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DIFFERENCES IN BIRD ASSEMBLAGES BETWEEN NATIVE NATURAL HABITATS AND SMALL-SCALE TREE PLANTATIONS IN THE SEMIARID MIDWEST OF ARGENTINA

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ABSTRACT.—We studied the effects on structure of bird assemblages after replacement of native natural habitats by small-scale tree plantations used for recreational purposes. The richness and diversity were similar among habitats; however, the total bird abundance was greater in the tree plantations compared to the natural habitats. Also, we found that small-bodied birds that forage in the foliage had higher abundance in the natural habitats, while larger-bodied species that live in open spaces and forage on the ground occurred in higher abundance in the tree plantations. The comparative evaluation of the seasonal effect on avian assemblages of the contrasting habitats showed that natural habitats had a greater annual fluctuation of abundance values, while the tree plantations were more constant. Our study demonstrates that small-scale tree plantations for recreational purposes exert strong effects on bird assemblages, because they increase the abundance of the generalist and common bird species in the region. *Received 16 December 2013. Accepted 8 July 2014.*

Key words: abundance, guilds, natural habitats, seasonality, species richness, tree plantations.

The structural complexity and productivity of ecosystems are key traits that influence the structure and composition of avian assemblages (e.g., richness, abundance, diversity, guilds) (MacArthur et al. 1966, Polo and Carrascal 1999, Hurlbert 2004, de la Montaña et al. 2006, Díaz 2006, Piper and Catterall 2006, Zurita et al. 2006, Carnicer and Díaz-Delgado 2008, Lantschner et al. 2008). Among the factors that may alter those ecosystem traits, human related activities emerge as severe modifiers, and therefore they may change the structure and composition of the avian assemblages of those ecosystems (Marone 1991, de la Montaña et al. 2006).

One highly topical effect derived from human intervention on ecosystems in South America (Argentina) is the substitution of native forest by monoculture tree plantation. This substitution produces a simplification of the vegetation structure and composition of the ecosystem (Zurita et al. 2006), that modifies the composition and reduces the richness of bird assemblages in it (Haro and Gutiérrez 1992, Gjerde and Saetersdal 1997, Marsden et al. 2001, Zurita et al. 2006).

Recreational areas (i.e., picnic areas, campsites) are often small-scale tree plantations and are usually assumed to have a low ecological impact. However, the installation of recreational areas in native habitats leads to the creation of edge habitats and may increase the access of some species to certain resources and create new resources, like open space, food, water and nesting materials (Piper and Catterall 2006). These changes in the structure and composition of vegetation in recreational areas may increase the presence of common and generalist species of relatively high body mass, while reducing the richness and local abundance of specialist species of relatively small body mass (Boyle and Samson 1985, Blakesley and Reese 1988, Piper and Catterall 2006). Moreover, Leveau and Leveau (2012) observed that urbanization produced an increase of common and generalist bird species.

The effect of small-scale tree plantations for recreational purposes on avifauna has not been studied in the semiarid midwest of Argentina. The Embalse La Florida water reservoir is the most important hydrological system in the San Luis province, Argentina (Cid et al. 2009, Cid et al. 2011). At present, areas around the shore may be divided into those where human intrusion has been low (the natural habitats), and those where the native vegetation was replaced by small-scale tree plantations with recreational uses (e.g., campsites) (Jofré et al. 2010). The existence of both natural habitats and small-scale tree planta-

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tions around the shores of Embalse La Florida allows us to examine the effects of habitat transformation on bird assemblage structure. The main objective of this work is to compare the composition/structure and seasonal dynamics of the bird assemblages between natural habitats and small-scale tree plantations for recreational purposes in this ecosystem.

MATERIALS AND METHODS

Study Area.—The study was performed in the Embalse La Florida (33° 07′ S, 66° 02′ W; 1,030 m asl), located in Coronel Pringles Department of San Luis province, Argentina, 46 km northeast of San Luis city. This water reservoir has a surface area of 651.86 ha, 36 km perimeter and a capacity of 100.97 hm^3 and phytogeographically belongs to the ''Chaqueño Serrano'' district (Cabrera 1976). The climate is temperate, a sub-humid highland, with a well-marked seasonal cycle with annual rainfalls of 500–600 mm concentrated mostly in the warm season and the mean temperature varies from 23 °C in January to 10 °C in July (Cid et al. 2011). The Embalse La Florida has a variety of environments on the shore represented by several plant assemblages, the *Prosopis caldenia* woodland, the *Acacia caven* shrubland, the *Lithraea ternifolia* woodland, the *Stipa* and *Festuca hieronymi* grasslands, saxicole vegetation and a zone with a high human interaction (Borisov et al. 1992). At present, there are five camping areas on the shore of the reservoir that receive considerable numbers of tourists during summer (Jan–Feb). In addition, there is human settlement near the Embalse La Florida with growing tourism development.

Sampled Environments.—Eleven sites were studied: six represent the pristine or scarcely modified natural habitats with low human disturbance (hereafter natural habitats), and five represent the small-scale tree plantations. In each habitat, vegetation horizontal structure was assessed using a visual cover method (Kennedy and Addison 1987). The cover of five vegetation strata was measured: (BG) bare ground, (SC) shrub, (HC1) lower herbaceous $<$10 cm, (HC2) higher herbaceous $>$10 cm, and (TC) tree stratum.

Natural habitats are primarily formed by *L. ternifolia* woodland and *A. caven* shrubland. The woodland has an open tree stratum dominated by *L. ternifolia*, a dense shrub layer and a dense grass layer. Other plant species of this community vegetation are *Abutilon grandifolium*, *Lantana grisebachii*, *Ophryosporus axilliflorus*, *Stipa pseudoichu*, *Lepechinia floribunda*, and *Iresine diffusa* (Borisov et al. 1992). The *Acacia caven* shrubland has two dense vegetation layers composed of grass and shrub. The characteristic species is the *Acacia caven* accompanied by other species of shrubs such as *Aloysia gratissima*, *Heterothalamus alienus*, *Baccharis coridifolia*, and *Cassia aphylla* (Borisov et al. 1992).

In contrast, the small-scale tree plantations are mainly exotic tree plantations of *Pinus* spp., *Eucalyptus* spp. and *Ulmus* spp. (at campsites), consisting of regular spaced trees $>$4 m in height without shrub layer and with grass maintained permanently mowed. In addition, these areas may have constructions (e.g., shacks, cabins, multiple lounges, bathrooms, soccer and tennis courts and barbecue areas) with electrical illumination.

Bird Sampling.—Abundance data were collected in 2001 and 2002 during the reproductive season (R; Oct–Dec) and non reproductive season (NR; Jul–Aug) using 100 m georeferenced line transects (30 m width, 15 m each side). All individual birds were recorded by direct visual observation within the transect boundaries. It is important to note that during these months there were no tourists in the recreational areas. In total, 11 transects were distributed in the different vegetation formations of the ecosystem, one per sampling site. The surface area of transects was always included in the same vegetation formation sampled, thus it represented only this environment. Each transect was visited four times (two in the morning and two in the afternoon) during each sampling season and year, so the abundance of each species by season was estimated as the average number of eight records. All the samplings were performed by the same observer (FDC) in the first 3 hrs of the morning (when light allowed) and in the last 3 hrs before sunset.

Before starting the field observations of this work, during January and February of 2001, we performed a 30-day pilot study. This study allowed the observer to become familiar with the visual identification of the resident and migratory birds of the Embalse La Florida ecosystem. We used the Narosky and Yzurieta (1987) field guide for assistance with bird identification. We used 7 $\times$ 50 binoculars to observe the birds. Nomenclature and arrangement of bird species follows the South American Classification Committee of the American Ornithologists' Union (Remsen et al. 2014).

TABLE 1. Mean (standard error) percent cover of vegetation strata and bare ground in natural habitats (N) and small-scale tree plantations (TP).

	Natural	Tree plantation
TC-tree cover	16.5 (4.2)	58.4 (10.4)
SC-shrub cover	40.2 (2.3)	
HC1-herbaceous cover (<10 cm)		51.2 (6.0)
HC2-herbaceous cover (>10 cm)	36.3 (6.1)	8.80 (0.9)
BG-bare ground	11.5 (2.4)	38.6 (3.1)

Species Characteristics.—Body masses of the observed species were taken from the literature (Contreras 1975, Contreras 1985, Contreras 1986, Peris 1990, Navarro and Bucher 1990, Beltzer 1990, Marini et al. 1997, Bó 1999, Jaksic et al. 2002, Ashton 2002, Piratelli 2003, Blendinger 2005). When more than two values were available for a species, we calculated an adult mean body mass using data from both sexes (Table 1). The body size of the surveyed species ranged between 5.2 g (*Anairetes flavirostris*) and 1,900 g (*Coragyps atratus*).

Species were classified according to their main diet and the stratum used for foraging in nine functional categories: GG (ground granivores; terrestrial granivores and granivore-insectivore birds); H (herbivores; birds feeding mainly on fruits and plant buds in the tree and shrub strata); GI (ground insectivores); FI (foliage insectivores); BI (bark insectivores); AI (aerial insectivores); O (omnivores); C (carnivores; carnivore-insectivores and scavenger birds were grouped as carnivores); Fr (frugivore; Table 2). Data used to categorize each species trophically were obtained from the literature and personal field observations (Marone 1991, Marone 1992, Cueto and Lopez de Casenave 2000, Milesi et al. 2002, Horlent et al. 2003, Isacch et al. 2003, Codesido and Bilenca 2004, Blendinger 2005, Giraudo et al. 2006, Lopez de Casenave et al. 2008, Heil et al. 2007).

Data Analyses.—Principal components analysis (PCA) was used to produce summary vectors (PCA axes) of the vegetation structure datasets. Ordinations were computed using correlation matrices of 11 habitats. Component scores of axes 1 were used to test (Student's *t*-test for independent samples) significance of differences in the vegetation structure between habitats.

Results are given as mean ± SE. We evaluated differences in the average bird abundance, guild abundance (GG, GI, FI and O), richness and diversity between natural habitats and small-scale tree plantations using a repeated measures ANOVA, which was appropriate as we sampled the same transects during the reproductive and the non-reproductive seasons. This ANOVA included a habitat x season interaction to test if differences between habitats were consistent across seasons. When the interaction was significant, we conducted a Tukey's Unequal N HSD post hoc test. All response variables (diversity, richness, and abundance) were $\log_{10}$ transformed for the analyses. Aerial insectivores were present only during the R season; thus the contrast between both habitats was carried out only for the R period using Mann-Whitney *U*-test, because the normality assumption was violated. Temporal variation for the H and BI guilds was assessed only in tree plantations, given that these species were found in <50% of the natural habitats. Since only two species were classified as Fr, no statistical comparisons were made for this functional category. The extremely high abundance of *Zenaida auriculata* in the tree plantations prevented an effective counting of individuals. For this reason this species was excluded from all the statistical analyses.

Since bird abundances were different among the different habitats we used rarefaction to explore if differences in richness and diversity were closely related to abundance. Rarefied richness and diversity to a common number of individuals (34) were tested using EcoSim version 7.0 (Gotelli and Entsminger 2007).

The mean body mass of each species in each sampled site was calculated using weighted averages, using the abundance of each species in each site as weights. Based on these indices, sites were classified with an agglomerative cluster software (Community Analysis Package- CAP - version 3.11; Seaby et al. 2004) using complete linkage and squared Euclidean distances. A repeated measures ANOVA was then used to evaluate seasonal differences; if differences between both habitats were significant, the interaction season x habitat was included in the analysis.

Abundance and richness differences between both habitats in species grouped by body mass (groups: 0–25 g, 25–50 g, 50–100 g, 100–200 g and 200–500 g; larger species were not included because of their low abundance) were tested using independent samples *t*-tests.

Normality was tested using Shapiro-Wilk's W, homogeneity of the variance examined with

TABLE 2. Common and scientific names, foraging guild, body mass, and average abundance (birds/transect) of bird species recorded in natural habitats (N) and small-scale tree plantations (TP) of the study area the Embalse La Florida (San Luis, Argentina).

					Average abundance (birds/transect)			
					Non-reproductive		Reproductive	
Species	Common name	Guild[a]	Body mass (g)	Species recorded only in N or TP	N	TP	N	TP
Anairetes flavirostris	Yellow-billed Tit-Tyrant	FI	5.2	N	0.06	----	0.02	----
Anthus correndera	Correndera Pipit	GI	20.0		0.02	----	----	0.05
Thectocercus acuticaudatus	Blue-crowned Parakeet	GG	160.0	TP	----	0.45	----	0.13
Asthenes baeri	Short-billed Canastero	GI	17.5	N	----	----	0.06	----
Camptostoma obsoletum	Southern Beardless-Tyrannulet	FI	7.3	N	0.04	----	----	----
Sporagra magellanica	Hooded Siskin	GG	13.9		----	0.58	0.50	1.33
Catamenia analis	Band-tailed Seedeater	GG	11.9	N	----	----	0.33	----
Circus buffoni	Long-winged Harrier	C	500.0	N	----	----	0.02	----
Cistothorus platensis	Sedge Wren	FI	8.5		0.02	----	1.04	0.33
Colaptes campestris	Campo Flicker	BI	192.2		0.10	0.12	0.23	----
Colaptes melanochloros	Green-barred Woodpecker	BI	165.6		0.04	0.03	0.06	0.05
Columba livia	Rock Pigeon	GG	350.0	N	0.02	----	----	----
Patagioenas maculosa	Spot-winged Pigeon	GG	336.3		3.23	13.76	1.94	8.13
Columbina picui	Picui Ground Dove	GG	46.7		0.13	0.58	----	0.03
Coragyps atratus	Black Vulture	C	1900.0		----	0.05	0.15	0.03
Coryphistera alaudina	Lark-like Brushrunner	GI	34.3	TP	----	0.38	----	0.08
Cranioleuca pyrrhophia	Stripe-crowned Spinetail	FI	10.8		0.08	0.10	0.31	0.25
Cyanoliseus patagonus	Burrowing Parakeet	HF	257.3	TP	----	0.05	----	0.95
Drymornis bridgesii	Scimitar-billed Woodcreeper	BI	82.3		0.02	0.18	0.17	0.10
Elaenia sp.	Elaenia	FI	16.1	N	----	----	0.23	----
Embernagra platensis	Great Pampa-Finch	GG	54.6	N	0.02	----	0.25	----
Eudromia elegans	Elegant Crested-Tinamou	GG	472.6		----	0.03	0.08	----
Falco sparverius	American Kestrel	C	133.5	N	0.02	----	----	----
Furnarius cristatus	Crested Hornero	GI	**	TP	----	0.15	----	----
Furnarius rufus	Rufous Hornero	GI	50.5		0.10	1.66	0.02	1.23
Empidonomus aurantioatrocristatus	Crowned Slaty Flycatcher	AI	27.8		0.06	----	----	0.05
Guira guira	Guira Cuckoo	C	151.9	N	0.23	----	----	----
Hydropsalis torquata	Scissor-tailed Nightjar	AI		N	----	----	0.08	----
Lepidocolaptes angustirostris	Narrow-billed Woodcreeper	BI	27.2	TP	----	----	----	0.05
Leptasthenura platensis	Tufted Tit-Spinetail	FI	9.1		----	0.10	0.19	0.08
Lophospingus pusillus	Black-crested Finch	GG	14.3	N	----	----	0.02	----
Machetornis rixosa	Cattle Tyrant	GI	33.7	TP	----	0.05	----	0.08
Milvago chimango	Chimango Caracara	C	332.2		0.08	0.10	0.02	0.48
Mimus saturninus	Chalk-browed Mockingbird	FI	59.0	N	0.04	----	----	----
Mimus triurus	White-banded Mockingbird	GI	46.7	N	0.04	----	----	----
Agelaioides badius	Bay-winged Cowbird	GG	36.5		----	0.84	0.08	2.48
Molothrus bonariensis	Shiny Cowbird	GG	60.6		----	0.10	0.27	1.05
Molothrus rufoaxillaris	Screaming Cowbird	GG	41.0	N	----	----	0.02	----
Myiarchus swainsoni	Swainson's Flycatcher	AI	29.2	N	----	----	0.02	----
Myiopsitta monachus	Monk Parakeet	HF	104.3	TP	----	1.95	----	2.23
Nothura maculosa	Spotted Nothura	O	240.0	N	0.02	----	----	----
Pygochelidon cyanoleuca	Blue-and-white Swallow	AI	11.0		----	----	0.06	0.03
Phrygilus plebejus	Ash-breasted Sierra-Finch	GG	**	TP	----	----	----	0.05
Phytotoma rutila	White-tipped Plantcutter	HF	36.5	N	----	----	0.06	----
Veniliornis mixtus	Checkered Woodpecker	BI	28.5	TP	----	0.20	----	----
Pitangus sulphuratus	Great Kiskadee	O	56.0		0.13	0.53	0.02	2.18
Polioptila dumicola	Masked Gnatcatcher	FI	26.8	N	0.19	----	0.04	----
Caracara plancus	Southern Caracara	C	1316.5		0.02	----	0.02	0.05
Poospiza melanoleuca	Black-capped Warbling-Finch	GG	11.0	TP	----	0.05	----	----

TABLE 2. Continued.

Species	Common name	Guild[a]	Body mass (g)	Species recorded only in N or TP	Average abundance (birds/transect)			
					Non-reproductive		Reproductive	
					N	TP	N	TP
Poospiza ornata	Cinnamon Warbling-Finch	GG	12.7	N	0.02	----	----	----
Poospiza torquata	Ringed Warbling-Finch	GG	10.1	N	----	----	0.02	----
Progne elegans	Southern Martin	AI	47.5		----	----	0.13	1.83
Pseudoseisura lophotes	Brown Cacholote	GI	66.5	TP	----	0.51	----	0.28
Saltator aurantiirostris	Golden-billed Saltator	H	44.6	N	0.04	----	----	----
Sappho sparganurus	Red-tailed Comet	O	5.6	N	----	----	0.04	----
Serpophaga munda	White-bellied Tyrannulet	FI	6.1	N	----	----	0.27	----
Serpophaga nigricans	Sooty Tyrannulet	GI	**	N	0.02	----	0.04	----
Serpophaga subcristata	White-crested Tyrannulet	FI	5.8		0.10	0.10	0.63	----
Sicalis flaveola	Saffron Finch	GG	16.0		----	0.13	0.35	0.75
Sicalis luteola	Grassland Yellow-Finch	GG	16.0		----	----	0.04	0.13
Stigmatura budytoides	Greater Wagtail-Tyrant	FI	8.8	N	----	----	0.08	----
Sublegatus modestus	Southern Scrub-Flycatcher	FI	11.7	N	0.13	----	----	----
Suiriri suiriri	Suiriri Flycatcher	FI	21.0	N	----	----	0.06	----
Synallaxis albescens	Pale-breasted Spinetail	GI	12.3	N	0.02	----	0.08	----
Synallaxis frontalis	Sooty-fronted Spinetail	GI	15.5	N	----	----	0.27	----
Pipraeidea bonariensis	Blue-and-yellow Tanager	Fr	36.3		----	0.03	0.25	----
Troglodytes aedon	House Wren	FI	10.1		0.46	0.15	0.81	0.10
Turdus chiguanco	Chiguanco Thrush	O	**		0.42	0.66	0.56	0.48
Turdus rufiventris	Rufous-bellied Thrush	Fr	70.3	TP	----	----	----	0.08
Tyrannus melancholicus	Tropical Kingbird	AI	43.8	TP	----	----	----	0.23
Tyrannus savana	Fork-tailed Flycatcher	AI	28.6		----	----	0.02	0.15
Tarphonomus certhioides	Chaco Earthcreeper	GI	23.4	N	----	----	0.04	----
Vanellus chilensis	Southern Lapwing	GI	280.0		0.08	0.10	----	0.03
Zenaida auriculata	Eared Dove	GG	137.0		x	x	X	X
Zonotrichia capensis	Rufous-collared Sparrow	GG	20.8		0.25	0.28	2.23	1.08

[a] Fr: frugivore.

Levene's test and homocedasticity of the covariance tested with the Box M test. The significance level selected to accept a difference for all statistical analyses performed was $\alpha < 0.05$.

RESULTS

Vegetation Structure.—The tree cover and lower herbaceous stratum were high at tree plantations, while natural habitats have low tree cover but an important shrub cover and higher herbaceous stratum (Table 1). PCA Axes 1 and 2 accounted for 88.63% of the variability of the vegetation structure datasets. The first PCA axis accounts for 73% of the variability in the data and indicates a great difference in the vegetation structure between natural habitats and small-scale tree plantations (*t*-test, $P < 0.001$).

Bird Assemblages.—We recorded 2932 individuals of 75 bird species during the surveys (Table 2), of which *Columba maculosa* exhibited the highest abundance in the study area, far beyond any other species. Abundance of *C. maculosa* was substantially higher in the tree plantations than in the natural habitats (Fig. 1 II).

For all seasons, average bird abundance was significantly higher in tree plantations than in natural habitats (RM ANOVA $F_{1,9} = 131.73$, $P <$ 0 .001; Fig. 1 II). Seasonal comparison of the total bird abundance for the natural habitat showed a significant difference (R > NR, Tukey Unequal N HSD, $P < 0.05$). If the most abundant species (*C. maculosa*) is excluded from analysis, abundance differences between habitats (RM ANOVA $F_{1,9} =$ 24.13, $P < 0.001$) and seasons (RM ANOVA $F_{1,9}$ = 85.37, $P < 0.001$) are still significant (Fig. 1 II).

Similar bird richnesses were observed between habitat types (RM ANOVA $F_{1,9} = 0.53$, $P =$ 0.482; Fig. 1 I). Seasonally, in the natural habitats, richness was higher in the R than in the NR season (Tukey Unequal N HSD, $P < 0.05$), while no seasonal differences were apparent in the tree plantations (Tukey Unequal N HSD, $P > 0.05$)

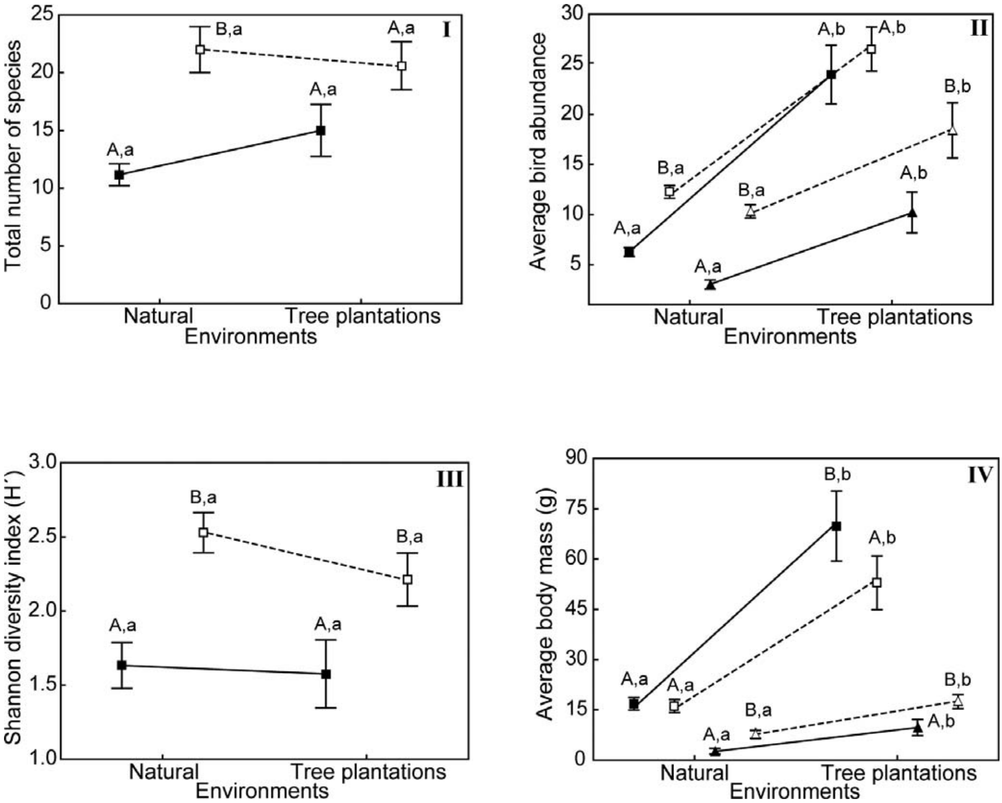

FIG. 1. Variation in the (I) bird species richness, (II) average bird abundance, (III) Shannon diversity index, and (IV) average body mass of bird species in natural habitats and small-scale tree plantations across the non-reproductive (thick line and filled squares) and reproductive seasons (dashed line and open squares). In graphs (II) and (IV), triangles represent average abundance and average body mass of birds excluding the most abundant species (*Columba maculosa*). Bars represent mean ± SE. In each season, different lowercase letters indicate significant differences between environments. In each environment, different capital letters indicate significant differences between seasons.

(Fig. 1 I). Most bird species were exclusively observed in one type of habitat. During NR, 19 species were observed only in the natural habitats, 17 species solely in the tree plantations, while 14 species were seen in both environments. During R, 22 species were common to both environments, and 25 and 14 species were found exclusively and respectively in the natural and the tree plantations.

Shannon's diversity index was similar between habitat types (RM ANOVA $F_{1,9} = 0.67$, $P = 0.43$); a seasonal variation was apparent (RM ANOVA $F_{1,9} = 67.27$, $P < 0.001$), with greater diversity for the R than the NR season (Fig. 1 III). Identical trends were found for bird species richness and diversity using rarefied and unrarefied data.

Guilds.—The rank of abundance considering both environments and seasons together was ground granivores > foliage insectivores = ground insectivores = omnivores = aerial insectivores = bark insectivores = carnivores = herbivores (Tukey HSD post hoc tests, $P < 0.05$). Total granivore abundance with and without the most abundant species (*C. maculosa*) was higher in the tree plantations than in the natural habitats for both seasons (RM ANOVA $F_{1,9} = 81.61$, $P < 0.001$, RM ANOVA $F_{1,9} = 14.67$, $P = 0.004$; respectively) (Fig. 2 I). In the natural habitats, the abundance of this guild was higher during the R than during the NR periods (Tukey Unequal N HSD, $P < 0.05$), while for the tree plantations no seasonal changes were apparent (Tukey Unequal N HSD, $P > 0.05$). During NR, we found 10 species of ground granivores form a guild in the tree plantations and 6 in the natural habitats, while during R, we found 10 species in the

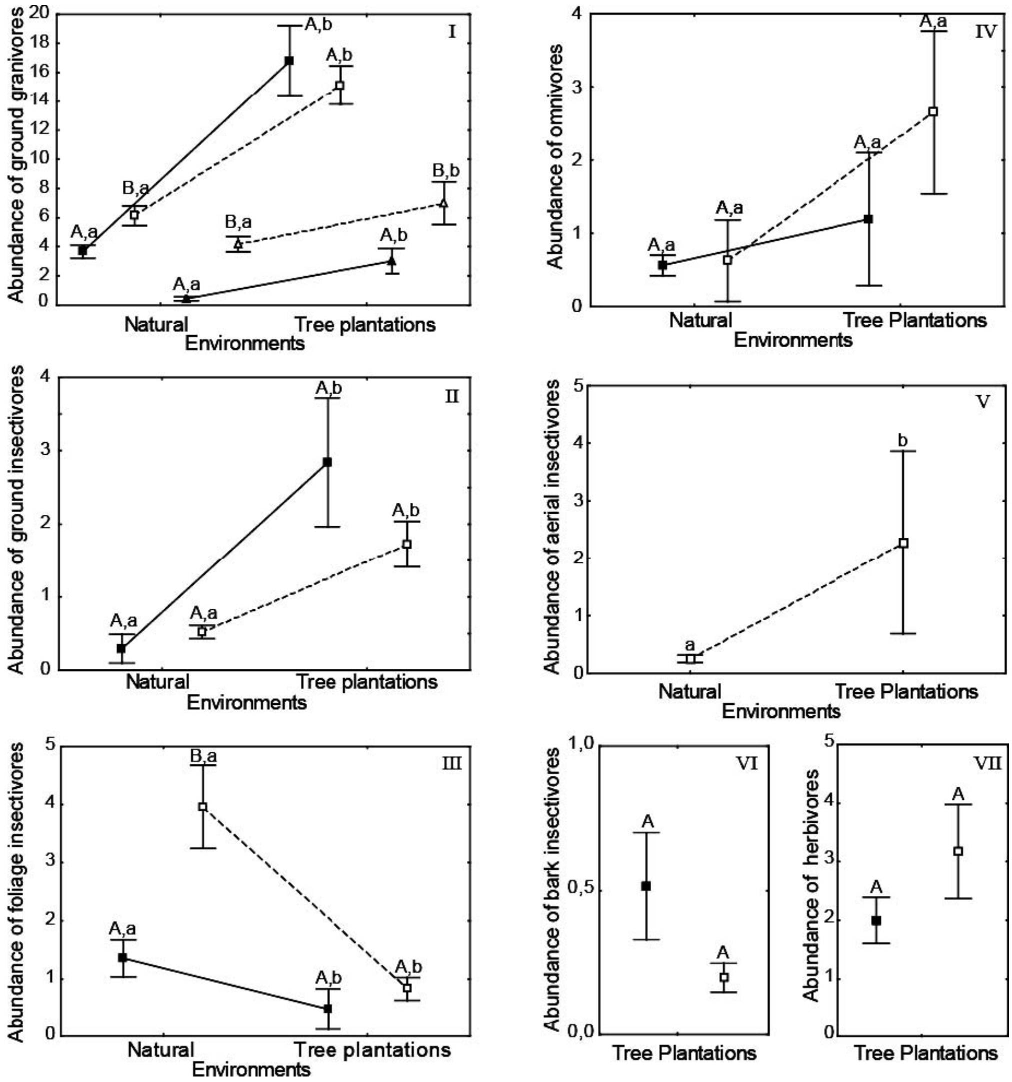

FIG 2. Variation in the average abundance of (I) ground granivores, (II) ground insectivores, (III) foliage insectivores, (IV) omnivores, (V) aerial insectivores, (VI) bark insectivores, and (VII) herbivores in natural habitats and small-scale tree plantations across the non-reproductive (thick line and filled squares) and reproductive seasons (dashed line and open squares). In graph (I) triangles represent average abundance of birds excluding the most abundant species (*Columba maculosa*). Bark insectivore and herbivore abundances in figures VI and VII respectively, are not displayed since these species were absent in 50% of the sampled natural habitat sites. Bars represent mean ± SE. In each season, different lowercase letters indicate significant differences between environments. In each environment, different capital letters indicate significant differences between seasons.

tree plantations and 12 in the natural habitats. Analyzing the temporal variation, 20% and 67% of the species of this guild persisted across seasons respectively, in the natural habitats and tree plantations.

Ground insectivores were denser in the tree plantations than in the natural habitats during both seasons (RM ANOVA $F_{1,9} = 12.85$, $P = 0.006$) (Fig. 2 II). The abundance of this guild did not show seasonal changes (RM ANOVA $F_{1,9} = 1.84$, $P = 0.21$). The same number of species (6) was observed in both environments during both seasons. Yet, 38% of the species in the natural habitats were detected in both seasons and 67% of the species persisted across seasons. The most representative and densest species of this guild was *Furnarius rufus*, which was observed almost exclusively in the tree plantations.

The abundance of the foliage insectivores was higher in the natural habitats than in the tree plantations during both seasons (RM ANOVA $F_{1,9} = 17.01$, $P = 0.003$) (Fig. 2 III). In natural habitat, abundance was higher during R than during NR (Tukey Unequal N HSD, $P < 0.05$), while in the tree plantations no seasonal differences were found (Tukey Unequal N HSD, $P > 0.05$) (Fig. 2 III). Richness of the foliage insectivores was higher in the natural habitats than in the tree plantations. In the natural habitats, we observed 10 species during NR and 13 during R, while for the tree plantations, five species were reported during both seasons (i.e., R and NR). Examining the guild composition during R and NR, we found that 35% of the species in the natural habitats and 43% of the species in the tree plantations stayed across seasons, while the rest of the species represented swaps and/or new inclusions.

The omnivore guild showed similar abundance between environments (RM ANOVA $F_{1,9} = 3.02$ $P = 0.12$) and seasons (RM ANOVA $F_{1,9} = 2.63$, $P = 0.14$) (Fig. 2 IV). The abundance of herbivores and bark insectivores in the tree plantations did not differ between seasons (Student's *t*-test for dependent samples, $P > 0.05$) (Fig. 2 VI and VII).

The aerial insectivores were only present during R and their abundance was higher in the tree plantations than in the natural habitats (Mann-Whitney *U*-test, $P < 0.05$) (Fig. 2 V). Seasonal variation in this guild was attributed to the fact that most species in this group are migratory. Four and five species respectively were reported for the natural habitats and the tree plantations. *Empidonomus aurantioatrocristatus* and *Tyrannus melancholicus* were only detected in the tree plantations, while *Myiarchus swainsoni* was observed exclusively in the natural habitats.

Body Mass.—The hierarchical agglomerative cluster analysis, using weighted mean body masses, showed that sampled sites were grouped into two clusters, one representing the tree plantations and the other representing the natural habitats (Fig. 3).

The weighted mean body mass of the bird species observed in the tree plantations was significantly higher than the weighed mean body mass of the species exploiting the natural habitats (RM ANOVA $F_{1,9} = 31.76$, $P < 0.001$) (Fig. 1 IV). Weighted mean body mass of bird species for the tree plantation was higher during NR than during R (Tukey Unequal N HSD, $P < 0.05$) (Fig. 1 IV). The interaction between environment and season was significant (RM ANOVA $F_{1,9} =$ 5,78, $P = 0.039$), meaning that the pattern was not consistent among sampled sites. On the other hand, if we do not include the most abundant species (*C. maculosa*), the weighted mean body mass was larger for the tree plantation species than for the natural habitat species (RM ANOVA $F_{1,9} = 17.03$, $P = 0.003$) and during R larger than during NR (RM ANOVA $F_{1,9} = 27.59$, $P =$ 0.001), with this pattern staying consistent between seasons (i.e., the interaction environment x season was not significant).

The number of species ranked by body mass was larger for the body mass range 0–25 g in the natural habitats than in the tree plantations during the R period ($P < 0.05$). Richness in the body mass range 50–100 g was higher in the tree plantations than in the natural habitats for both seasons ($P < 0.05$). The number of species in the rest of the body mass ranks (25–50 g, 100–200 g and 200–500 g) was similar between environments and seasons ($P > 0.05$). However, if the individual abundance by body mass rank is considered, the abundance in the range 0–25 g was significantly higher in the natural habitats than in the tree plantations during the R period ($P < 0.05$). The abundance of the heavier bird groups was higher in the tree plantations than in the natural habitats for both seasons ($P < 0.05$).

DISCUSSION

Spatial Variations.—This constitutes the first study that examines the differences in bird assemblage structure and composition between native natural habitats and small-scale tree plantations that serve recreational purposes in an arid ecosystem of the central zone of the sierras of San Luis. The replacement of native woodland by tree plantations may have a large influence on the richness and composition of a bird assemblage because of simplification of the structure and composition of vegetation (Zurita et al. 2006). Tree plantations have been reported to have reduced (Haro and Gutiérrez 1992, Gjerde and Saetersdal 1997, Zurita et al. 2006) or similar bird species richness (Collazo and Bonilla Martínez 1988, Vergara and Simonetti 2004, Lantschner

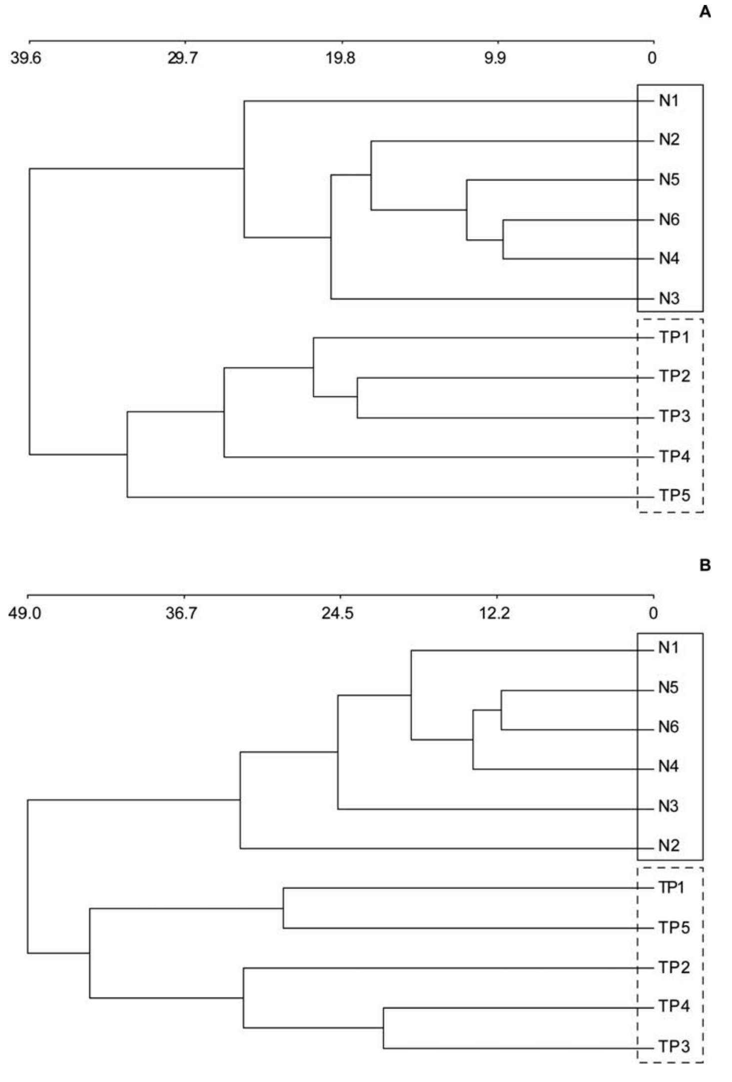

FIG. 3. Cluster analyses (complete linkage, squared Euclidean distance) on weighted average body mass of bird species from the Embalse La Florida (San Luis, Argentina). The clusters show the association of the sites during the non-reproductive (A) and the reproductive seasons (B). Solid-line boxes enclose natural habitats and dashed-line boxes enclose small-scale tree plantation.

and Rusch 2007, Lantschner et al. 2008) relative to comparable native environments. In this study, we failed to find differences in richness or diversity of birds between natural habitats and small-scale tree plantations. Analyses with rarefied parameters discarded a potential effect of the dissimilar bird abundance found in the contrasted habitats, further supporting our results. The absence of differences in bird richness between habitats may be because of the presence of native woods surrounding the small-scale tree plantations (Mazurek and Zielinski 2004, Yamaura et al. 2007, Lantschner et al. 2008). However, while the total number of species was similar between environments, the species composition was different; only around 50% of the species were found in both natural habitats and tree plantations. This finding suggests that the conversion of natural habitat to forest plantations produces a loss of specialist birds and an increase in the abundance of other species. In this sense, at the tree plantations most of the foliage insectivores were not registered (e.g., *Polioptila dumicola*, *Elaenia* sp., *Serpophaga munda*, *Stigmatura budytoides*, *Sublegatus modestus*, *Suiriri suiriri*) and other species of small body mass, but the structure of plantations facilitate the presence of generalist bird species that roost and nest in trees (e.g., *C. maculosa*, *Z. auriculata*, *Myiopsitta monachus*, *Pitangus sulphuratus*, *Agelaioides badius*). Particularly, the most abundant species (*Z. auriculata*) at the small-size tree plantation is also a very common species in urban areas and pine plantations of Argentina (Haro and Gutiérrez 1992, Leveau and Leveau 2004). Other studies in different regions of the world also documented that urbanization and/or forestry produce the dominance of a small group of generalist bird species (Beissinger and Osborne 1982, Boyle and Samson 1985, Blakesley and Reese 1988, Pomeroy and Dranzoa 1998, Chace and Walsh 2006, Piper and Catterall 2006, Villegas and Garitano-Zavala 2010).

The maneuverability constraints hypothesis states that bird body size is related to habitat structure and the stratum in which birds forage (Polo and Carrascal 1999). Bird species inhabiting a structurally more complex environment and foraging in the foliage or around thin tree branches may have smaller body masses as a consequence of ecomorphological constraints to maneuvering when foraging, in contrast to species that exploit open areas and forage on the ground (Miles and Ricklefs 1984, Polo and Carrascal 1999, De La Montaña et al. 2006). Our result shows that the weighted mean body mass was significantly higher for species found in the tree plantation than for species found in the natural habitats. Species with low body mass (0–25 g) and that forage in the foliage (e.g., foliage insectivores) were found in higher abundance in the natural habitats, perhaps because these habitats had a more complex structure, while species with higher body mass that live in open spaces and forage on the ground (e.g., ground granivores and ground insectivores) or in the air (aerial insectivores) were found in higher abundance in the tree plantation. These results support the hypothesis of maneuverability constraints (Polo and Carrascal 1999). Additionally, these results also are coincident with an urbanization effect observed across different environments, where increased urbanization leads to an increase in avian biomass, which is produced by an increase of granivores, aerial insectivores, and ground foraging insectivores (Emlen 1974, Chace and Walsh 2006).

Seasonal Variation.—Seasonal climate changes generate modifications in biological communities (Juárez 1995). Generally, seasonal climate changes, in addition to the structural complexity of the environment and the seasonality of the trophic resources, seasonally modify the composition and structure of the bird assemblages (Rotenberry et al. 1979, Capurro and Bucher 1986). In our study, the natural habitat exhibited a seasonal change in most of the bird assemblage parameters we examined. Seasonal variations have also been reported for the avifauna of natural habitats of the central Monte desert (Mendoza, Argentina) and the central region of the San Luis province (Marone 1992, Isacch et al. 2003, Lopez de Casenave et al. 2008). However, in spite of the markedly seasonal climate, the bird richness for tree plantations did not exhibit seasonal changes, suggesting that bird assemblage did not respond to the seasonal changes, or that resources were not altered, and/or that this apparent stability may be the result of dissimilar species-specific responses of its component species (Milesi et al. 2002).

Aerial insectivores were exclusively detected during the R period in both environments, since these species are migratory birds that nest in Argentina during spring and summer and then migrate to North America (Narosky and Yzurieta 2003). In addition, a large number of non-migratory species disappeared during winter, indicating that these species perform short geographic movements.

In conclusion, our results indicate that the structure and composition of the bird assemblage of the small-scale tree plantations and the natural habitat are significantly different in abundances, guild structures and mean body masses of the birds. Additionally, the results give support to the birds' maneuverability hypothesis, in which the vegetation structure may constrain or favor the presence of birds based on the size of them. In these sense, natural habitats include a high shrub density, which favors the presence of bird species of small body masses that feed in the foliage. However, the open vegetation structures of the tree plantation increase the presence of generalist bird species that forage on the ground and have a relatively large body mass.

Even though at present, the small-size tree plantations for recreational proposes represent a relatively small portion of the Embalse La Florida ecosystem and no special concerns about bird conservation issues were detected, the footprint of these plantations may grow quickly in the near future. Therefore, setting aside patches of native woods, shrubs, and grasses in new areas of tree plantations may be important in providing refuge and alimentary resources to species that may be affected by loss of natural habitats.

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