysis of their diet *in situ* is needed.

Our study location is close to Ciénegas del Lerma Flora and Fauna Protected Area (approximately 25 linear km) and it is also surrounded by several artificial wetlands and dams; this creates a variety of close alternative habitats for the waterfowl with different quality and changing available resources; therefore, the species richness that we observed may be related to the regional diversity created by those wetlands. The features of this particular wetland, such as its protection, food availability, roosting sites, and refuge in the surrounding and aquatic vegetation, favor the presence and abundance of the species that we observed. Contrastingly, we did a reconnaissance visit to the six nearby reservoirs, less than 1.6 Km away, and we saw that they have different surfaces, depths, water sources, do not have any kind of protection, and the vegetation at their interior and edges was scarce, allowing people and cattle access to them creating disturbances constantly. The exception was the wetland situated Northwest from our study site which had similar vegetation islands; however, the number of aquatic birds that we observed in all of them was limited.

It should be also considered that the inter and intraspecific interactions, natural variations such as the vegetation succession, human usage of wetlands, and catastrophic events like fires, diseases or natural disasters, have a strong influence on the community composition (Sebastián-González *et al.* 2013). During the period of our visits, a fire affected the South edge of the wetland on January 2011 and the vegetation recovered entirely in the following months; likewise, during December 2010 and January 2011 the water level dropped gradually around 0.5 m because the water was used for irrigation. Nevertheless, we did not observe changes in the species richness or abundance throughout these events; therefore, also the magnitude of these alterations is relevant. Thus, in order to have an integrated understanding of the waterfowl community in Bordo las Maravillas wetland and in the region, including population tendencies, changes in the species distribution and abundance, the long term analysis of the habitat selection is needed.

Artificial wetlands, like those constructed in the central highland region to satisfy the human demand for water (Barragán *et al.* 2002), have a recognized importance for waterfowl because they provide functions and resources, like food and refuge, and they can partially mitigate the loss or reduction of natural wetlands (Carmona *et al.* 2011). Large numbers of migratory and resident birds use artificial wetlands, at least temporally, which makes them beneficial to the bird communities, although they should not be considered as substitutes because natural wetlands are capable of supporting a greater diversity of species (Carmona *et al.* 2011, Sebastián-González *et al.* 2013). By considering not only the wetlands' origin but also their intrinsic properties, artificial wetlands become relevant and their protection should continue to be encouraged (Carmona *et al.* 2011). For instance, from the 142 Ramsar Sites (Wetlands of International Importance) that cover 8.6 million ha in Mexico, 37 are human-made wetlands (Ramsar 2014). Regarding the waterfowl, conservation programs should consider it as a priority group (Pineda-López and Arellano-Sanaphre 2010) and in that sense, the improvement of wetland conditions, especially concerning water quality, the increase of vegetation, nesting resources, and protection from disturbances such as cattle, benefits the diversity of waterfowl and other associated species (Pérez-Arteaga *et al.* 2002, Pineda-López and Arellano-Sanaphre 2010).

Although the conservation efforts traditionally take place in zones with high ecologic value, this does not necessarily mean that only large and diverse habitats should be prioritized; the importance of small habitats (10 - 40 ha) as refuge for certain species or as connecting nodes has being highlighted previously (Pineda-López and Arellano-Sanaphre 2010, Sebastián-González *et al.* 2013). This is especially relevant in Mexico, as most of its 14,000 wetlands are small in size (<10 ha) (Ramírez-Bastida *et al.* 2008). Thus, the extensive system of small wetlands from the central highlands can represent a broad habitat for waterfowl as a whole (Ramírez-Bastida *et al.* 2008) and the wetland of our study show just a part of it. The species richness and abundance that we recorded show that even small artificial wetlands could be relevant for the conservation of waterfowl, as this wetland is a refuge for migratory species, can host rare species, and is a suitable place for the reproduction of threatened species.

The study of biodiversity on a local scale is an essential requirement for conservation interests (Martínez-Morales *et al.* 2013). It can influence management decisions, inform particular scientific inquiries, detect specific situations of interest, and together with other studies, can provide a valuable aid for the regional management of natural resources. Therefore, it is recommended that other studies be performed in the Lerma-Chapala-Santiago basin including several natural and artificial wetlands comparing their characteristics, particularly the vegetal resources for roosting, covering and nesting, the foraging features, water quality, the degree of perturbation, and the distribution, richness, and abundance of waterfowl.

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CIPAMEX

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