ISSN Versión Impresa 1816-0719 | ISSN Versión en linea 1994-9073 | ISSN Versión CD ROM 1994-9081

The Biologist (Lima), 2019, 17(1), ene-jun: 41-50

The Biologist (Lima)

ORIGINAL ARTICLE / ARTÍCULO ORIGINAL

WATERBIRDS OF PÍRITU LAGOON, VENEZUELA, AS A KEY ELEMENT FOR ITS LEGAL RESTORATION AND MANAGEMENT: A PRELIMINARY STUDY

AVES ACUÁTICAS DE LA LAGUNA DE PÍRITU, COMO ELEMENTO CLAVE PARA SU RESTAURACION Y MANEJO LEGAL: UN ESTUDIO PRELIMINAR

Steffani Olivares-Márquez[1]; Gedio Marín-Espinoza[2]* & Jorge Muñoz-Gi[3]

[1]Postgrado del Instituto Oceanográfico de Venezuela, Universidad de Oriente, Cumaná, Venezuela.
[2]Laboratorio de Ecología de Aves, Departamento de Biología, Universidad de Oriente, Cumaná, Venezuela.
[3]Centro de Investigaciones Ecológicas Guayacán, Universidad de Oriente, Venezuela.
Post Address: Urbanización Villa Olímpica, Bloque 03, Apto. 01-03, Cumaná, State of Sucre, Venezuela.
*Corresponding author: E-mail: gediom@yahoo.com

ABSTRACT

Coastal lagoons ecosystems in Venezuela are recognized as important habitats for birds. However the seasonal community of these waterbird communities and factors influencing the use of these wetlands habitats have not been sufficiently studied. We estimated waterbird richness and individual abundance in the Píritu lagoon, state of Anzoátegui, in the channel area leading out to the sea from monthly surveys conducted during August to November 2015 and January 2016. Overall, we recorded 45 waterbird species, belonging to 12 families. Richness was lesser in August, greater in November following the inflow of Nearctic migrants. Waterbird families with the most number of species included Scolopacidae (12 spp.), Ardeidae (10 spp.) and Laridae (9 spp.). Six species accounted for 78.44% of all individuals detected (*Pelecanus occidentalis* L. 1758, *Thalasseus maximus* Boddaert 1783, *Ardea alba* L. 1758, *Sterna hirundo* L. 1758, *Phalacrocorax brasilianus* Gmelin 1789 and *Phaetusa simplex* Gmelin 1789). Diversity and evenness indices varied moderately from 2.41 to 3.14 and 0.55 to 0.69, respectively. Shallow waters habitats (<0.5 m depth) contributed to high waterbird richness in this lagoon, around which many people live. Long term investigations are essential to formulate management and conservation plans for waterbird species. The integrity of the Píritu lagoon ecosystem may not survive the next decades unless more citizens engage in its conservation. We propose protection and integrated management through cooperative action of the two municipalities sharing the Píritu lagoon.

Key words: abundance – aquatic birds – coastal wetland – diversity – richness

RESUMEN

En Venezuela, los ecosistemas de lagunas costeras están reconocidos como hábitat importantes para las aves. No obstante, la dinámica estacional en la comunidad de aves acuáticas y los factores que la condicionan no ha sido suficientemente estudiada. Se estimó la abundancia individual y riqueza de especies en el área del canal que conduce hacia el mar de la Laguna de Píritu, estado Anzoátegui, mediante inventarios mensuales desarrollados desde agosto a noviembre de 2015 y enero de 2016. En total se registraron 45 especies de aves acuáticas pertenecientes a 12 familias. La riqueza fue menor en agosto y mucho mayor en noviembre, debido al arribo de especies migratorias del Neártico. Las familias con mayor número de especies fueron Scolopacidae (12 spp.), Ardeidae (10 spp.) y Laridae (9 spp.). Seis especies acumularon el 78,44% del total de la abundancia (*Pelecanus occidentalis* L. 1758, *Thalasseus maximus* Boddaert 1783, *Ardea alba* L. 1758, *Sterna hirundo* L. 1758, *Phalacrocorax brasilianus* Gmelin 1789 y *Phaetusa simplex* Gmelin 1789). La diversidad y equitabilidad variaron moderadamente: de 2,41 a 3,14 y 0,55 a 0,69, respectivamente. Los hábitat de aguas someras (<0,5 m de profundidad) aportaron la más alta contribución a la riqueza de especies en esta laguna, alrededor de la cual habita una gran cantidad de personas. Investigaciones a largo plazo serán vitales para formular planes de manejo y conservación de las aves acuáticas que utilizan la laguna. La integridad y supervivencia de los ecosistemas de la Laguna de Píritu se verá comprometida en las próximas décadas si la mayoría de sus ciudadanos no se involucra en su conservación. Se propone la protección ambiental de la laguna de Píritu mediante el manejo cooperativo por parte de los dos gobiernos municipales que comparten este importante humedal.

Palabras clave: abundancia – aves acuáticas – diversidad – humedal costero – riqueza

INTRODUCTION

The ecological dynamic of coastal lagoons is influenced by the exchange processes between freshwater inputs and the adjacent sea (Kennish & Paerl, 2010). Coastal lagoon ecosystems located along densely populated areas in developing countries render these systems among the most threatened in the world. Disorganized human occupation around impacts coastal lagoons through eutrophication, salinization, exotic species introduction, imposing stressors on the biodiversity of these wetlands (Gattenlöhner *et al.*, 2004; Nagarajan & Thiyagesan, 2006; Esteves *et al*., 2008; Lloret *et al*., 2008; Marín & Marín, 2011; Newton *et al*., 2014).

Waterbirds represent one of the best monitored biological components of coastal lagoons and other transitional coastal waters. Moreover, the functional role of waterbirds as bioindicators of enviromental changes has been discussed in previous studies (Kushlan, 1993; Comin & Herrera-Silveira, 2000; Amat & Green, 2010; Farinós & Robledano, 2010).

Waterbirds, comprising a large group of species including Anseriformes, Ardeiformes, Charadriiformes, Gaviiformes, Gruiformes, Pelecaniformes, Phoenicopteriformes, Podicipediformes and Procellariformes, exploit coastal lagoons given the diversity of habitats for feeding, nesting and resting. Waterbirds communities experience seasonal and anual fluctuations in abundance and species composition. Variations may be associated with the habitat characteristics and the arrival of seasonal migratory species (Brown & Dinsmore, 1986; Elmberg *et al.*, 1994; Gimenes & dos Anjos, 2003). Abundance of invertebrates and fishes (Mercier & McNeil, 1994; Paszkowski & Tonn, 2000; Shealer, 2002; Marín *et al.*, 2003) are major factors contributing to the distribution and density of waterbird populations. Finally, human disturbance can has a considerable effect on the numbers of waterbirds using a site and in some circumstances may have consequences for the size of populations (Robinson & Cranswick, 2003).

Given the documented species-habitat relationships of waterbirds and wetlands, they are an important useful taxonomic group to monitor given their value as indicators of ecosystem conditions and as tools (Bibby *et al*., 2002; USEPA EPA, 2002; Hollamby *et al*., 2006; Sekercioglu, 2006; Esteves *et al.*, 2008; Conway, 2011).

The importance of Venezuelan coastal lagoons as waterbird habitats have been reported by previous authors (McNeil *et al*., 1985; Rodner, 2006; Marín & Marín, 2011). However, the seasonal dynamics of the waterbird community of waterbird species in the Píritu lagoon, a site of regional importance for birds (BirdLife International and Conservation International, 2005), and the factors influencing wetland have not been studied. Our objective in this study was to generate information on the ecological characteristics of this wetland and seasonal variation of abundance and richness of waterbirds, as a key element for its legal restoration and management. We discuss the conservation implications of our findings, and hope they serve to formulate the rationale for its legal restoration and management.

MATERIALS AND METHODS

Study site

Píritu lagoon, located in Anzoátegui state (10°02′ ~ 10°03′N and 65°00′ ~ 65°09′ W) is the second largest saltwater continental lagoon in notheastern Venezuela (Fig. 1). The open water covers *ca*. 2600 km^2; surrounded by an extense area of mangroves (*Rhizophora mangle* L. 1753 and *Avicennia germinans* L. 1753). Like most lagoons located in the Venezuelan northeastern coast, Píritu lagoon is separated from the sea by a narrow sand barrier (*ca*. 13.5 km in lenght) which is *ca*. 390 m at its widest sector and *ca*. 250 m at its narrowest portion, with a xeric and psamophilic vegetation. There is only one outlet to sea at the northeastern sector of the lagoon. Mean annual rainfall pluviosity is 700 mm peaking during the rainy season months between June and November and high temperature, *i.e*., Min/Max: 27-32°C (González, 1987; Rodríguez & González, 2001).

The lagoon volume varies throughout the day because the marine water tidal input through the mouth. This oulet was partially refilled reducing marine water influx (Suárez, 1994). The main freshwater inputs to the lagoon are direct rainfall, sewage spills and surface runoff. One shrimp farm, located on the western end of the lagoon has altered its natural hydrodynamic. In addition, artisanal fishing and tourism boating remain uncontrolled (Ramírez *et al*., 1986; Bravo & Silva, 2012; Suárez, 2016).

Field methods

We surveyed birds using line transects with aid of a boat (according to Bibby *et al*., 2000), with which the lagoon channel leading out to the sea (length: *ca*. 1,9 km, width: *ca*. 100 m) (Fig. 2). Waterbird observations were made along a *ca*. 3.5 km continuous transect covering both lagoon north and south borders. Transparency and salinity were measured, in the morning (always beginning two hours after sunrise) and in the afternoon (always beginning two hours after midday), every *ca*. 300 m in five stations (Fig. 2), using a Secchi disk and refractometer, respectively.

We estimated waterbird richness and abundance using binoculars (Celestron Outland 10x42) during counts. Surveys were conducted in August, September, October, November 2015 (rainy season) and January 2016 (transition rainy-dry season). Monthly surveys were conducted in the morning (beginning two hours after sunrise), each sighted bird was identified to species (AOU, 1983; Hilty, 2003) and status recorded (resident, nearctic migrant, intratropical migrant, local migrant). Individuals flying were not recorded, unless these were observed leaving from the lagoon or landing in it.

Relative abundance was obtained by dividing the number of individuals registered a the given month overall all individuals periods. The monthly data abundance was pooled to compare species composition and eveness in each month, estimated using Simpson's Diversity Index (Krebs, 1989; Moreno, 2001). Simpson's Index gives more weight to the more abundant species in a sample. The taxonomy, nomenclature and common names of the bird species were according to Verea *et al*. (2017).

Ethic aspects

Authors indicate that procedures followed ethical standards of the country.

RESULTS

Mean salinity in the lagoon oscillated between 32.0 and 34.0 ppt and mean transparency ranged between 24.0 and 49.1 cm (Table 2), whereas intertidal water height averaged *ca*. 1,6 m.

Overall, 45 waterbird species, belonging to 12 families (Table 1) were recorded in five census carried out during the study period (included the Osprey, *Pandion haliaetus* L. 1758, the most conspicuously water-associated of all Venezuelan Falconiformes). Except for August, species occurrence varied lightly month after month, being August with the lowest species richness, whereas November species richness was higher especially with the inflow of Nearctic migratory birds; in fact, of the 45 bird species, 17 (37.7%) were migrants from the boreal latitudes.

The total abundance was 2.390 individuals; it was greater in November than other months. The total number of species and monthly abundance of waterbirds is shown in the Table 2. The higher value for Simpson's diversity index was observed in January.

The most representative families noted were Scolopacidae (12 spp.), Ardeidae (10 spp.), and Laridae (9 spp.). Six species concentrated 78.44% of abundance, *i.e*., Brown Pelican (*Pelecanus occidentalis* L. 1758), Royal Tern (*Thalasseus maximus* Boddaert 1783), Great Egret (*Ardea alba* L. 1758), Common Tern (*Sterna hirundo* L. 1758), Olivaceus Cormorant (*Phalacrocorax brasilianus* Gmelin 1789) and Large-billed Tern (*Phaetusa simplex* Gmelin 1789).

Waterbirds observed were observed mostly feeding and roosting. Feeding habitats varied from dry mudflats to wet mud and shallow waters of no more than 20 cm. Small shorebirds and plovers, *e.g*., Semipalmated Plover (*Charadrius semipalmatus* Bonaparte 1825), Gray Plover (*Pluvialis squatarola* L. 1758), Ruddy Turnstone (*Arenaria interpres* L. 1758) and *Calidris* spp., foraged on the dry banks, wet mud and/or water which was less than 3 cm deep; medium sized waders such as Black-necked Stilt (*Himantopus mexicanus* Müller 1776), Willet (*Tringa semipalmata* Gmelin 1789), Greater Yellowlegs (*Tringa melanoleuca* Gmelin 1789) and Lesser Yellowlegs (*Tringa flavipes* Gmelin 1789) exploited water depths less than 10 cm for feeding, while the relatively big egrets and herons fed in water up to 17 cm deep (*Ardea* spp., *Egretta* spp.), or they fed on the mangroves at the branches near the water (mainly, *Butorides striatus* L. 1758 and *Nycticorax* spp.).

Roosting sites comprised dry mud banks within the lagoon, and mangroves. Herons, egrets, Brown Pelican and Olivaceus Cormorant roosted commonly on mangroves branches, or structures such as sticks used by fishermen for fishingworks. All the tern and gull species used the exposed mud banks of the lagoon as roosting habitat (Figure 1) and foraged mainly at sea; however, Large-billed Tern, Least Tern (*Sternula antillarum* Lesson 1847), Common Tern (*Sterna hirundo*) and Laughing Gull (*Leucophaeus atricilla* L. 1758) sometimes foraged on the lagoon.

DISCUSSION

During the study period, monthly and spatial patterns of waterbirds were distinct. The local abundance and composition of waterbird assemblages seemed to be affected by the interplay of several environmental and human factors.

The seasonal pattern in individuals and species observed coincides with expected fluctuations due to regional movements and interhemispheric migration (Brandolin & Blendinger, 2016). Additionally, differences in abundance and richness values may be related to variations in tidal regimens (Ma *et al*., 2010; Calle *et al*., 2016).

Water depth and clear water phases are also important (Kushlan, 1986; David, 1994; Lantz *et al*., 2011; Moreno-Ostos *et al*., 2008; Bolduc & Afton, 2008), for instance, water depth regulates the bird's feeding capacity over the benthic fauna (except diving birds) (Erwin *et al*., 1994); on the other hand, because of shallowness caused by tidal fluctuations in the water level, a coastal lagoon usually provides waterbirds with different feeding opportunities at varying water depths (Ntiamoa-Baidu *et al*., 1998). Vegetation type and

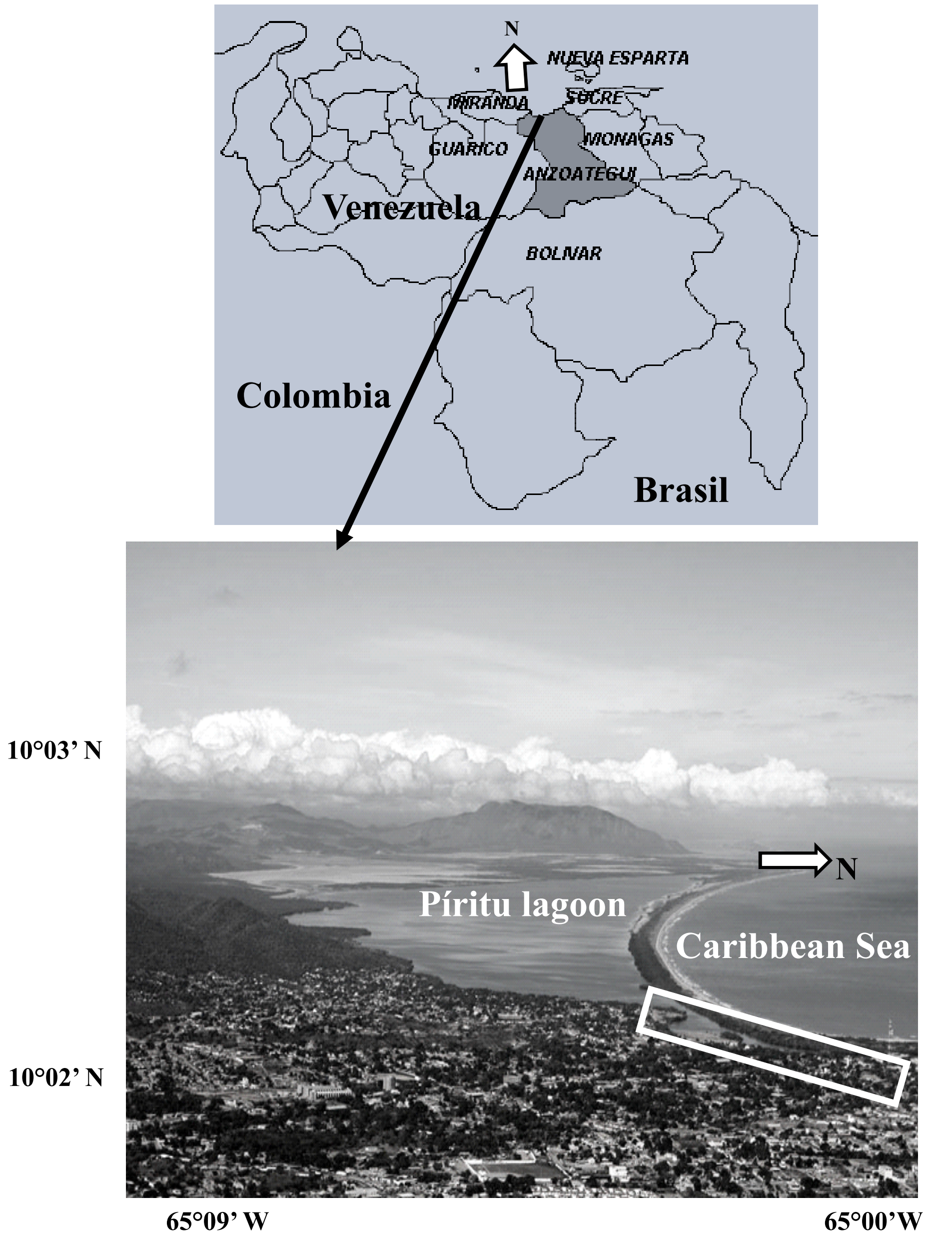

Figure 1. Panoramic view of Píritu lagoon with study area framed within a white rectangle.

distribution are also an important criteria for avian distribution and diversity in coastal wetlands (Hoyer & Canfield, 1994; Paracuellos & Telleria, 2004; Hassen-Aboushiba, 2015; Jahanbakhsh *et al.*, 2017).

Habitats with shallow waters (<0.5 m depth) seem to be crucial determinants of high waterbird richness in this lagoon sector around which many people live. Indeed, water depth is paramount in explaining waterbird density, and determining whether or not habitat is available (Kushlan, 1986; Bolduc & Afton, 2008; Raposa *et al.*, 2009; Lantz *et al.*, 2011; Calle *et al.*, 2016); in fact, shorebirds, terns and gulls were most abundant on the lagoon during the low tide when water levels in the lagoon were falling and the shallow waters and exposed mudflats offer favourable conditions for foraging and resting (Ntiamoa-Baidu *et al.*, 1998; Mercier & McNeil, 1994).

Although the differences in abundance and

Figure 2. Sampling transect (dotted line), sampling abiotic sites (white circles) and tidal mudbanks and shallow waters (white polygons).

richness between the five months may be a function of low sampling effort, the observed abundance patterns likely reflect the presence of Neartic migrants (mainly gulls and terns), which were observed roosting in flocks mainly in the dry mud banks. The relative lesser abundance of the some Ardeiformes in January may be asssociated to their breeding cycle as most species nest during the dry season in the savannas of Venezuela (McNeil *et al*., 1985; Vilella & Baldassarre, 2010). Similarly, Large-billed Tern and Black Skimmer (*Rynchops niger* L. 1758) nest in sandbanks during shallow waters pulses in Orinoco river corresponding to drought period (Navarro *et al*., 2010).

Our sampling methodology resulted in failure to account for some waterbird species due to lack of access. For example, Caribbean Flamingo (*Phoenicopterus ruber* L. 1758) was observed periodically in the shallower areas on its western sector (not included in study area), an area inaccessible by boat. The flamingo population in this area is estimated to be approximately *ca*. 10,000 (Espinoza, 2014).

Likewise, Brown Pelican in the Píritu lagoon exhibited the greater abundance (34.42% of total abundance). Although brown pelicans have few natural enemies and nests are sometimes destroyed by natural disasters (*e.g*., hurricanes), the biggest threat to pelicans comes from people (Collazo, 2000; U.S. Fish and Wildlife Service, 2009). Indeed, disturbance from human activity in their coastal nesting habitats can cause problems. For instance, although disturbances to breeding colonies and consumption of chicks by humans may be inusual, in northeastern Venezuela this activity is surprisingly common. Abandoned fishing line also threatens this species.

In effect, directly or indirectly, the major threat of wetlands is the pressure of increase human population growth (Watzin & Gosselink, 1992). Most coastal lagoons in Venezuela are under some degree of threat because habitat destruction, human encroachment especially from recreational uses, and pollution of industrial and untreated sewage origin, sedimentation and drainage (Suárez, 2016). For instance, we observed wastewater discharges in our sampling area but we have no study as to how or if nutrient enrichment has played a role in altering patterns of waterbirds distribution in Píritu lagoon. In the Everglades, USA, bird abundance appeared to increase in nutrient-enriched areas; however, this increase was accompanied by a shift in species composition (Crozier & Gawlik, 2002).

For the coastal lagoons of Unare and Píritu, the BirdLife Venezuelan partner designed a program focused on the local fishermen communities and aimed to create an awareness of the value of the local avifauna, and developing human resources for birding tourism (Rodner, 2006); however, as we have seen recently public indifference and goverment policies encourage, unfortunately, the lagoon degradation and it has revealed that this valuable program has been failed.

Our study contributed information on the waterbird community of Píritu lagoon and highlight the need for the adoption of conservation strategies. However, we recognize the short-term recognize nature of our study does not account for the particular dynamics of this lagoon. Thus, long-term studies will be needed to address management and conservation needs of the waterbird community Píritu lagoon. The area is under intense pressure from hydrological alterations, sewage discharges, shrimp aquaculture, overfishing and human-induced urbanism, as in other lagoons of Northeastern Venezuela (Pagavino, 1993; Marín *et al*., 2006; Marín *et al*., 2012a; Marín *et al*., 2012b; Suárez, 2016; Marín *et al*., 2017). Thus, future studies should evaluate waterbirds habitat use in this coastal lagoon, in order to improve restoration and management strategies. In addition, the interpretation of ecological preferences and the response of waterbirds to environmental pressures can serve to assess the conservation status of species at local or regional scales, and act as a warning tool for changes in similar ecosystems (O'Neal *et al*., 2008; Farinós & Robledano, 2010). However, our preliminary investigation suggests that the cultural, hydrological and biological settings of the lagoon is extremely heterogeneous, and cannot be readily evaluated using a priori criteria.

ACKNOWLEDGEMENTS

We wish to thank the Venezuelan company ICM Proyectos 2001 which funded this investigation.

REFERENCES

Amat, J.A. & Green, A.J. 2010. *Waterbirds as bioindicators of environmental conditions*. In: *Conservation monitoring in freshwater habitats. A practical guide and case studies*. Hurford, C.; Scheider, M. & Cowx, I. (ed.). Springer, The Netherlands. pp. 45–52.

A.O.U. (American Ornithologist's Union). 1983. *Field guide of the birds of North America*. 6th ed. American Ornithologists' Union. Washington, D.C, USA.

Bibby, C.J.; Burgess, N.D. & Hill, D.A. 2000. *Bird census techniques*. Academic Press. London, UK.

Bolduc, F. & Afton, A.D. 2008. Monitoring waterbird abundance in wetlands: The importance of controlling results for variation in water depth. Ecological Modelling, 216:402–408.

BirdLife International and Conservation International. 2005. *Áreas importantes para la conservación de las aves en los Andes Tropicales*. BirdLife International. Quito, Ecuador.

Brandolin, P.G. & Blendinger, P.G. 2016. Effect of habitat and landscape structure on waterbird abundance in wetlands of central Argentina. Wetland Ecology and Management, 24:93–105.

Bravo, I. & Silva, L. 2012. *Lineamientos para la elaboración de un plan de desarrollo turístico sostenible para la localidad de Puerto Píritu en el Municipio Peñalver, Estado Anzoátegui*. Trabajo de grado para obtener el título de Licenciatura en Administración de Empresas Turísticas. Caracas, Venezuela: Universidad Nueva Esparta, Escuela de Administración de Empresas Turísticas.

Brown, M. & Dinsmore, JJ. 1986. Implications of marsh size and isolation for marsh bird management. Journal of Wildlife Management, 50:392–397.

Calle, L.; Gawlik, D.E.; Xie, Z.; Green, L.; Lapointe, B. & Strong, A. 2016. Effects of tidal periodicities and diurnal foraging constraints on the density of foraging wading birds. The Auk, 133:378–396.

Collazo, J.; Saliva, J. & Pierce, J. 2000. *Conservation of the Brown Pelican in the West Indies*. In: *Status and conservation of West Indians seabirds*. Schreiber, E.A. & Lee, D.S. (eds.). Society of Caribbean Ornithology, Spec. Publication # 1, Ruston, LA, USA. pp. 39–45.

Comin, F.A. & Herrera-Silveira, J.A. 2000. *The role of birds on the trophic structure and nutrients cycles of aquatic ecosystem: a review*. In: *Limnology and waterfowl, monitoring, modelling and management*. Comin, F.A., Herrera-Silveira, J.A. & Ramírez, J. (eds.). Workshop Aquatic Birds Working Group, Societas Internationalis Limnologiae, Universidad Autónoma de Yucatán, Mexico. pp. 205–218 .

Conway, C.J. 2011. Standardized North American marsh bird monitoring protocol. Waterbirds, 34:319–346.

Crozier, G. & Gawlik, D. 2002. Avian response to nutrient enrichment in an oligotrophic wetland, the Florida Everglades. Condor, 104:631–642.

David, P.G. 1994. Wading bird use of lake Okeechobee relative to fluctuating waters levels. Wilson Bulletin, 106:719–732.

Elmberg, J ; Nummi, P.; Pöysä, H. & Sjöberg, K. 1994. Relationships between species number, lake size and resource diversity in assemblages of breeding waterfowl. Journal of Biogeography, 21:75–84.

Erwin, R.M.; Hatfield, J.S.; Howe, M.A. & Klugman, S.S. 1994. Water bird use of salt marsh ponds created for open marsh water management. Journal of Wildlife Management, 58:516–524.

Espinoza, F. 2014. El flamenco del Caribe. Río Verde, 13:91–101.

Esteves, F.A.; Caliman, A.; Santangelo, J.M.;Guariento, R.D; Farjalla, V.F. & Bozelli, R.L. 2008. Neotropical coastal lagoons: an appraisal of their biodiversity, functioning, threats and conservation management. Brazilian Journal of Biology, 68:968–971.

Farinós, P. & Robledano, F. 2010. Structure and distribution of the waterbird community in the Mar Menor coastal lagoon (SE Spain) and relationships with environmental gradients. Waterbirds, 33:479–473.

Gattenlöhner, U.; Hammerl-Resch, M. & Jantschke, S. 2004. *Restauración de humedales: Manejo sostenible de humedales y lagos someros*. Global Nature Fund. Radolfzell, Alemania.

Gimenes, M. & Dos Anjos, L. 2003. Influence of lagoons size and prey availability on the wading birds (Ciconiiformes) in the Upper Paraná River floodplain, Brazil. Archives of Biology and Technology, 49:463–473.

González, C.J. 1987. *Condiciones hidrogeoquímicas de la Laguna de Píritu, Venezuela*. Tesis de Magíster Scientiarum. Instituto Oceanográfico de Venezuela, Universidad de Oriente. Cumaná, Sucre, Venezuela.

Hassen-Aboushiba, A. 2015. Assessing the effects of aquatic vegetation composition on waterbird distribution and richness in natural freshwater lake of Malaysia. American Journal of Life Sciences, 3: 316–321.

Hilty, S.L. 2003. *Birds of Venezuela*. Princeton University Press. Princeton and Oxford, USA.

Hollamby, S.; Afrema-Azihumi, J.; Waigo, S.; Cameron, K.; Gandolf, A.; Norris, A. & Sikarsie, J. 2006. Suggested guidelines for use of avian species as biomonitors. Environment and Monitoring Assessment, 118:1–3.

Hoyer, M.V. & Canfield, D.E. 1994. Bird abundance and species richness on Florida lakes: influence of trophic status, lake morphology, and aquatic macrophytes. Hydrobiologia, 297/280:107–119.

Jahanbakhsh, M.; Khorasani, N.; Morshedi, J.; Danehkar, A. & Naderi, M. 2017. Factors influencing abundance and species richness of overwintered waterbirds in parishan international wetland in Iran. Applied Ecology and Environmental Research, 15:1565–1579.

Kennish, M.J. & Paerl, H.W. 2010. *Coastal* *lagoons: Critical habitats of enviromental changes*. CRC Press. Florida, USA.

Krebs, C. 1989. *Ecological methodology*. Harper-Collins Publisher. New York, USA.

Kushlan, J.A. 1986. Responses of wading birds to seasonally fluctuating water levels: Strategies and their limits. Colonial Waterbirds, 9:155–162.

Kushlan, J.A. 1993. Colonial waterbirds as bioindicators of environmental change. Colonial Waterbirds, 16:223–251.

Lantz, S.M.; Gawlik, D.E. & Cook, M.I. 2011. The effects of water depth and emergent vegetation on foraging success and habitat selection of wading birds in the Everglades. Waterbirds, 34:439–447.

Lloret, J.; Marín, A. & Marín-Guirao, L. 2008. Is coastal lagoon eutrophication likely to be aggravated by global climate change? Estuarine, Coastal and Shelf Science, 78: 403–412.

Ma, Z.; Cai, Y.; Li, B. & Chen, J. 2010. Managing wetland habitats for waterbirds: an international perspective. Wetlands, 30:15–27.

Marín, G. & Marín, B. 2011. Figuras innovadoras para la conservación de la diversidad: Marco teórico-conceptual. Interciencia, 36:471–476.

Marín, G.; Guevara, E. & Bastidas, L. 2003. Algunos componentes de la dieta de aves Ciconiiformes en ecosistemas marino-costeros del estado Sucre, Venezuela. Saber, 15:99–155.

Marín, G.; Muñoz, J. & González, L.G. 2017. *La avifauna acuática marino-costera de la península de Araya, Venezuela: Guía fotográfica comentada*. Sistema de Bibliotecas de la Universidad de Oriente. Cumaná, Venezuela.

Marín, G.; Blanco, L.; Prieto, A.; Muñoz, J. & Alzola, R. 2006. Dependencia de pequeñas lagunetas y charcas costeras para la avifauna residente y migratoria: dos casos en Venezuela. Boletín del Instituto Oceanográfico de Venezuela, 45:149–163.

Marín, G.; Carvajal, Y. & Muñoz, J. 2012a. Perspectivas conservacionistas de la avifauna en la laguna litoral urbana El Maguey, Estado Anzoátegui, Venezuela. Boletín del Instituto Oceanográfico de Venezuela, 49:91–101.

Marín, J.; Marín, G. & González, L.G. 2012b. Variación estacional de la estructura comunitaria en aves playeras Charadriiformes, y perspectivas de conservación, de la laguna de Punta de Mangle, isla de Margarita, Venezuela. Boletín del Instituto Oceanográfico de Venezuela, 50:49–57.

McNeil, R.; Ouellet, H. & Rodríguez, J. 1985. Urgencia de un programa de conservación de los ambientes costeros (lagunas, planicies fangosas, laderas costeras y manglares) del Norte de América del Sur. Boletín de la Sociedad Venezolana de Ciencias Naturales, 50:449–474.

Mercier, F. & McNeil, R. 1994. Seasonal variations in intertidal density of invertebrate prey in a tropical lagoon and effects of shorebird predation. Canadian Journal of Zoology, 72:1755–1763.

Moreno, CE. 2001. *Métodos para medir la diversidad*. Vol.1. M&T-Manuales y Tesis SEA. Zaragoza, España.

Moreno-Ostos, E.; Paracuellos, M.; de Vicente, I.; Nevado, J. & Cruz-Pizarro, L. 2008. Response of waterbirds to alternating clear and turbid water phases in two shallow Mediterranean lakes. Aquatic Ecology, 42:701–706.

Nagarajan, R. & Thiyagesan, K. 2006. The effects of coastal shrimp farming on birds in Indian mangrove forests and tidal flats. Acta Zoologica Sinica, 52:41–48.

Navarro, R.; Leal, S.; Marín, G. & Bastidas, L. 2010. Anidación de cinco especies de aves acuáticas Charadriiformes en bancos aluviales del río Orinoco. Saber, 22:232–237.

Newton, A.; Icely, J.; Cristina, S.; Brito, A.; Cristina-Cardoso, A.; Colijn, F.; Dalla-Riva, S.; Gertz F.; Würgler-Hansen, J.; Holmer, M.; Ivanova, K.; Leppäkoski, E.; Melaku- Canu, D.; Mocenni, C.; Mudge, S.; Murray, N.; Pejrup, M.; Razinkovas, A. & Zaldívar, J.M. 2014. An overview of ecological status, vulnerability and future perspectives of European large shallow, semi-enclosed coastal systems, lagoons and transitional waters. Estuarine Coastal Shelf Science, 140:95–122.

Ntiamoa-Baidu, Y.; Piersma, T.; Wiersma, P.; Poot, M.; Battley, P. & Gordon, C. 1998.

Water depth selection, daily feeding routines and diets of waterbirds in coastal lagoons in Ghana. Ibis, 140:89–103.

O'Neal, B.J.; Heske, E.J. & Stafford, J.D. 2008. Waterbird response to wetlands restored through the conservation reserve enhancement program. Journal of Wildlife Management, 72:654–664.

Pagavino, M. 1992. *Condición actual de las pesquerías de las lagunas de Tacarigua, Unare y Píritu, Venezuela*. Trabajo de grado para obtener el título de Licenciatura en Biología. Universidad de Oriente, Núcleo de Sucre. Cumaná, Venezuela.

Paracuellos, M. & Tellería, J. 2004. Factors affecting the distribution of a waterbird community: the role of habitat configuration and bird abundance. Waterbirds, 27:446–489.

Paszkowski, C.A. & Tonn, W.M. 2000. Community concordance between the fish and aquatic birds of lakes in northern Alberta, Canada: the relative importance of environmental and biotic factors. Freshwater Biology, 43:421–437.

Ramírez, I.; Huq, M.F.; Parra, B. & Pagavino, M. 1986. *Observaciones acerca de la pesquería artesanal de las lagunas costeras de Tacarigua, Unare y Píritu, Venezuela.* Actas de la Conferencia Internacional sobre la Pesca Artesanal y el Desarrollo Económico. Rimousky, Canadá. pp. 755–767.

Raposa, K.B.; McKinney, R.A. & Beaudette, A. 2009. Effects of tide stage on the use of salt marshes by wading birds in Rhode Island. Northeastern Naturalist, 16:209–224.

Robinson, J. & Cranswick, P. 2003. Large-scale monitoring of the effects of human disturbance on waterbirds: a review and recommendations for survey design. Ornis Hungarica, 12-13:199–207.

Rodner, C. 2006. *Waterbirds in Venezuela*. Sociedad Conservacionista Audubon de Venezuela. Caracas, Venezuela.

Rodríguez, J.L. & González, D.I. 2001. *Estudio ambiental de la cuenca del río Unare y Píritu y las lagunas de Unare y Píritu*. CENAMB, Universidad Central de Venezuela. Caracas, Venezuela.

Sekercioglu, C.H. 2006. Increasing awareness of avian ecological function. Trends in Ecology and Evolution, 21:464–471.

Shealer, D.A. 2002. *Foraging behavior and food of seabirds*. In: *Biology of marine birds*. Schreiber, E.A. & Burger, J. (eds.). CRC Press, Florida, USA. pp. 137–178.

Suárez, C. 1994. Cambios costeros en la boca de la laguna de Píritu (Venezuela nororiental) por influencia de los espigones. Acta Científica Venezolana, 45:238–244.

Suárez, C. 2016. Uso y abuso de las lagunas costeras venezolanas. Revista de Investigación, 40:63–94.

US EPA (United States Environmental Protection Agency). 2002. *Methods for evaluating wetlands condition: Biological assessment methods for birds*. Office of Water, U.S. Environmental Protection Agency. Washington, DC, USA.

US Fish & Wildlife Service. 2009. *Brown Pelican Pelecanus occidentalis*. U.S. Fish and Wildlife Service Endangered Species Program. Arlington, Virginia, USA.

Verea, C.; Rodríguez, G ; Ascanio, D.; Solórzano, A.; Sainz-Borgo, C.; Alcocer, D. & González, L.G. 2017. *Los nombres comunes de las aves de Venezuela.* 4ta. Ed. Comité de Nomenclatura Común de las Aves de Venezuela. Unión Venezolana de Ornitólogos (UVO). Caracas, Venezuela.

Vilella, F.J. & Baldassarre, G.A. 2010. Abundance and distribution of waterbirds in the llanos of Venezuela. Wilson Journal of Ornithology, 122:102–115.

Watzin, M.C. & Gosselink, J.G. 1992. *The fragile fringe: coastal wetlands of the continental*. Louisiana Sea Grant College Program, Louisiana State University / Washington, DC: U.S. Fish and Wildlife Service and Washington / Rockville, MD. National Oceanic and Atmospheric Administration United States. Baton Rouge, LA, USA.

Received October 15, 2018.
Accepted January 31, 2019.