ORNITOLOGIA NEOTROPICAL 22: 229–246, 2011

BIRD COMMUNITY COMPOSITION OF CENTLA MARSHES BIOSPHERE RESERVE, TABASCO, MEXICO

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Resumen. – Composición de la comunidad de aves de la Reserva de la Biósfera Pantanos de Centla. – La reserva de la biósfera Pantanos de Centla se localiza en el estado mexicano de Tabasco y es uno de los sitios más importantes de humedales en Mesoamérica. A pesar de esto, aún existe un conocimiento precario sobre su flora y su fauna. El presente estudio describe la composición avifaunística de la reserva de la biósfera Pantanos de Centla, por medio de un muestreo extensivo realizado de febrero de 1998 a enero de 1999. Registramos 213 especies de aves pertenecientes a 49 familias y 18 órdenes. Muestreamos los cinco principales hábitats dentro de la reserva, en donde registramos 144 especies en bosque bajo semideciduo de Tinto (*Haematoxylon campechianum*; Fabaceae), 141 especies en pastizales/hidrófitas, 135 en manglar, 114 en bosque semideciduo de Pukte (*Bucida buceras*; Combretaceae), y 44 en palmares/hidrófitas (popal). Veintidós especies se registraron bajo algún estatus de protección nacional. Adicionalmente presentamos nueve nuevos registros para el estado de Tabasco. La composición avifaunística de los hábitats boscosos fue más parecida entre sí que con la de los hábitats abiertos (áreas de pastizales e hidrófitas), y 74 (34.7%) de las especies fueron aves migratorias Neárticas ó regionales. Finalmente, discutimos la importancia de las zonas boscosas en la conservación de las aves de humedales del sur de México y proponemos que la Reserva de la Biosfera Pantanos de Centla sea incorporada en el Registro Montreux de la convención RAMSAR.

Abstract. – Centla Marshes is a biosphere reserve located in the Mexican state of Tabasco and is one of the most important wetland areas in Mesoamerica; however, knowledge about its flora and fauna is precarious. The present study describes the bird community composition of Centla Marshes Biosphere Reserve through extensive field surveys conducted from February 1998 to January 1999. We recorded 213 bird species distributed in 49 families and 18 orders. We sampled the five main habitats within the reserve, where we recorded 144 species in semi-deciduous Logwood (*Haematoxylon campechianum*; Fabaceae) lowland forest, 141 in grasslands/hydrophytes, 135 in mangrove forests, 114 in semi-deciduous Bullet Tree (*Bucida buceras*; Combretaceae) forest, and 44 in palm-tree forest/hydrophytes (popal). Twenty two species have a national protection status. Additionally, we present nine new records for the state of Tabasco. Wooded habitats were more similar to each other in species composition than to open habitats (hydrophyte and grassland areas), and 74 (34.7%) of the species were either Neartic or regional migrants. Finally, we discuss the relevance of forested lands for the conservation of wetland birds in southern Mexico and propose the inclusion of Centla Marshes Biosphere Reserve under the Montreux Record of the RAMSAR convention. *Accepted 14 April 2011.*

Key words: Centla Marshes Biosphere Reserve, Tabasco, avifauna, bird communities, bird conservation.

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INTRODUCTION

Wetlands are highly productive life-support systems that maintain water quality, act as natural filters, keep the supply of surface and underground water, control sediment accumulation and erosion, regulate water regimes, contribute to climatic stability, provide habitat for wildlife, and sustain fisheries, grazing, agriculture, and outdoor human activities (Smart 1997). Wetlands have immense socioeconomic and ecological relevance for humans, and are critical for biodiversity maintenance because they are nursery places for thousands of marine and freshwater species, as well as for many terrestrial species that depend on these ecosystems (Hails 1997, Bacon 1997). However, the clear conservation relevance of wetlands was not officially acknowledged until 1971, when the RAMSAR convention was created, given that wetland areas were normally drained, filled for construction, and degraded for economic profit (Hails 1997).

Centla Marshes Biosphere Reserve (hereafter CMBR) was created in 1995 and is located at the northeast section of Tabasco State in Mexico, within the Grijalva-Usumacinta basin (Fig. 1a). CMBR has permanently flooded freshwater swamps as its most prevalent wetland type. It is one of the largest wetland areas in Mesoamerica and an important wintering ground for several species of aquatic fowl (Anonymous 1994, Hails 1997, INIREB 1988). The North American Wetlands Conservation Council has designated this region as priority for conservation, it is a RAMSAR site (RAMSAR 2009), and it has been identified as an Important Area for Bird Conservation (IBA; Arriaga-Weiss *et al.* 2000). In recent decades the state of Tabasco has undergone severe environmental degradation, which is mainly due to oil exploitation, extensive cattle ranching, and urban development (Cálix *et al.* 1996, Santiago-Alarcon 2003). Studies dealing with the biodiversity of this region are scarce, but efforts are being made to improve this situation and to include a diverse array of taxa in research programs (Barragán 2000, Florido *et al.* 2000, Guadarrama & Ortiz 2000, López & Cappello 2000, Molina 2000, Reséndez & Salvadores 2000).

The ornithological knowledge in Tabasco is scarce and it has remained as such since the last major ornithological publications for the region by Brodkorb (1943) and Berrett (1962). Centeno (1994) conducted a bibliographic revision on the state's avifauna, and Winker *et al.* (1999) surveyed two localities in the State adding 80 species to the 457 previously reported by Berret (1962). More recently, Santiago-Alarcon *et al.* (2000), Ibarra *et al.* (2001), and Santiago-Alarcon (2003) have described the bird community composition and structure at different localities in the state, including agrosystems. Moreover, there are three ornithological studies in the CMBR region, Grantham (1993), Winker *et al.* (1999), and Santiago-Alarcon (2003), only the last one was specifically designed for the reserve. Considering the poor knowledge on avian diversity in the reserve, it is surprising that the National Audubon Society (Anonymous 1994) and other authors (see INIREB 1988) have deemed bird populations of several species in the zone as stable. With the increasing pressure of anthropogenic activities and the precarious knowledge on the region's avifauna, it is a priority to identify the avian composition of CMBR to have baseline information for subsequent and more detailed ecological studies. Thus, our main goal was to determine the avian composition in different vegetation types of CMBR by conducting extensive sampling around the reserve's area using both mist nets and sight and hearing records, and to compare this avifauna with that of other reserves with similar habitats and to other Neotropical regions.

METHODS

We conducted observations from February 1998 to January 1999 at CMBR, which is located at the northeastern section of the state of Tabasco, Mexico, (17°57'45"N–18°39'58"N and 92°06'30"W–92°47'58"W, Fig. 1a), expanding an area of 302,706 ha. The zone has a mean annual temperature of 25° C and a mean annual precipitation of 1500–2000 mm. The total extension of river systems within the reserve is 463 km. There are 110 (permanent and temporary) freshwater bodies for a total surface of 13,665 ha. Vegetation assemblages within the reserve are grouped into: hydrophyte communities (68.1% of the reserve surface), semi-deciduous *Bucida buceras* (puktal) forest (6.4%), semi deciduous lowland forest of *Haematoxylon campechianum* (tintal, 0.3%), mangrove forests (2%), *Dalbergia brawnii* (mucal) shrubs (1.8%), and *Acoelorraphe wrightii* (tasistal), and *Sabal mexicana* (guanal) palm forest (1%) (López-Hernández 1993). Around 360 plant species have been identified in CMBR belonging to 89 families, of which 76 species are used by human communities (López-Hernández 1993, López-Hernández & Pérez 1993).

We collected and recorded bird specimens using mist nets (Ralph *et al.* 1996), and by sight and hearing records using point counts (Hutto *et al.* 1986, Ralph *et al.* 1995; Fig. 1B; Appendix 1). We conducted 11 field trips for a total of 49 days. We were unable to set up mist nets during nine days due to adverse climate conditions. The field effort comprised a total of 1696,5 net-hours, with an average of 42.4 net-hours/day, and with an average of 7 mist nets (SD = 3.1) operated per working day, and we conducted three point counts per day at each sampling site (Fig. 1B and Appendix 1) for 10 min each, for a total of 147 point counts, counting birds within and out of a 25 m. Radius (Hutto *et al.* 1986). Collected specimens are deposited in the División Académica de Ciencias Biológicas de la Universidad Juárez Autónoma de Tabasco (DACB-UJAT), which is registered at the National Institute of Ecology of the Bureau of Natural Resources, Environment, and Fisheries (INE-SEMARNAP, Instituto Nacional de Ecología – Secretaría de Medio Ambiente, Recursos Naturales y Pesca). For new records in Tabasco State we have checked the Avibase database (the world bird database maintained by BirdLife Int., http://avibase.bsc-eoc.org/). Each bird species recorded was assigned to a feeding guild based on previously published information (De Graaf *et al.* 1985; Howell & Webb 1995).

We used Jaccard's similarity index and the nearest-neighbor clustering method (Krebs 1989) to analyze avian similarity among the different habitats. The distance measure used for the dendrogram was Wishart's objective dissimilarity function (Wishart 1969). Analyses were performed in PC-ORD v4.01 (McCune & Mefford 1999). We predicted that similarity among aquatic and wooded habitats would be low, unless many bird species from one habitat (e.g., woodlands) are strongly dependent from resources of the other habitat (e.g. hydrophyte communities). We used the program EstimateS v.8.2 to calculate species accumulation curves by implementing the first-order nonparametric Jackknife and the Bootstrap estimators of species richness based on incidence-based data, we used species number detected per month as our sampling unit (Colwell 2009). We performed a total of 1000 randomizations with replacement.

Specimen collection was performed under regulation from INE-SEMARNAP. We generated a database of collected specimens and census records using BIOTICA v. 5.0 (CONABIO; Comisión Nacional para el Conocimiento y Uso de la Biodiversidad 2009). Our surveys were not systematically performed and different sampling intensity was applied

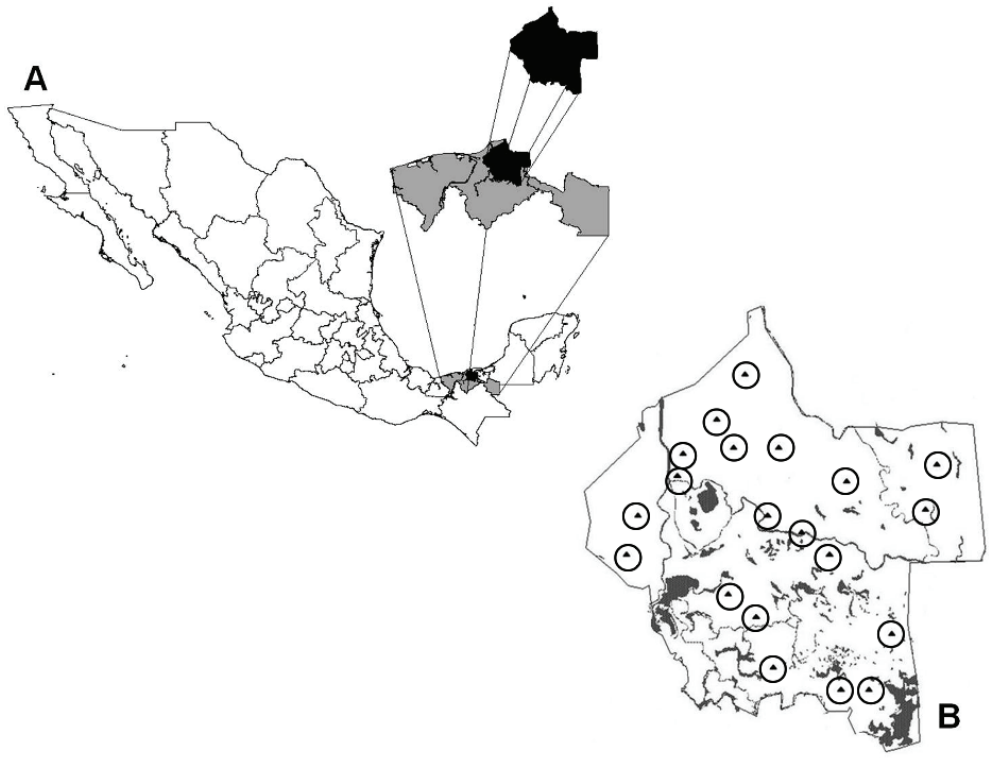

FIG. 1. Geographic location of Centla Marshes Biosphere Reserve (CMBR) in Tabasco State, Mexico (a), and location of sampling areas (black triangles inside black circles) within CMBR, also shown are the most important water bodies and rivers of the reserve (b). See also Appendix 1 for the geographic coordinates of sampling locations.

to different habitats, in order to sample as much area of the reserve as possible; thus, we did not obtain appropriate abundance data.

RESULTS

We recorded 213 species of 49 families and 18 orders (Appendix 2). Orders with the highest species richness were Passeriformes (100), Ciconiiformes (22), Charadriiformes (20), and Falconiformes (15). Families with highest species richness were Parulidae (22), Tyrannidae (22), Ardeidae (16), and Icteridae (13). Seventy-four species (34.7%) were either Neartic or regional migrants. There were 69 aquatic species (32%) and 144 (68%) terrestrial species. The number of species by feeding guild was: fishes/crustacean 15, vertebrates (except fishes) 15, vertebrates (except fishes)/arthropods 17, mollusks 1, vegetation/insects 7, vegetation/aquatic invertebrates 8, insects 84, carrion eaters 4, insects/crustacean 12, seeds/insects 28, omnivores 14, fruits/seeds 3, and nectar/insects 6 (see Appendix 2 for species-specific information). Species accumulation curves showed that the observed species richness is within the confidence intervals of both Jack-

knife and Bootstrap estimators, and that species richness has reached a plateau by the end of the sampling period (Fig. 2), this indicates that our sample included almost all species in this reserve. Only the second sampling month (March) showed a significantly lower number of species compared to both of the estimates (Fig. 2). Voucher samples comprising 251 bird skins of 75 species and prepared according to Winker (2000) were assembled during 1996 and 1998 and deposited in the collection of the DACB-UJAT.

The number of species by vegetation type was: semi-deciduous lowland forest of *Haematoxylon campechianum* 144, grasslands/hydrophytes 141, mangrove forests 135, semi-deciduous forest of *Bucida buceras* 114, and palm-tree forest/hydrophytes (popal) 44. The distribution of species among the different sampled habitats was 33 (15.4%) species were restricted to one habitat type, 63 (29.4%) to two, 67 (31.3%) to three, 28 (13.1%) to four, and 23 (10.7%) to five different habitats (Appendix 2). All Parulidae species were restricted to forested habitats with the exception of the Common Yellowthroat (*Geothlypis trichas*) and the Gray-crowned Yellowthroat (*G. poliocephala*). According to the similarity analysis, wooded habitats were more similar among themselves than to the open habitats (hydrophytes/grasslands and palm-tree forests). Mangroves and *B. buceras* forests were the most similar followed by *H. campechianum* forest (Fig. 3).

We detected a total of 22 species under a protection category of the NOM-059-ECOL-2001 (Diario Oficial de la Federación 2002). From these, 15 bird species were recorded as under special protection, four were recorded as threatened, two as endangered, and one as rare (Appendix 2). Ten of these species are waterfowl, some of which are locally used as food (e.g., *Cairina moschata*); six are raptors, two of which heavily depend on fish (*Pandion haliaetus*) and snails (*Rostrhamus sociabilis*), making them, together with waterfowl, vulnerable to heavy metal accumulation through pollution generated by nearby oil recovery. Two species of parrots (*Aratinga nana* and *Amazona oratrix*) are commonly used in the state as pet birds. The rest of species under a protection category are those that depend heavily on wooded areas for both breeding and foraging (e.g., *Notharchus hyperrhynchus*, *Dendrocincla anabatina*, *Vireo pallens*).

We have recorded nine species that constitute new state records (Berrett 1962): 1) *Tigrisoma lineatum*, previously known to be distributed from Belize to Argentina; our record extends its northern distribution and is the first Mexican record; 2) *Rallus limicola* breeds from Alaska to northern South America, it has been recorded as a migrant in Veracruz, Oaxaca, and Chiapas; 3) *Amazilia beryllina* was previously recorded in Veracruz, Oaxaca, and Chiapas for the southern region of Mexico, but occurs in western Mexico as well (Weller 1998); 4) *Tyrannus verticalis* has been recorded in Oaxaca, Chiapas and it is rare in Veracruz; 5) *V. pallens* has been recorded in the Yucatán Peninsula, Chiapas and Oaxaca; 6) *Tachycineta thalassina* has been recorded in Veracruz, Oaxaca, Chiapas and the Yucatán Peninsula; 7) *Dendroica tigrina* has been recorded in the Yucatán Peninsula, and it is rare in Veracruz, Oaxaca and Chiapas; 8) *Zonotrichia capensis* is distributed from Mexico to Argentina, in Mexico it has only been recorded in Chiapas, so this record represents a northern expansion of its distribution; 9) *Icterus chrysater* has been recorded in Veracruz, Chiapas, Oaxaca, Campeche, and the Yucatán Peninsula.

DISCUSSION

The total number of species recorded in this study (213) represents 47.7% of the bird species reported by Berrett (1962) for the state of Tabasco and 19.6% of the 1085 reported for

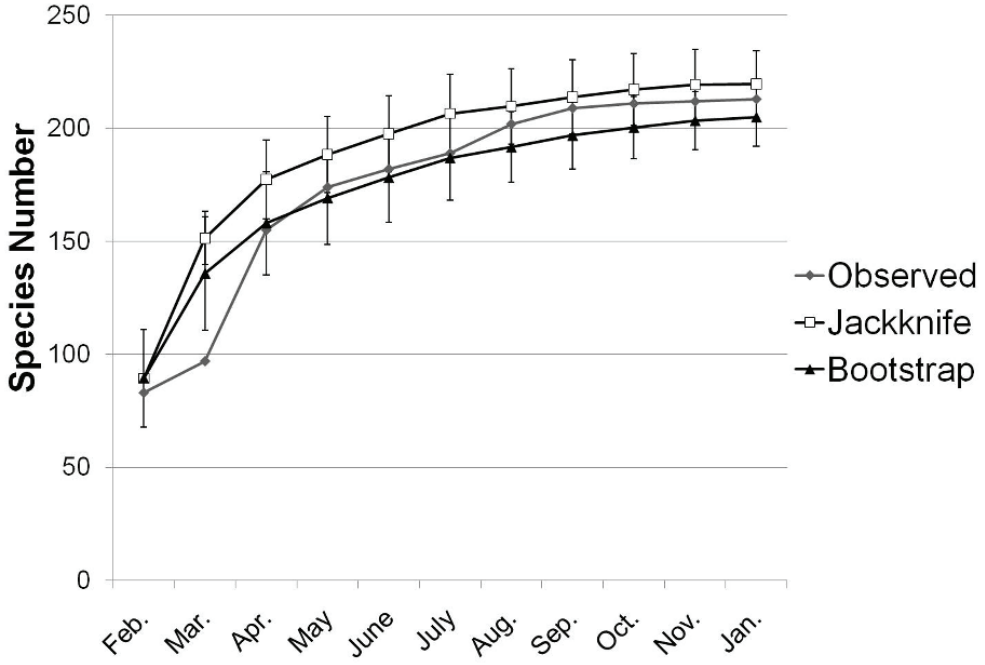

FIG. 2. Species accumulation curves for the sampling period as estimated with EstimateS v.8.2 (Colwell 2009). Shown are the observed species number and both the Jackknife and Bootstrap richness estimators, calculated based on 1000 randomizations with replacement. Bars indicate one ± SD.

Mexico (Peterson & Chalif 1999). Species richness in this study was lower compared to that of the Sian Ka'an wetlands in the Yucatán peninsula (320 species, RAMSAR 2009), which was declared a RAMSAR site in 2003; however, we must consider that Sian Ka'an has a higher diversity of ecosystems and a larger area (528,147 ha) than Centla (302,706 ha). Ría Lagartos in northeastern Yucatán peninsula is also a RAMSAR site with an area of 55,350 ha, it has 72 migratory species, a similar number to the 74 migratory species reported in this study, and 141 resident bird species (Cervantes 1997). This gives a total of 213 bird species for Ría Lagartos, which is the same number of birds recorded in CMBR despite its smaller area. This high diversity compared to the present study might be due to the presence of xeric forests in the Yucatán Peninsula, which are completely absent from CMBR. Other areas in Campeche and Chiapas with tropical rain forest, such as Montes Azules (with 300 species in an extension of 723,185 ha) and Calakmul (with 235 species in an extension of 723,185 ha), present a relatively low number of bird species taking as a reference their large extension (Puebla-Olivares *et al.* 2002). Areas like El Ocote (with more than 350 species in an area of 48,140 ha) and Yaxchilán (with 235 species in a small area of 2621 ha) in Chiapas (Puebla-Olivares *et al.* 2002), with much smaller extensions than the reserves mentioned above harbor a higher bird diversity. Grantham (1993) reported 237 species in the Aztec island (Campeche) and El Bosque

beach (Centla municipality; both of which are places located next to the CMBR), number similar to the one reported here. Sian Ka'an and Ría Lagartos are wetland areas like CMBR; so, these comparisons are more relevant if we consider that the other sites are different habitats. However, if we take into account the shared biogeographical history of all the mentioned areas (i.e., they are found on the east side of the Tehuantepec Isthmus), we may consider avifauna comparisons among the different habitats valid. After all, biodiversity patterns are explained by both local and regional processes at different spatial and temporal scales (Ricklefs 2004).

In this study, we recorded nine new species for Tabasco, five of which are migratory. One of the later species (*R. limicola*) is a waterbird and the other four (*T. verticalis*, *T. thalassina*, *D. tigrina*, and *Z. capensis*) depend on both wooded and wetland habitats. Peterson & Chalif (1999) mentioned a record of a juvenile *T. lineatum* in Chiapas, but this record has never been confirmed. *T. lineatum* has only been recorded in Hawaii (AOU 1998, 2011). Moreover, it is considered an accidental/casual non-breeding visitor within the AOU region (AOU 1998, 2011). Thus, we can consider our record as the first one for Mexico. *Jabiru mycteria* remained unrecorded in our surveys, which is an unexpected result considering that CMBR has been considered an important area for this species (Correa & Luthin 1988). Authors have sighted this species previously in the reserve area, but only rarely. Thus, we conclude that this species is rather rare in CMBR. *Saltator maximus* is a species that has been commonly seen in CMBR and around Tabasco State, but we were unable to record it during the present survey.

We report a higher number of species for the semi-deciduous lowland forest of *H. campechianum* (144) compared to the 83 spp. reported by Santiago-Alarcon (2003) in the same kind of habitat. This might be due to the higher number of sampled localities of this type of community in the present study and to the fact that some of these localities were surrounded by vegetation types not found in the surroundings of the two localities sampled previously by Santiago-Alarcon (2003). Insectivores were the guild with the highest number of species, which is in agreement with results of studies conducted in other Neotropical forests (e.g., Loiselle 1988, González-García 1993, Greenberg *et al.* 1997, Borges & Stouffer 1999). According to the similarity analysis, mangrove and *B. buceras* forests were the most similar followed by the *H. campechianum* forest (Fig. 3). The result from the similarity analysis was expected because mangrove and *B. buceras* forests are broadly mixed across the reserve, whereas *H. campechianum* forests are clearly separated from other wooded habitats due to their adaptation to flooding regimes (López-Hernández 1993). In addition, *H. campechianum* forests have a different vertical and horizontal structure compared to the other forest types of the region, which might influence the bird species that prefer this habitat. There is a clear differentiation between wooded lands and open habitats in bird species composition (Fig. 3); such differences are mainly due to species restricted to aquatic and grassland environments.

Blake (2007) made a comparison of bird species richness at different taxonomic levels and at local and regional scales in tropical terra firme forests. He found that differences are more pronounced between avifaunas of Central and South America most likely due to different biogeographical histories and large-scale processes (Blake 2007). Within a region (e.g., South America) diversity (i.e., beta diversity) varied from place to place depending on the taxonomic level that was considered; at the family level communities across the region were more similar than at the genus or species level, indicating that local microhabitat characteristics and processes act to create

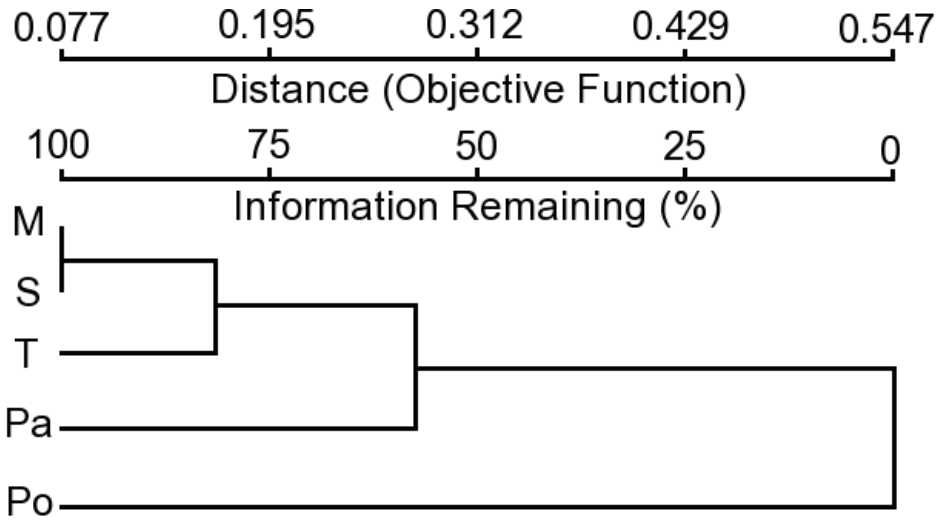

FIG. 3. Dendrogram (nearest-neighbor algorithm) showing the similarity among the different habitats as determined by Wishart's objective function. The objective function is a measure of information loss as agglomeration proceeds. Pa = grasslands/hydrophytes, T = semi-deciduous lowland forest of *Haematoxylon campechianum*, M = mangrove forests, S = semi-deciduous forest of *Bucida buceras*, Po = palm-tree forest/hydrophytes (popal). Avifauna in wooded habitats is more similar among themselves than to open habitats due to birds specializing in aquatic and grassland habitats.

differences in alpha diversity (Blake 2007). Our results indicate that CMBR shares 28 bird families of the 43 reported by Blake (2007); however, only Tyrannidae were shared as one of the most important families in terms of number of species in both studies. This clearly reflects first the different habitat characteristics (CMBR has many families of aquatic birds absent from Amazonian forests), and second the different biogeographical histories and processes underpinning the different regions (North and Central America and in particular CMBR are species-poor for families that are highly diverse in Amazonian forests, such as Furnariidae, Thamnophilidae, Thraupidae, and Pipridae; Blake 2007, Newton 2003).

Species richness of Anseriformes was below the expected number according to former records for the zone (Brazda 1988). We recorded 6 of 10 species reported by Brazda (1988), who recorded population abundances in the thousands (60,555 in 1967 up to 334,320 in 1979) for several species of ducks in Tabasco lagoons, which contrast with the scarcity of records for this group in our surveys (all duck species reported here had numbers in the tens and some in the hundreds, data not shown). This situation might be due to the El Niño event of 1998, which was a very dry year; thus, reducing the number of water bodies available to waterfowl. On the other hand, the permanent destruction of wetland habitats by ranching, construction, and oil activities might be reducing the suitable habitat for aquatic bird species (Bacon 1997). From a conservation perspective, it is important to highlight that in some wetland areas more than 75% of foraging waterfowl are migrants (15,678 individuals of 40 species were recorded in wetlands from Surinam) coming from the north, with a minority being

local resident species (Swennen & Spaans 1985). In the case of terrestrial birds, most of the species in the Parulidae family are Neartic migrants that are restricted to forested lands. Due to the low area occupied by forested habitats in the reserve (~ 10%, see López-Hernández 1993 for exact figures) and the increasing logging activities and oil exploitation in the zone, such areas might disappear in the near future compromising wintering populations of these migrant species. Furthermore, Santiago-Alarcon (2003) has shown that the most frequent and abundant species in semi-deciduous lowland forest of *H. campechianum* are Neartic migrants (e.g., American Redstart [*Setophaga ruticilla*] and Yellow Warbler [*Dendroica petechia*]), which further enhances the need for protection of the reserve's woodlands. More than half of the recorded species are dependent on woodlands, directly or indirectly, as judged by the 183 bird species that use two or more habitat types within CMBR.

If we consider that our surveys were conducted 11 years ago, and that since then oil activities and human encroachment have increased, it is realistic to consider that the ecosystems' health at CMBR has deteriorated. Recently, the Instituto Mexicano del Petróleo (IMP) has started contacting local universities (UJAT, Universidad Juárez Autónoma de Tabasco) and research institutes (e.g., ECOSUR, El Colegio de la Frontera Sur) in order to conduct biodiversity surveys at CMBR to develop a new management plan for the reserve with the intention of finding arguments which permit entering core areas of CMBR for gas extraction. This is an alarming situation and local NGOs, universities, and the Mexican government should act promptly. A way to safeguard CMBR is through the involvement of the RAMSAR convention, if the reserve would be listed under the Montreux Record, which protects RAMSAR sites against undesirable human impacts and supports their restoration and conservation through funds given for conservation projects.

ACKNOWLEDGMENTS

We thank to A. Ibarra-Macías and J. Hernández de la Cruz for help in the field and in the preparation of bird skins. Two anonymous reviewers, A. Navarro-Sigüenza, and A. Weller provided helpful comments that improved the quality of the manuscript. Funds for this project were provided by CONABIO (Comisión Nacional para el Conocimiento y Uso de la Biodiversidad).

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APPENDIX 1. Geographic location of sampling sites. * Geographic coordinates of places where nets were set at each sampling locality. ** Pa = grasslands/hydrophytes, T = semideciduous lowland forest of *Haematoxylon campechianum*, M = mangrove forests, S = semideciduous forest of *Bucida buceras*, Po = palm-tree forest/hydrophytes (popal).

Locality	Latitude*	Longitude	Vegetation type**
Arroyo Polo	18°29'23"N	92°38'28"W	M
Estación Tres Brazos	18°24'20"N	92°38'47"W	Pa
Laguna El Coco	18°29'12"N	92°41'13"W	M
Tres Brazos	18°23'56"N	92°38'32"W	Po, Pa
Chilapa, 3a. sección	18°15'54"N	92°40'09"W	T
Estación Tres Brazos	18°24'23"N	92°38'52"W	Pa
Monte Grande, Jonuta	18°29'23"N	92°38'28"W	Pa
Los Bitzales, 7a. sección	17°58'11"N	92°16'47"W	T, Po
Rancho ganadero Boquerón	18°03'53.8"N	92°30'12.6"W	Pa
Ranchería Nabor Carrillo	18°38'10.5"N	92°30'41"W	Pa
Rancho El Timón	17°58'38.7"N	92°18'54.4"W	Pa
Entrada a Ranchería Luis Echeverría, km 7 carretera Frontera-Jonuta	18°18'25.4"N	92°40'24.9"W	Po, M
Laguna Cometa	18°26'20"N–18°28'07"N	92°38'33"W-92°26'43"W	M
Rancho El Escoro	18°28'26"N–18°32'54"N	92°27'02"W-92°34'47"W	Pa, S
Ribera Alta 2a. sección	18°19'37"N–18°32'21"N	92°29'09"W-92°34'27"W	Po
Ranchería San Juanito	18°19'36"N–18°22'20"N	92°29'06"W-92°38'31"W	S
Bitzal 5a. sección	18°03'55"N–18°21'50"N	92°25'54"W-92°38'30"W	T, M
Ejido Faisán	18°03'51"N	92°25'57"W	Pa
Laguna Los Idolos	18°31'54"N	92°33'22"W	S
Ejido Tres Brazos	18°16'45"N–18°23'51"N	92°37'53"W-92°38'44"W	T
Rancho El Cocal	18°16'35"N	92°12'32"W	Pa

APPENDIX 2. Seasonal status, feeding guild, habitat distribution, and protection status of the species recorded in this study. *R = resident, M = migratory; **1 = fishes/crustacean, 2 = vertebrates (except fishes), 3 = Mollusks, 4 = vegetation/insects, 5 = vegetation/aquatic invertebrates, 6 = insects, 7 = vertebrates/insects, 8 = carrion eaters, 9 = insects/crustacean, 10 = seeds/insects, 11 = omnivores, 12 = fruits/seeds, 13 = nectar/insects; ***Pa = grasslands/hydrophytes, T = semi deciduous lowland forest of *Haematoxylon campechianum*, M = mangrove forests, S = semi deciduous forest of *Bucida buceras*, Po = palm-tree forest/hydrophytes (popal); § P = endangered, A = threatened, R = rare, Pr = under special protection (following NOM-059-ECOL-2001 Mexican Ecological Norm).

Family/species	Seasonal status*	Guild**	Habitat***	§Protection status
Anatidae				
Dendrocygna autumnalis	R	4	Pa, M, T, S	
Dendrocygna bicolor	R	4	Pa, M, T, S	
Cairina moschata	R	4	Pa, M, T, S	
Anas discors	M	4	Pa, M, T	P
Aythya collaris	M	5	T, Pa	
Oxyura jamaicensis	M	5	Pa	
Cracidae				
Ortalis vetula	R		T, S, M	
Podicipedidae				
Tachybaptus dominicus	R	1	Pa	
Podilymbus podiceps	R	1	Pa	
Pelecanidae				
Pelecanus erythrorhynchos	M	1	M	
Pelecanus occidentalis	R	1	M	
Phalacrocoracidae				
Phalacrocorax brasilianus	R	1	M, T, S	
Phalacrocorax auritus	M	1	M	
Anhingidae				
Anhinga anhinga	R	1	M, T, S	
Fregatidae				
Fregata magnificens	R	1	Pa, M	
Ardeidae				
Botaurus pinnatus	R	7	Pa, Po	R
Botaurus lentiginosus	M	7	Pa, Po	A
Ixobrychus exilis	R	7	Pa, M	
Tigrisoma lineatum	R	7	S, M, Pa	
Tigrisoma mexicanum	R	7	S	Pr
Ardea herodias	R	7	Pa, Po, M, T, S	Pr
Ardea alba	R	7	Pa, Po, M, T, S	
Egretta thula	R	7	Pa, Po, M, T, S	
Egretta caerulea	R	7	Pa, Po, M, T, S	
Egretta tricolor	R	7	Pa, Po, M, T, S	
Bubulcus ibis	R	7	Pa, Po, M, T, S	
Butorides virescens	R	7	Pa, Po, M, T, S	
Agamia agami	R	7	T, Pa	Pr
Nycticorax nycticorax	R	7	Pa, Po, M, T, S	
Nyctanassa violacea	R	7	Pa, Po, M, T, S	A
Cochlearius cochlearius	R	7	M, T, S	

APPENDIX 2. Continuation.

Family/species	Seasonal status*	Guild**	Habitat***	Protection status
Threskiornithidae				
Eudocimus albus	R	4	Pa, T	
Platalea ajaja	R	4	M, Pa	
Ciconiidae				
Mycteria americana	M	2	Pa, Po, M, T, S	Pr
Cathartidae				
Coragyps atratus	R	8	Pa, Po, M, T, S	
Cathartes aura	R	8	Pa, Po, M, T, S	
Cathartes burrovianus	R	8	Pa, Po, M, T, S	
Accipitridae				
Pandion haliaetus	R	1	Pa, Po, M, T, S	
Elanus leucurus	R	2	Pa, Po, M, T, S	
Rostrhamus sociabilis	R	3	Pa, Po, M, T, S	Pr
Busarellus nigricollis	R	2	P, M, T	Pr
Circus cyaneus	M	2	S, T, Pa	
Buteogallus anthracinus	R	2	Pa, M, T, S	Pr
Buteogallus urubitinga	R	2	T, S	Pr
Buteo magnirostris	R	2	Po, M, T, S	
Buteo nitidus	R	2	Po, M, T, S	
Falconidae				
Micrastur semitorquatus	R	2	M, S	Pr
Caracara cheriway	R	8	Pa, T, M, S	
Herpetotheres cachinnans	R	2	S, Pa	
Falco sparverius	M	2	T	
Falco femoralis	R	2	Pa, T	A
Falco rufigularis	R	2	Pa	
Rallidae				
Laterallus ruber	R	5	Pa	
Rallus limicola	M	5	Pa, Po	Pr
Aramides cajanea	R	5	M, T, S	
Porphyrio martinica	R	5	Pa, Po	
Gallinula chloropus	R	5	Pa, Po	
Fulica americana	R	5	Pa, Po	
Heliornithidae				
Heliornis fulica	R	1	M, S	Pr
Aramidae				
Aramus guarauna	R	7	Pa, Po, M, T	
Charadriidae				
Pluvialis squatarola	M	9	Pa	
Charadrius semipalmatus	M	9	Pa	
Charadrius vociferus	M	9	Pa	
Recurvirostridae				
Himantopus mexicanus	R	9	Pa	
Jacanidae				
Jacana spinosa	R	4	Pa, Po, T	

APPENDIX 2. Continuation.

Family/species	Seasonal status*	Guild**	Habitat***	Protection status
Scolopacidae				
Actitis macularius	M	9	Pa, M	
Tringa solitaria	M	9	Pa	
Tringa melanoleuca	M	9	Pa	
Tringa flavipes	M	9	Pa	
Arenaria interpres	M	9	Pa	
Calidris alba	M	9	Pa	
Calidris mauri	M	9	Pa	
Calidris bairdii	M	9	Pa	
Laridae				
Leucophaeus atricilla	R	11	Pa, T, M	
Leucophaeus pipixcan	M	11	Pa, T, M	
Hydroprogne caspia	M	11	Pa, T, M	
Sterna hirundo	M	11	Pa, T, M	
Thalasseus maximus	R	11	Pa, T, M	
Thalasseus sandvicensis	R	11	Pa, T, M	
Rynchops niger	R	11	Pa, T, M	
Columbidae				
Patagioenas flavirostris	R	11	Pa, Po, T, M, S	
Zenaida asiatica	R	11	Pa, T, M	
Columbina talpacoti	R	11	Pa, T, M, S	
Leptotila verreauxi	R	11	T, S	
Leptotila plumbeiceps	R	11	T, S	
Psittacidae				
Aratinga nana	R	12	Pa, T, M	Pr
Amazona albifrons	R	12	Pa, T, M	
Amazona oratrix	R	12	T, M	P
Cuculidae				
Piaya cayana	R	6	T, M, S	
Coccyzus americanus	R	6	Pa, T	
Crotophaga sulcirostris	R	6	Pa, T, S	
Tytonidae				
Tyto alba	R	2	M	
Strigidae				
Glaucidium brasilianum	R	2	M, S, T	
Caprimulgidae				
Chordeiles acutipennis	R	6	Pa, S, M	
Nyctidromus albicollis	R	6	Pa, S, M	
Nyctibiidae				
Nyctibius jamaicensis	R	6	M, S	
Apodidae				
Streptoprocne zonaris	R	6	Pa, T, M	
Chaetura vauxi	M	6	Pa, T, M	
Trochilidae				
Anthracothorax prevostii	R	13	Pa, T	

APPENDIX 2. Continuation.

Family/species	Seasonal status*	Guild**	Habitat***	Protection status
Trochilidae				
Amazilia candida	R	13	Pa	
Amazilia beryllina	R	13	Pa	
Amazilia tzacatl	R	13	Pa, T	
Amazilia yucatanensis	R	13	Pa, T, M, S	
Archilochus colubris	M	13	Pa	
Trogonidae				
Trogon melanocephalus	R	6	M, S	
Alcedinidae				
Megaceryle torquata	R	1	Pa, Po, T, M, S	
Megaceryle alcyon	R	1	Pa, T, M	
Chloroceryle amazona	R	1	Pa, T, M, S	
Chloroceryle americana	R	1	Pa, T, M, S	
Chloroceryle aenea	R	1	M, S	
Bucconidae				
Notharchus hyperrhynchus	R	6	M	A
Picidae				
Melanerpes aurifrons	R	6	Pa, T, M, S	
Picoides scalaris	R	6	T, M	
Colaptes rubiginosus	R	6	M, S	
Dryocopus lineatus	R	6	Pa, T, M, S	
Furnariidae				
Synallaxis erythrothorax	R	6	T, S	
Dendrocincla anabatina	R	6	M, T	Pr
Xiphorhynchus flavigaster	R	6	M, S	
Lepidocolaptes souleyetti	R	6	M, T, S	
Thamnophilidae				
Thamnophilus doliatus	R	6	S	
Tyrannidae				
Camptostoma imberbe	R	6	S, M	
Elaenia flavogaster	R	6	S	
Oncostoma cinereigulare	R	6	Pa, T, S	
Poecilotriccus sylvia	R	6	S	
Todirostrum cinereum	R	6	Pa, T, S	
Tolmomyias sulphurescens	R	6	M, S	
Contopus virens	M	6	M, S	
Empidonax virescens	M	6	Pa, T	
Empidonax albigularis	M	6	T, M	
Pyrocephalus rubinus	R	6	Pa, T	
Attila spadiceus	R	6	M, T, S	
Myiarchus tuberculifer	R	6	Pa, T, S	
Myiarchus tyrannulus	R	6	Pa, T, S	
Pitangus sulphuratus	R	6	Pa, T, M	
Megarynchus pitangua	R	6	Pa, T	
Myiozetetes similis	R	6	Pa, T, S	

APPENDIX 2. Continuation.

Family/species	Seasonal status*	Guild**	Habitat***	Protection status
Tyrannidae				
Tyrannus melancholicus	R	6	Pa, T	
Tyrannus vociferans	M	6	Pa, T	
Tyrannus verticalis	M	6	Pa, T, S	
Tyrannus forficatus	M	6	Pa, M	
Tyrannus savana	M	6	Pa, M	
Pachyramphus aglaiae	R	6	Pa, T	
Vireonidae				
Vireo griseus	M	6	Pa, S, M	
Vireo pallens	R	6	T, M	Pr
Vireo philadelphicus	M	6	T	
Vireo olivaceus	M	6	T, S	
Vireo flavoviridis	R	6	Pa, T	
Cyclarhis gujanensis	R	6	Pa, T, M, S	
Corvidae				
Cyanocorax morio	R	11	Pa, T, M, S	
Cyanocorax yucatanicus	R	11	Pa, T, M, S	
Hirundinidae				
Progne subis	M	6	Pa, Po	
Progne chalybea	R	6	Pa, Po	
Tachycineta bicolor	M	6	Pa, Po	
Tachycineta albilinea	R	6	Pa, Po	
Tachycineta thalassina	M	6	Pa, Po	
Stelgidopteryx serripennis	R	6	Pa, Po, T	
Hirundo rustica	M	6	Pa, Po	
Troglodytidae				
Campylorhynchus zonatus	R	6	S, M, T	
Thryothorus maculipectus	R	6	S, M	
Henicorhina leucosticta	R	6	S, M	
Sylviidae				
Polioptila caerulea	R	6	Pa, M, S, T	
Turdidae				
Catharus ustulatus	M	6	M	
Turdus grayi	R	6	Pa, M, S, T	
Mimidae				
Dumetella carolinensis	M	10	M, S, T	
Mimus gilvus	R	10	Pa, M, T	
Parulidae				
Vermivora pinus	M	6	M, S, T	
Vermivora peregrina	M	6	M, S, T	
Dendroica petechia	M	6	M, S, T	
Dendroica pensylvanica	M	6	M, S, T	
Dendroica magnolia	M	6	M, S, T	
Dendroica tigrina	M	6	M, S, T	
Dendroica coronata	M	6	M, S, T	
Dendroica virens	M	6	M, S, T	

APPENDIX 2. Continuation.

Family/species	Seasonal status*	Guild**	Habitat***	Protection status
Parulidae				
Dendroica dominica	M	6	M, S, T	
Mniotilta varia	M	6	M, S, T	
Setophaga ruticilla	M	6	M, S, T	
Protonotaria citrea	M	6	M, S, T	
Helmitheros vermivorum	M	6	M, T	
Seiurus aurocapilla	M	6	M, S, T	
Seiurus noveboracensis	M	6	M, S, T	
Oporornis formosus	M	6	M, S, T	
Geothlypis trichas	M	6	Pa, M, S, T	
Geothlypis poliocephala	R	6	Pa, M, S, T	
Wilsonia citrina	M	6	M, S, T	
Icteria virens	M	6	M, S, T	
Emberizidae				
Volatinia jacarina	R	10	Pa, Po, T	
Sporophila torqueola	R	10	Pa, Po, T	
Passerculus sandwichensis	M	10	Pa, Po	
Zonotrichia capensis	M	10	Pa, Po, T	
Cardinalidae				
Saltator coerulescens	R	10	Pa, T	
Saltator atriceps	R	10	Pa, T	
Piranga rubra	M	10	T, S	
Piranga olivacea	M	10	T, S	
Habia fuscicauda	R	10	M, S	
Pheucticus ludovicianus	M	10	Pa, T	
Cyanocompsa parellina	R	10	Pa, M, T	
Passerina caerulea	M	10	Pa, M, T	
Passerina cyanea	M	6	Pa, M	
Passerina ciris	M	6	Pa, M	
Icteridae				
Agelaius phoeniceus	R	10	Pa, Po, T	
Sturnella magna	R	10	Pa	
Dives dives	R	10	Pa, Po, T	
Quiscalus mexicanus	R	10	Pa, Po, T, M, S	
Molothrus aeneus	R	10	Pa, T, M, S	
Icterus spurius	M	10	Pa, T, M, S	
Icterus cucullatus	R	10	Pa, T, M, S	
Icterus chrysater	R	10	Pa, T, M, S	
Icterus mesomelas	R	10	Pa, T, M, S	
Icterus gularis	R	10	Pa, T, M, S	
Icterus galbula	M	10	Pa, T, M, S	
Amblycercus holosericeus	R	10	M	
Psarocolius montezuma	R	10	M, S	Pr
Fringillidae				
Euphonia hirundinacea	R	10	Pa, T	