ORNITOLOGIA NEOTROPICAL 17: 419–432, 2006

BIRD SPECIES COMPOSITION AND DIVERSITY AT MIDDLE ARGENTINEAN COAST OF LA PLATA RIVER

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Resumen. – Composición y diversidad de especies de aves en la costa Argentina media del Río de la Plata. – Los objetivos de este estudio fueron determinar la composición de aves de la región estuarial de la costa del Río de la Plata (Argentina), describir los patrones temporales y espaciales de la comunidad y de gremios tróficos particulares, y describir el gradiente en la composición de aves y vegetación a lo largo de un gradiente de salinidad. Transectas de ancho fijo fueron usadas para censar aves, aproximadamente cada 2 meses, en el ambiente ribereño y la costa desde Diciembre de 1999 hasta Abril de 2001 en el sector medio del Río de la Plata (mayormente influido por agua dulce). Para estudiar el gradiente, seis hábitat fueron relevados para aves y vegetación solo en el ambiente ribereño vegetado desde sitios dominados por bosques ribereños (río arriba) hasta sitios dominados por marismas (río abajo). La costa media del Río de la Plata tiene una gran diversidad de aves, comparado con ambientes cercanos. En ambientes ribereños y costa hay pocas especies migratorias. Se registraron pequeños cambios estacionales en riqueza de aves y abundancia. Se registró un gradiente de vegetación (florístico y fisonómico) y de aves a lo largo de la costa del Río de la Plata asociado con el gradiente de salinidad. La vegetación cambió de un follaje heterogéneo y alta riqueza de especies de plantas río arriba a un estrato vegetal dominado por una marisma río abajo. Al mismo tiempo la riqueza de aves disminuyó mientras que la composición de especies de plantas y la heterogeneidad del follaje disminuyó también a lo largo del gradiente.

Abstract. – The goals of this study were to determine the composition of birds at the middle portion of the coast of La Plata River (Argentina), to describe the temporal and spatial patterns of the community and particular guilds, and to describe the gradient of bird and vegetation species along the salinity gradient. The strip transect method was used to survey birds, approximately every 2 months, in marsh-riparian forest and open coast from December 1999 to April 2001 in the middle portion of La Plata River coast (freshwater dominated area). To study the gradient, six riparian habitats along the river coast were surveyed for birds by using strip transect and for vegetation by using transects, perpendicular to the coast from a coast dominated by riparian forest (upstream) to a typical saltmarsh (downstream). The middle portion of La Plata River coast has a large diversity of bird species, compared with nearby habitats. There were only few migratory species in the open coast and marsh-riparian forest. Seasonal change in bird species and number of individuals was small. There was a recognizable gradient of vegetation (floristic and physiognomic) and birds species along the coast of La Plata River associated with a gradient of salinity. Vegetation physiognomy changed from a community with heterogeneous foliage and higher richness upstream to a single species saltmarsh downstream. Similarly, bird species richness decrease while species composition and foliage heterogeneity changed along this gradient. *Accepted 1 May 2006*.

Key words: Riparian habitats, gradient, bird richness, guilds, marsh, tidal flat.

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INTRODUCTION

The La Plata River is a large basin with a total area of about 3 million km^2 whose main tributaries are the Paraná, Paraguay and Uruguay rivers; it forms and conforms one of the largest estuaries of South America (Guerrero *et al.* 1997). The cities of Buenos Aires (Argentina) and Montevideo (Uruguay), with nearly 15 million inhabitants, are located on their borders (Mianzan *et al.* 2001). As a result of human use, the estuary is affected by activities such as damming, deforestation, pollution, urban development and navigation (Tucci & Clarke 1998). These activities affect the region and generate environmental concerns, but very few studies have addressed these issues on the coastal and aquatic habitats (Mianzan *et al.* 2001).

The Argentinean coast of the La Plata River is interesting because different biogeographic regions meet in a relatively restricted geographic range (Cabrera 1976). From the north, and bordering the river coast, extends the southernmost distribution of the gallery forest (Paranaense Province, *sensu* Cabrera 1976) intermixed with typical riparian vegetation (dominated by freshwater marshes). The gallery forest extends to southern Brazil, where it covers very large extensions (Cabrera 1976). In the area of La Plata River, this forest becomes a relict habitat, forming a continuous narrow strip (less than 1 km) bordering the riverside. Next to the gallery forest, there are patches of thorn forest ("Espinal", *sensu* Cabrera 1976), and inland, the "Pampas" (*sensu* Cabrera 1976), a large grass area that covers most of the central-eastern region of Argentina. The riverside is influenced by estuarine conditions that increase in salinity from northwest to southeast, resulting in extensive saltmarshes at Samborombón Bay (Fig. 1).

This environmental complexity is also associated with a large diversity of birds (see Cueto & López de Casenave 1999). It has been suggested that ecotones support relatively high biological diversity (Pattern *et al.* 1985). Wetland ecotones can have high species diversity, but species diversity for a particular wetland boundary may be affected by a variety of factors (Van der Maarel 1976), and thus may be difficult to predict (Holland *et al.* 1990). On the other hand, riparian areas are often critical corridors that allow wildlife movement from one important habitat to another (Johnson 1989). Without such corridors, many isolated wildlife habitats may be too small to support the maximum diversity of species as compared with the regional diversity.

Seasonal changes of bird species number are related with the addition of migratory species to the group of resident species in different periods of the year (e.g., Herrera 1978, Cueto & López de Casenave 2000a, but see Greenberg & Marra 2005). Number of individuals of populations and guilds of birds change along the year mainly associated with fluctuations in the abundance of resources (Stiles 1980, Levey 1988, Loiselle & Blake 1991, Poulin *et al.* 1993). La Plata river coast is situated on a subtropical climate region, and thus seasonal changes are moderate (Servicio Meteorológico Nacional 1992*)*. Then we should expect little seasonal change in the abundance and richness of birds in riparian habitats of the La Plata River area (Cueto & López de Casenave 2000a).

Study on the avifauna of La Plata river coast has mostly addressed the birds of the inland native thorn forest (Cueto 1996, Soave *et al.* 1999, Cueto & López de Casenave 2000a, b, 2002), or the birds of some preserved areas (Klimaitis & Moschione 1987, Juárez 1995). Other studies addressed particular topics of bird species or group of species, like diet (Darrieu *et al.* 1996, Camperi *et al.* 1998), plant-bird relationships (Montaldo 1993, Montaldo 2000), and breeding habits (Mason 1985, Milat & Klimaitis 1993, Darrieu

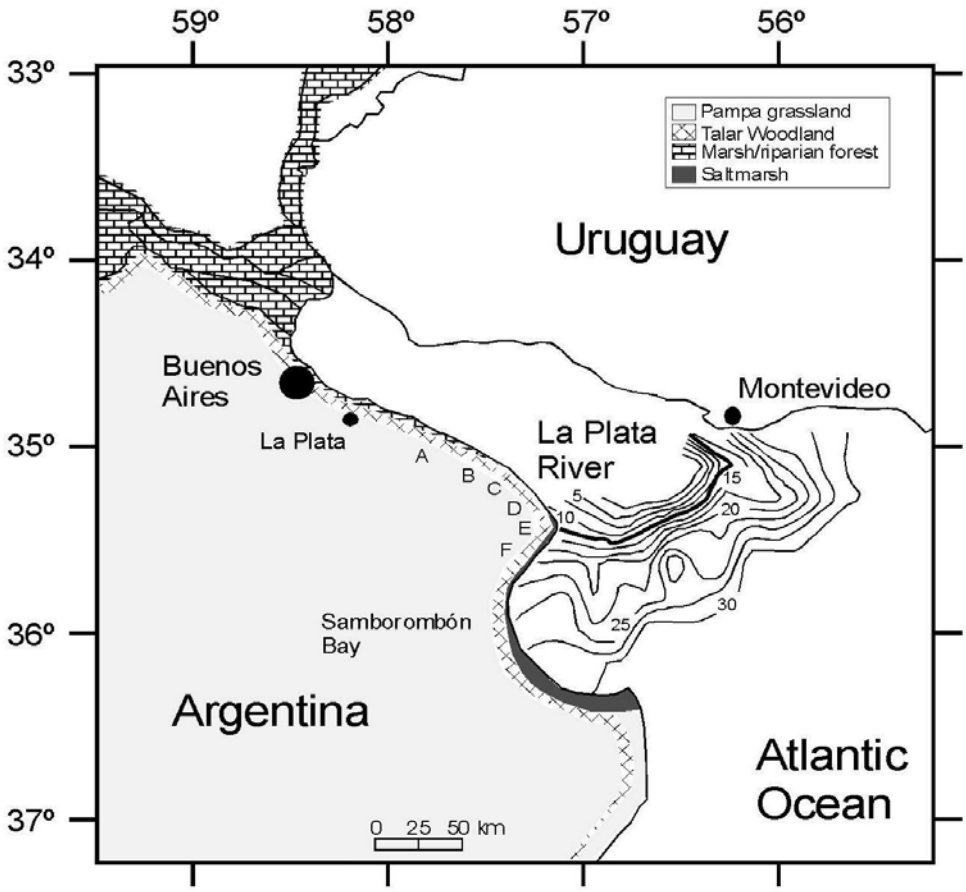

FIG. 1. La Plata River in South America with the study sites in Argentina. In the map are represented the bottom salinity distribution (isohalines each 2.5 salinity units; bold isohaline represents center of salinity frontal position; after Acha *et al.* 2003) and phytogeographic units (after Cabrera 1976, Narosky & Di Giacomo 1993, adapted by the authors). Study sites included: La Balandra (A), Magdalena (B), El Destino Ranch (C), Punta Indio (D), La Matilda (E) and Samborombón Bay (F).

et al. 1998), or include general anecdotic information about birds of La Plata River coast (Pereyra 1938). However, there is no published information dealing with the basic spatial and temporal distribution patterns of the avifauna on the coast of a large representative area of the middle portion of La Plata river. Such information can help to have a wider view of La Plata river coastal avifauna, which should be useful as a baseline for management plans or environmental impact assessment (e.g., Wegner *et al.* 2005).

Therefore, the goals of this study were (1) to describe the composition of the avifauna of the middle Argentinean coast of La Plata River (freshwater dominated coast), an area with almost pristine vegetation and located down-river from largely populated cities, (2) to analyze the temporal and spatial patterns of the community and particular guilds, and (3)

to characterize the gradient of bird and vegetation diversity from that freshwater dominated coast to saltwater dominated coast.

STUDY AREAS AND METHODS

Study areas. The study area included the Argentinean coast of La Plata River from 34º54'49"S, 57º45'1"W to 35º7'30"S, 57º23' 23" (Fig. 1). The study focused on the coastal environment, represented by the following habitats (from water to inland): river (deep and shallow waters), tidal flats (with monospecific patches of *Schoenoplectus californicus*), coastal short grass prairie (dominated by *Hydrocotyle modesta*, *Eleocharis montana*, *Bacopa monnieri*, *Triglochin striata* and *Acmella decumbens*), fresh marshes (dominated by *Zizanopsis bonariensis*, *Typha latifolia*, *Schoenoplectus californicus*, *Scirpus giganteus*, *Iris pseudacorus* and *Eryngium pandanifolium*), and the riparian forest dominated by native (*Erythrina crista-galli*) and exotic trees (mainly *Salix* sp. and *Gleditsia triacanthos*; Cabrera & Zardini 1979).

The climate is subtropical (annual mean temperature 16ºC and precipitation in the order of 1000 mm, Servicio Meteorológico Nacional 1992). Rainfall occurs mainly during autumn and spring, with maximum values in March and October and minimum values in June. Mean precipitation range from 1093 mm $year^{-1}$ on the northwestern side (i.e., city of La Plata) to 1014 mm $year^{-1}$ on the southeastern side (i.e., town of Punta Indio; Servicio Meteorológico Nacional 1992). The water quality of the estuary changes abruptly from freshwater to brackish waters in the central part of the estuarine area, along a gradient that exhibits little seasonal variation (Guerrero et al. 1997).

Spatial and temporal patterns of bird species composition and diversity. The coastal habitats were arbitrarily divided into two groups: the open coast (river, tidal flats and coastal short grass prairie) and the marsh-riparian forest (only the strip of 30 m along the coast). Birds were counted using strip transects (following Conner & Dickson 1980). Study sites (Fig. 1) were La Balandra (A), Magdalena (B) and El Destino (C). Open coasts were surveyed approximately at 3-month intervals from December 1999 to January 2001 (N = 32 counts), and the marsh-riparian forests at 2 or 3-month intervals from December 1999 to April 2001 (N = 68 counts). Two or three transects were surveyed in each site once by date, however the number of surveys were not the same among dates given that sometimes extreme weather conditions prevented the access to the coastal area. Those conditions were stronger on the open coast determined by the river influence, thus several surveys in that habitat were lost. Bird species and number of individuals were surveyed in each transects. Counts were done during the first 4 h after sunrise and the 3 h before sunset. Transects in the open coast (700 m long) were surveyed walking parallel to the coast and recording all birds observed from the short grass prairie to approximately 150 m into the water. Transects in the marsh-riparian forest consisted of strips of 250 x 30 m. In both cases birds observed outside of the sampling areas were recorded only for the species list. Survey data were used to describe the composition and seasonality of the bird community. Seasonality was described only for marsh-riparian forest, since the conditions of the river that vary from one sampling date to another can bias the interpretation of seasonal trends.

Gradient of vegetation and birds along the river coast. To investigate the potential relationship between vegetation and bird species a specific survey was carried out at La Balandra (A), Magdalena (B), El Destino (C), Punta Indio (D), La Matilda (E) and Samborombón Bay (F) during February 2002 (see Fig. 1). These areas encompass the whole transition from

TABLE 1. Total abundance, occurrence (number of surveys in which the species was recorded; between brackets) and migratory status (MS) of bird species recorded in open coast (coast) and marsh-riparian forest (marsh) of the upper estuary of La Plata river. Trophic guild (TG) is showed only for marsh-riparian forest birds included in the analysis but not for aquatic birds and raptors.

	Coast (n = 32)	Marsh (n = 68)	MS[1]	TG[2]
Nothura maculosa - Spotted Nothura	0	1(1)	Pr	
Macronectes giganteus - Common Giant-Petrel	+	0	A	
Puffinus puffinus - Manx Shearwater	+	0	A	
Podiceps major - Great Grebe	1(1)	0	Pr	
Podiceps rolland - White-tufted Grebe	2(1)	0	Pr	
Phalacrocorax olivaceus - Neotropic Cormorant	5(4)	0	Pr	
Anas georgica - Yellow-billed Pintail	3(2)	0	Pr	
Anas flavirostris - Speckled Teal	9(4)	0	Pr	
Amazonetta brasiliensis - Brazilian Duck	7(3)	0	Pr	
Ardea cocoi - With-necked Heron	12(10)	2(2)	Pr	
Casmerodius alba - Great Egret	5(4)	2(1)	Pr	
Egretta thula - Snowy Egret	4(3)	0	Pr	
Trigrisoma lineatum - Rufescent Tiger-heron	0	1(1)	Pr	
Nycticorax nycticorax - Black-crowned Night-heron	0	6(3)	Pr	
Ixobrychus involucris - Stripe-backed Bittern	0	+	Pr	
Syrigma sibilatrix - Whistling Heron	+	0	Pr	
Plegadis chihi - White-faced Ibis	2(1)	0	Pr	
Buteo magnirostris - Roadside Hawk	0	1(1)	Pr	
Elanus leucurus - White-tailed Kite	+	0	Pr	
Circus buffoni - Long-winged Harrier	0	+	Pr	
Rostramus sociabilis - Snail Kite	0	1(1)	Pr	
Polyborus plancus - Crested Caracara	17(9)	4(4)	Pr	
Polyborus chimango - Chimango Caracara	28(11)	9(9)	Pr	
Aramus guarauna - Limpkin	26(4)	3(3)	Pr	
Aramides ypecaha - Giant Wood-rail	2(1)	3(3)	Pr	
Pardirallus sanguinolentus - Blackish Rail	4(4)	0	Pr	
Lateralus melanophaius - Rufous-sided Crake	0	+	Pr	
Fulica armillata - Red-gartered Coot	1(1)	0	Pr	
Gallinago paraguaiae - Common Snipe	5(3)	1(1)	Pr	
Tringa melanoleuca - Greater Yellowlegs	5(4)	0	Sv	
Tringa flavipes - Lesser Yellowlegs	6(2)	0	Sv	
Himantopus melanurus - Southern Stilt	9(4)	0	Pr	
Vanellus chilensis - Southern Lapwing	25(4)	0	Pr	
Charadrius semipalmatus - Semipalmated Plover	1(1)	0	Sv	
Larus dominicanus - Kelp Gull	103(9)	0	Pr	
Larus maculipennis - Brown-hooded Gull	228(13)	0	Pr	
Sterna trudeaui - Trudeaus Tern	18(1)	0	Pr	
Columba picazuro - Picazuro Pigeon	6(2)	8(5)	Pr	G
Zenaida auriculata - Eared Dove	1(1)	8(6)	Pr	G
Leptotila verreauxi - White-tipped Dove	0	5(5)	Pr	G
Podager nacunda - Nacunda Nighthawk	1(1)	0	Sr	

TABLE 1. Continued.

	Coast (n = 32)	Marsh (n = 68)	MS[1]	TG[2]
Eleothreptus anomalus - Sickle-winged Nightjar	0	1(1)	A	
Chlorostilbon aureoventris - Glittering-bellied Emerald	0	23(15)	Pr	N
Hylocharis chrysura - Gilded Sapphire	0	13(11)	Pr	N
Ceryle torquata - Ringed Kingfisher	0	+	Pr	
Chloroceryle americana - Green Kingfisher	1(1)	0	Pr	
Colaptes campestris - Field Flicker	2(1)	0	Pr	
Colaptes melanochloros - Green-barred Woodpecker	1(1)	1(1)	Pr	
Picoides mixtus - Checkered Woodpecker	0	2(1)	Pr	
Lepidocolaptes angustirostris - Narrow-billed Woodcreeper	0	2(2)	Pr	I
Cinclodes fuscus - Bar-winged Cinclodes	16(6)	0	Wv	
Furnarius rufus - Rufous Hornero	21(10)	37(23)	Pr	I
Phleocryptes melanops - Wren-like Rushbird	17(9)	5(4)	Pr	I
Phacellodomus striaticollis - Freckle-breasted Thornbird	0	12(12)	Pr	I
Synallaxis spixi - Spix's Spinetail	0	9(5)	Pr	I
Synallaxis albescens - Pale-breasted Spinetail	0	5(5)	Sr	I
Limnornis curvirostris - Curve-billed Reedhaunter	1(1)	15(13)	Pr	I
Cranioleuca sulphuriphera - Sulphur-bearded Spinetail	0	1(1)	Pr	I
Tamnophilus ruficapillus - Rufous-capped Antshrike	0	8(8)	Pr	I
Pitangus sulphuratus - Great Kiskadee	28(14)	28(25)	Pr	FI
Tyrannus melancholicus - Tropical Kingbird	0	4(3)	Sr	Ai
Suiriri suiriri - Suiriri Flycatcher	0	+	Pr	
Tachuris rubrigastra - Many-colored Rush-tyrant	3(1)	3(3)	Pr	Ai
Pyrocephalus rubinus - Vermilion Flycatcher	0	+	Sr	Ai
Myiophobus fasciatus - Bran-coloured Flycatcher	0	1(1)	Sr	Ai
Serpophaga subcristata - White-crested Tyrannulet	0	3(3)	Pr	Ai
Hymenops perspicillata - Spectacled Tyrant	0	1(1)	Sr	Ai
Pseudocolopteryx flaviventris - Warbling Doradito	2(2)	10(7)	Pr	Ai
Cyclarhis gujanensis - Rufous-browed Peppershrike	0	2(2)	Pr	I
Turdus rufiventris - Rufous-bellied Thrush	2(1)	14(11)	Pr	FI
Turdus amaurochalinus - Creamy-bellied Thrush	0	1(1)	Pr	FI
Mimus triurus - White-banded Mockingbird	0	1(1)	Wv	I
Troglodytes aedon - House Wren	1(1)	95(46)	Pr	I
Polioptila dumicola - Masked Gnatcatcher	0	2(2)	Pr	I
Phaeoprogne tapera - Brown-chested Martin	3(2)	2(1)	Sr	
Tachycineta leucorrhoa - White-rumped Swallow	7(1)	7(3)	Sr	
Parula pitiayumi - Tropical Parula	0	3(2)	Pr	I
Geothlypis aequinocatialis - Masked Yellow-throat	0	32(19)	Pr	I
Basileuterus culicivorus - Golden-crowned Warbler	0	2(2)	Pr	I
Zonotrichia capensis - Rufous-collared Sparrow	22(12)	136(42)	Pr	G
Coryphospingus cucullatus - Red-crested Finch	0	1(1)	Pr	G
Donacospiza albifrons - Long-tailed Reed-finch	2(1)	13(5)	Pr	G
Poospiza nigrorufa - Black-and-rufous Warbling-finch	8(5)	73(39)	Pr	O
Embernagra platensis - Great Pampa-finch	7(4)	1(1)	Pr	O
Icterus cayanensis - Epaulet Oriole	0	5(3)	Pr	FI

TABLE 1. Continued.

	Coast (n = 32)	Marsh (n = 68)	MS[1]	TG[2]
Agelaius thilius - Yellow-winged Blackbird	126(23)	56(21)	Pr	O
Molothrus badius - Bay-winged Cowbird	0	37(4)	Pr	O
Molothrus bonaerensis - Shiny Cowbird	0	8(4)	Pr	O

[1]Migratory status after Narosky & Di Giacomo (1993): A = accidental, Pr = permanent resident, Sr = summer resident, Sv = summer visitant, Wv = winter visitant. Residents are those species that breed in coastal La Plata River. Visitants are those migratory species that only winter in coastal La Plata River.

[2]Trophic guild after Canevari *et al.* 1991, Martínez 1993, Cueto 1996): Ai = Aerial insectivorous, FI = frugivorous-insectivorous, G = granivorous, I = insectivorous non aerial, N = nectarivorous , O = omnivorous.

+ Bird species detected in the habitat but outside transects

the southernmost part of the gallery forest (upstream) to a typical saltmarsh (downstream; Fig. 1). Birds were surveyed only on habitats with presence of vegetation (marsh-riparian forests, freshwater marshes and saltmarshes).

Vegetation data were obtained from a representative area from one sampling unit of 100 x 10 m located perpendicular to the coastline on each site. Plant species were exhaustively collected within the sampling units for further determination, and a floristic list was constructed for each site. Species were classified into life forms in order to achieve the relative frequencies of trees, shrubs, herbs, weeds, climbing/vines, hydrophytes and salt marsh plants. Sites were arranged based on these percentages by an incremental sum of squares clustering method (Ward 1963) using Euclidean distance dissimilarity index (Hair *et al.* 1995). Bird data came either from two or three transects (according to accessibility and logistic possibilities) of 250 x 30 m on riparian vegetation parallel to the coast. Sites were classified based on the bird species presence using a clustering procedure (Hair *et al.* 1995) with Jaccard's index of similarity (Magurran 1998). The mean value of all similarity distances for plants and for birds was selected as the criteria to separate groups. These values are represented as dotted lines into the tree diagrams with the groups at the left of the line.

The relationships between plant species richness and water salinity (see Fig. 1) with bird species richness were analyzed through simple correlations and partial correlation analysis (Zar 1999). The last analysis was used to solve the problem of the interactions between vegetation and salinity variables (Zar 1999).

RESULTS AND DISCUSSION

Bird species composition and diversity. Eighty-six bird species were recorded in the whole coastal area (Table 1), with more species in the marsh-riparian forest than in the open coast. Thirty percent of the species occurred in both habitats.

Forty seven species were recorded on the open coast. Kelp (*Larus dominicanus*) and Brown-hooded (*Larus maculipennis*) gulls, and the Yellow-winged Blackbird (*Agelaius thilius*) (6% of total species) represented 57% of total abundances, and they were also the most frequently occurring species. Eighty three percent of the recorded species had frequencies

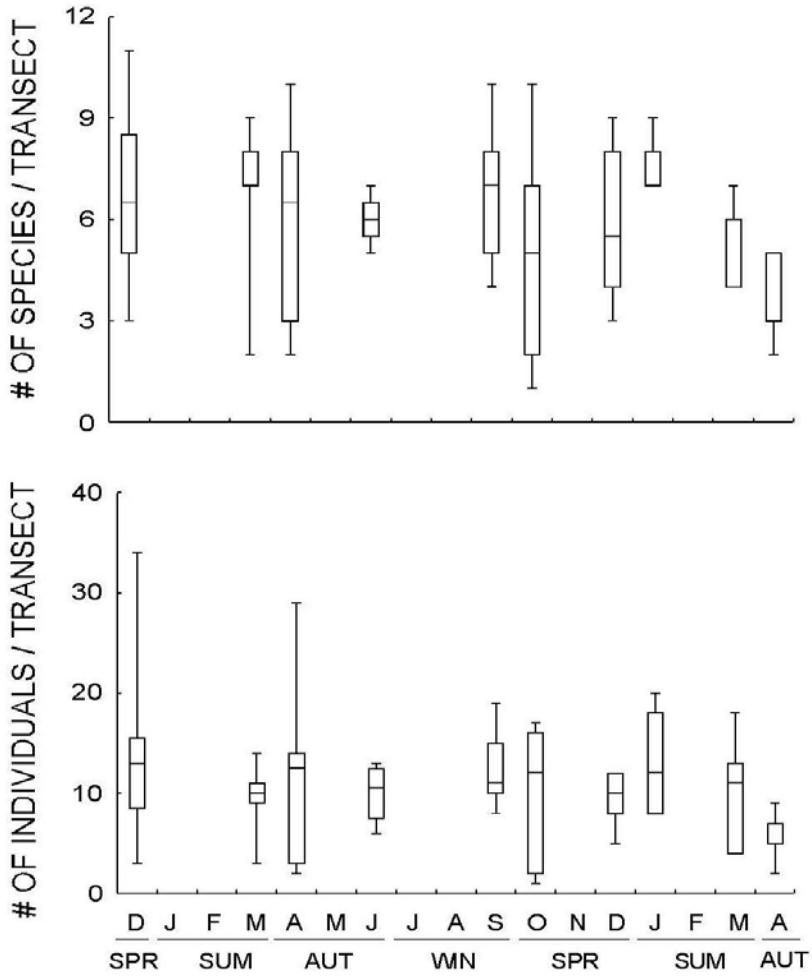

FIG. 2. Number of species and individuals of birds along seasons in marsh-riparian forests of La Plata River coast between December 1999 and April 2001. Here and thereafter, limits of the boxes represent 25th and 75 th percentiles, lines represent 1st and 99th percentiles, and lines inside boxes represent medians.

lower than 30%, while 56% were recorded only once (Table 1).

Thirteen migratory species (12.5% of which were austral summer visitants and residents) accounted for 14.5% of the total number of species registered at the study area, and the Bar-winged Cinclodes (*Cinclodes fuscus*) was the only austral winter visitant (Table 1). Our results confirm that the upper-middle coast of the La Plata River is not an important wintering site for migratory shorebirds. There were only a few species (N = 3) and with relatively low numbers (no more than three individuals together in one transect); which contrast with the nearby southeastern coast of the Samborombon Bay (Fig. 1), which is well known to support large numbers of Nearctic shorebirds during the austral sum-

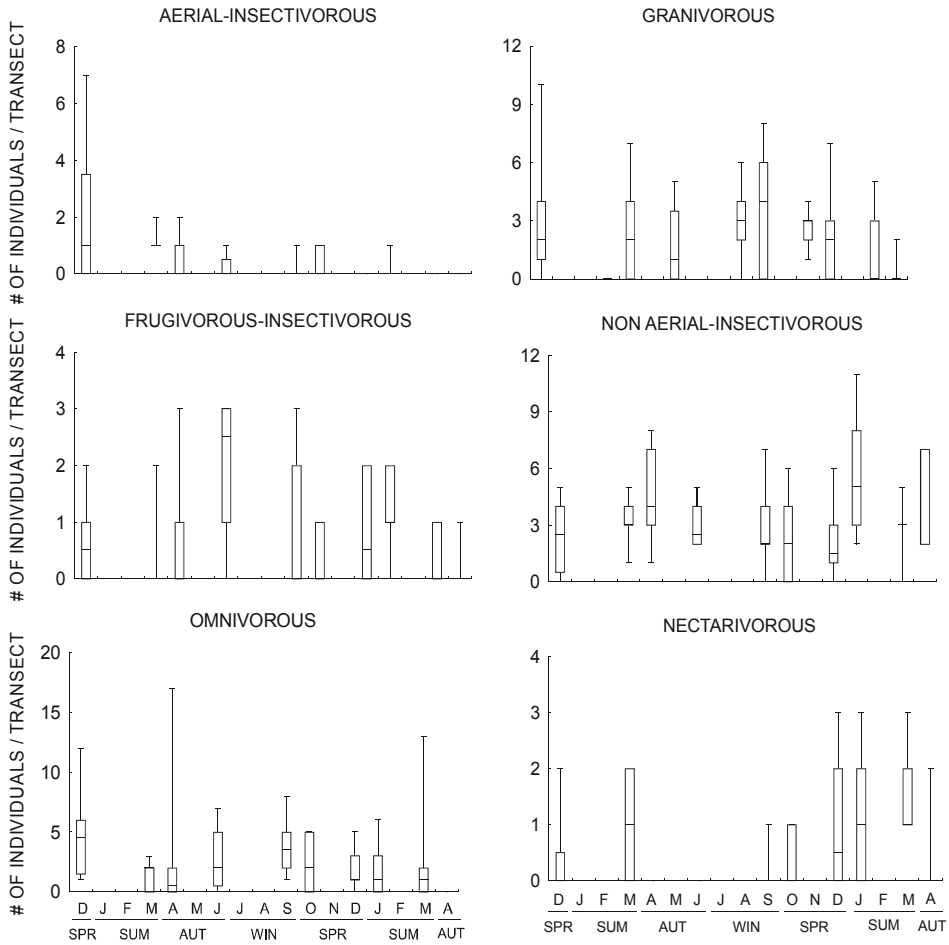

FIG. 3. Abundance along seasons of trophic-functional guilds of the bird community in marsh-riparian forests of La Plata River coast. Surveys were conducted between December 1999 and April 2001.

mer (Morrison & Ross 1989, Vila *et al*. 1994).

There were 56 species recorded for the marsh-riparian forest. Rufous-collared Sparrows (*Zonotrichia capensis*), House Wrens (*Troglodytes aedon*) and Black-and-rufous Warbling-finches (*Poospiza nigrorufa*)] accounted for 42% of total abundance and were also the most frequent species. Twenty five percent of all species were recorded only once (Table 1). Only one globally endangered bird species, the Sickle-winged Nightjar (*Eleothreptus anomalus*; Birdlife 2004) was recorded in the marsh-riparian forest. Migratory species represented 8.9% of species registered in the marsh-riparian forest (four austral summer resident and one austral winter visitant species; Table 1). Tyrannidae and Hirundinidae were the best-represented families within the migratory species. Individuals and species numbers showed little change during the annual cycle (Fig. 2).

Granivorous, non-aerial insectivorous, and omnivorous were the most abundant trophic-

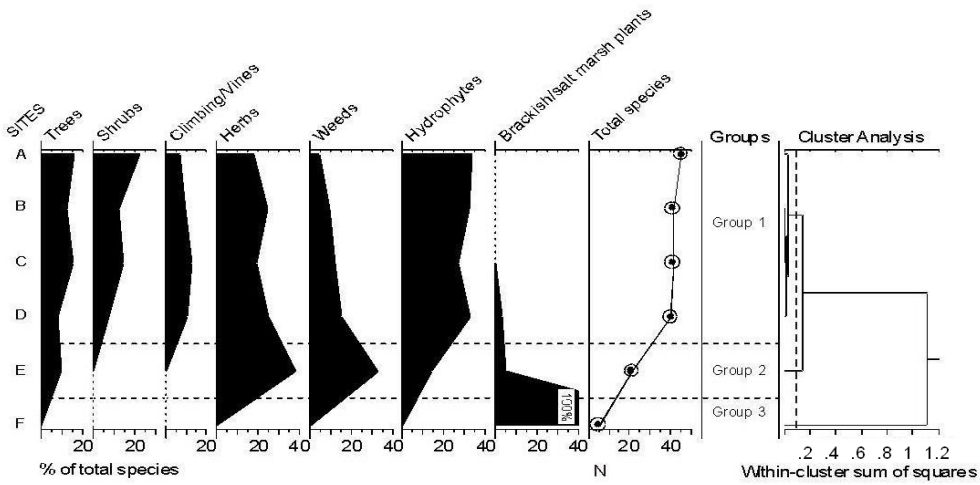

FIG. 4: Cluster analysis and percentage composition of trees, shrubs, climbing vines, herbs, weeds, hydrophytes, and brackish-salt marsh plants for each site. For study sites, see Figure 1. Dotted line into the tree diagram represents the cut off value to discriminate groups.

functional guilds in marsh-riparian forest (Table 1). Nectarivorous and aerial-insectivorous were the only guilds which showed variation in seasonal abundance, with peaks during the spring-summer period (Fig. 3).

Studies about bird communities on inland thorn forest habitats near La Plata river coast (Soave *et al.* 1999, Cueto & López de Casenave 2000a) showed little seasonal change of number of individuals, species and the more common trophic guilds. This pattern coincides with the pattern recorded in this study for the marsh-riparian forest habitat, and may be due to the subtropical climate regime of this region, mainly due to the stabilizing effect of the La Plata river and also due to the high number of permanent resident species (Cueto & López de Casenave 2000a).

Two low-represented trophic guilds, nectarivorous and aerial-insectivorous were the only guilds that showed a seasonal pattern, since they depend mainly on seasonal resources (e.i., flowers and flies). There were no seasonal changes in the other guilds, which can be explained by their generalist trophic habits (frugivorous-insectivorous and omnivorous) or because their densities are not related with the insect availability (e.g., non aerial-insectivorous; Holmes & Recher 1986, Marone 1992).

The land-water ecotone represented in our study area by the marsh-riparian forest showed larger diversity of bird species (56 species) when compared with the respective inland and water habitats bird communities [47 species in the open coast (this study), 52 species in the thorn forest (Cueto 1996) and 35 species in the native tall grass habitats (Comparatore *et al.* 1996)]. This pattern agrees with predictions about higher biodiversity in land-water ecotone habitats than in the respective aquatic and terrestrial habitats (Pattern *et al.* 1985).

Gradient of vegetation and birds along the river coast. Total plant species decreased from 45 at La Balandra (site 1), to only 5 at Samborombón Bay (F; Fig. 1). The highest decrease was registered between Punta Indio (site D) and La

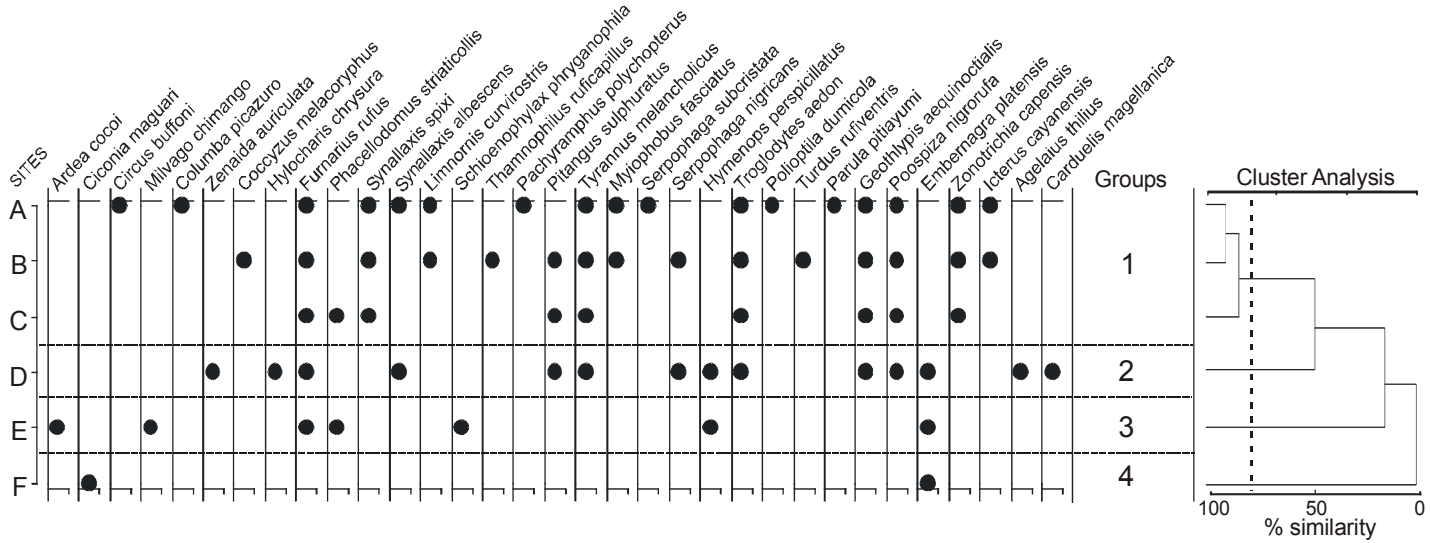

FIG. 5: Composition of bird species for study sites along of La Plata River coast and cluster showing similarities (Jaccard's index) between sites. For study sites see Figure 1. Dotted line into the tree diagram represents the cut-off value to discriminate groups.

Matilda (site E) where numbers of species decreased from 40 to 21 (Fig. 4).

The percentage of trees, shrubs, climbing/vines, and hydrophytic species exhibited a decreasing trend towards the SW, while salt marsh plants exhibited the opposite pattern (Fig. 4). Site F was represented only by salt marsh species. Species composition at site E had the highest percentages of herbs (38%) and weeds (33%) in agreement with the decrease of tree values. Hydrophytes showed the highest percentages values at sites A and D (33%).

Thirty-seven bird species were recorded exclusively in this survey but not in the regular transects (Fig. 5). Bird species richness decreased downstream, but with higher richness at Punta Indio (Fig. 5). Sites A, B and C formed a group with relatively similar species composition, but the other three sites becomes progressively less similar downstream (Fig. 5).

Iterms of bird species composition, the cluster analysis classified sites into four groups (Fig. 4). Group 1 (sites A–C) was characterized by typical marsh-forest species. Group 2 (site D) was characterized by the appearance of open marsh species [Spectacled Tyrant (*Hymenops perspicillatus*), Great Pampa Finch (*Embernagra platensis*) and Yellow-winged Blackbird]. Group 3 (site E) was characterized by the appearance of a typical thorn forest species [Chotoy Spinetail (*Schoeniophylax phryganophila*)]. Group 4 (site F) was characterized by low number of species and represented by a typical open-marsh species (Great Pampa Finch).

Bird richness was positively correlated with plant species richness ($r = 0.91$, $N = 6$, $P = 0.012$), and negatively with water salinity ($r = -0.89$, $N = 6$, $P = 0.016$). Plant species richness was negatively correlated with water salinity ($r = -0.94$, $N = 6$, $P = 0.004$). The relationship between bird richness and plant species richness was maintained also after the effect of water salinity was controlled (Partial correlation analysis, $r = 0.96$, $P = 0.002$). However, salinity was not correlated when plant richness was controlled (Partial correlation analysis, $r = -0.38$, $P > 0.05$).

The La Plata River coast shows a gradient of salinity, vegetation, and bird species richness. Vegetation changed from higher heterogeneous foliage (Fig. 4) and plant species richness upstream to a single species saltmarsh downstream (dominated by *Spartina densiflora*). At the same time, bird species richness along this gradient varied according to plant species richness, suggesting that more heterogeneous and diverse habitats support more bird species than homogeneous ones (e.g., MacArthur & MacArthur 1961, Cueto & López de Casenave 1999). The decreasing of plant species richness was associated with increased salinity, since diverse freshwater tolerant species upstream are replaced by fewer saltwater tolerant species downstream.

ACKNOWLEDGMENTS

We thank Oscar Johnson for comments on earlier draft of this article and four anonymous reviewers for helpful comments on the manuscript. This project was supported by Universidad Nacional de Mar del Plata, Fundación Antorchas, ANPCyT and CONICET (grants to O. Iribarne). J.P. Isacch was supported by a postdoctoral fellowship from CONICET (Argentina).

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