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BIRD COMMUNITIES OF THE SOUTHEASTERN CERRADO REGION, BRAZIL

Augusto Piratelli[1,3] & John G. Blake[2]

[1]Post-Doctoral Program, Department of Biology, University of Missouri–St. Louis, One University Boulevard, St. Louis, Missouri, 63121, USA.

[2]Department of Biology and International Center for Tropical Ecology, University of Missouri–St. Louis, One University Boulevard, St. Louis, Missouri, 63121, USA. *E-mail:* blakej@msx.umsl.edu

Resumo. – Comunidades de aves no sudeste da região do Cerrado, Brasil. – Nós estudamos comunidades de aves em Mato Grosso do Sul, Brasil central, de Julho de 1994 a Dezembro de 1996. As aves foram amostradas com redes de neblina em 14 locais de estudo, incluindo vegetação nativa (cerrado, cerradão, mata de galeria) e exótica (plantação de eucalipto). Foram efetuadas 1306 capturas, que amostraram 99 espécies, incluindo uma endêmica da região do Cerrado, *Antilophia galeata*. As famílias mais bem representadas foram Tyrannidae (24 espécies) e Emberizidae (18 espécies). A análise de agrupamento separou os locais amostrados em quatro grupos principais (cerrados e cerradões, cerrados senso restrito, eucaliptais e "florestas"). Os cerrados compartilharam mais espécies com os cerradões do que com a mata de galeria ou com as plantações de eucalipto. Das 41 espécies com seis ou mais capturas, apenas duas estiveram restritas a somente um habitat; 13 ocorreram em dois; 17 usaram três hábitats e nove foram encontradas nos quatro ambientes amostrados. Oito espécies foram mais capturadas na estação chuvosa e 34 espécies foram consideradas residentes. As guildas mais abundantes foram as dos insetívoros de folhagem e onívoros, e as espécies insetívoras prevaleceram nos quatro ambientes estudados, representando mais da metade das capturas. As aves do Cerrado necessitam de um mosaico de hábitatas, e oferecer condições para que se desloquem entre eles é crucial para a manutenção das populações de aves.

Abstract. – We investigated bird communities in Mato Grosso do Sul, central Brazil, from July 1994 to December 1996. We sampled birds with mist nets in 14 study sites, including native (cerrado, cerradão and gallery forest) and exotic (*Eucalyptus*) vegetation. Ninety-nine species from 21 families were represented in 1306 captures, including *Antilophia galeata*, endemic to cerrado region. Tyrannidae (24 species) and Emberizidae (18 species) were the most well-represented families. Cluster analyses arranged the study sites in four main groups (cerrados and cerradões, cerrados *sensu stricto*, *Eucalyptus* plantations, and "forest" habitats). Cerrados shared more species with cerradões than with gallery forests and *Eucalyptus* plantations. Of 41 species with six or more captures, only two were restricted to one habitat, 13 occurred in two habitats, 17 used three habitats, and 9 were found in all four habitats. Eight species were captured more often in the wet season. Thirty-four species were considered residents. Leaf-insectivores (20.2%) and omnivores (16.2%) were the most abundant guilds; insectivores dominated all four habitats and accounted for 53.5% of all captured species. Birds in Cerrado need a mosaic of habitats, and an opportunity to move among them is a crucial premise for maintaining bird populations. *Accepted 11 December 2005.*

Key words: Bird communities, Brazil, cerrado, cerradão, *Eucalyptus*, gallery forest, mist nets, Neotropical, savanna.

[3]*Current address:* Departamento de Biologia Animal, Instituto de Biologia, Universidade Federal Rural do Rio de Janeiro, Rodovia BR 465, Km 07, Seropédica, RJ, 23890-000, Brazil. *E-mail*: pirateli@ufrrj.br

INTRODUCTION

The Cerrado is the largest savanna of South America, occupying almost a quarter of Brazil's surface, mostly in the central part of the country (Eiten 1993, Myers *et al.* 2000). Landscapes in cerrado are dominated by mosaics of several habitats, including gallery forests, cerradões, tropical dry forests, wetlands and fields, and savannas. In a restricted sense, cerrado is characterized by a generally sparse layer of shrubs and short trees with thick and tortuous stems and wide leaves (Eiten 1993).

In earlier studies on birds in this region, a typical avifauna of this ecosystem was not clearly defined, because even the most characteristic species also occur in other, very different, open habitats (Sick 1965, 1966). Despite some recent efforts, birds from Brazilian Cerrado still are poorly known, but typical species for the different cerrado formations have been identified (Macedo 2002). Silva (1995a) recognized 837 bird species of 64 families as being from this ecosystem, with 759 (90.7%) known or assumed to breed there; 29 (3.8%) were considered endemics. Sick (1965), however, had previously argued that when the term "cerrado" is restricted to typical vegetation, the number of bird species associated with that vegetation would be less than 200.

Silva (1995c) estimated that about 70% of the Cerrado region has never been satisfactorily sampled for birds. He listed 85 localities in Cerrado that he considered to have been at least minimally well sampled (i.e., with more than 80 specimens of birds collected during the last two centuries); only six sites were from Mato Grosso do Sul, illustrating the need for more studies in that state. Recently, studies have focused on bird communities near Brasilia (D.C.) and have provided information on 1) species richness found per locality (Cavalcanti 1999), 2) responses of birds to the thinning of tree and shrub cover in plots of cerrado *sensu stricto* (Tubelis & Cavalcanti 2000), 3) community similarity in open areas of cerrado (Tubelis & Cavancanti 2001), and 4) effects of forest fragmentation on birds (Marini 2001). New tools also have appeared that have increased our knowledge of Cerrado birds. For example, Bates *et al.* (2003) used mitochondrial DNA sequences to compare populations of three non-passerines and seven passerines from both extremes of the Cerrado region. They found much less genetic differentiation within those species than in those found in neighboring Amazonian forest.

The current study was designed to help fill this "gap" in our knowledge of Cerrado birds. A better understanding of the distribution and abundance of birds in Cerrado habitats is particularly important when we consider how quickly this region has been dramatically disturbed and fragmented. To date, there have been few efforts at conservation in this ecosystem, and only 1.2% of its range is protected in conservation units (Myers *et al.* 2000, Klink & Machado 2005, Marini & Garcia 2005).

Thus, the main objective of this study is to evaluate ecological characteristics of bird communities in a Cerrado region in eastern Mato Grosso do Sul state, Central Brazil. More specifically, we address the following questions: first, how does bird community composition vary from one local habitat to another? Bird species have different responses to distinct environmental factors. Therefore, we expect strong associations between communities and specific habitats (Tubelis & Cavalcanti 2001). Both local and regional habitat characteristics influence species richness and community structure (Gillespie & Walter 2001, Pearman 2002) and in Cerrado, the mosaic of open and forest habitats is likely to influence bird species composition in different ways. Second, how do species richness and abundance vary among groups that differ, for example, in

migratory status and trophic structure (Blake 1983, Pearman 2002)? Third, are there predictable seasonal and/or annual fluctuations in bird composition? Many tropical bird species display seasonal migratory movements in response to changes in resource availability (Levey & Stiles 1992), habitat structure, weather conditions and community components (Malizia 2001). Such movement can have a strong impact on composition of local communities.

STUDY AREA AND METHODS

Field work was conducted in eastern Mato Grosso do Sul state, Brazil, outside the cities of Brasilândia (21°25'S, 52°03'W), Selvíria (20°36'S, 51°41'W), and Três Lagoas (20°75'S, 51°67'W), in an area with a mixture of native vegetation and non-native *Eucalyptus* plantations. Biogeographically, this region is located in the southeastern Cerrado region, at the peripheral depression of the Paraná river (Silva 1995a). The regional climate is characterized by distinct dry (May to September) and wet (October to April) seasons. Human influences include large areas of *Eucalyptus* plantations, pastureland for raising cattle, and dams for hydroelectric power plants.

We sampled four different vegetation types, with different levels of disturbance: cerrado *sensu stricto* (five study sites) "cerradão" (a tropical dry forest) (six study sites), gallery forest (one study site) and *Eucalyptus* plantations (with and without understory – two study sites). Natural patches were classified following Eiten (1993): 1) cerrado *sensu stricto*, a woodland (5–8 m tall) with close scrub and scattered trees; 2) cerradão, a dense forest type (8–15 m) that often has a completely closed canopy; and 3) gallery forests, humid forests (20–30 m) that border rivers and streams (see Piratelli 2003 for details).

Birds were sampled with mist nets at these 14 study sites from August 1994 to December 1996. From 10 to 16 mist-nets (36- and 61-mm mesh; 12 x 2 m) were alternately spaced along linear transects at each site, and nets typically were operated from 05:30 to 15:00. Captured birds were marked with numbered metallic bands. Although mist nets have some limitations (e.g., Poulsen 1994, Remsen & Good 1996, their use has provided satisfactory results in many studies (e.g., Bierregaard & Stouffer 1997, Blake & Loiselle 2001, Wang & Finch 2002). Bird nomenclature followed Sick (1997).

Shannon-Wiener diversity index (H') was calculated to estimate alpha diversity; a jackknife technique was used to reduce bias. Beta-diversity was obtained for a non-specific gradient (McCune & Grace 2002) as proposed by Whittaker (1972): ß w = (Sc/S) -1, where Sc is total number of species in the whole data set and S is the average species richness in the sample units. Calculations on the number of species (S) and individuals (N), species richness (D; Margalef: d = [S-1]/log S), Pielou's evenness (J´; J´ = H´/log [S]) and Shannon diversity index (H´; H´ = ∑ [Pixlogn Pi]) were calculated using the package Primer 5 for Windows (Clarke & Gorley 2001). All birds and species recorded in a given site or habitat were summed to calculate these values.

We used a Friedman's two-way nonparametric analysis of variance to examine differences in captures rates (number of captures per 100 mist-net h) among habitats (cerrado, cerradão, gallery forest and *Eucalyptus* plantations) across years and seasons. This analysis was run using Statistix 8 (Analytical Software 2003).

We evaluated similarity among sites with cluster analysis, using Bray-Curtis distance and ß-flexible linkage (ß = 0.25) methods. Bray-Curtis is considered a better distance metric when measuring such a heterogeneous gradient as studied here (MacCune & Grace 2002). For this analysis, the numbers of birds

TABLE 1. Number of species (S) and individuals (N), species richness (D), Pielou's evenness (J´) and Shannon diversity index (H´), for the 14 sample sites in eastern Mato Grosso do Sul state, Brazil. CE1 CE2, CE3, CE4 and CE5 = cerrado *sensu stricto*; CO1, CO2, CO3, CO4, CO5 and CO6 = cerradão; GAL = gallery forest; EC1 and EC2 = *Eucalyptus* plantations.

	S	N	D	J'	H' (Log e)	Sample effort (net-h)
Per sample sites						
CE1	56	178	10.614	0.902	3.63	1720
CE2	12	29	3.267	0.936	2.325	350
CE3	7	10	2.606	0.943	1.834	260
CE4	21	57	4.947		2.808	800
CE5	24	85	5.177	0.829	2.634	620
CO1	19	45	4.729	0.923	2.719	1743
CO2	29	130	5.752	0.841	2.831	1339
CO3	17	54	4.011	0.908	2.572	813
CO4	33	141	6.466	0.846	2.958	788
CO5	20	39	5.186	0.903	2.704	619
CO6	17	37	4.431	0.883	2.503	708
GAL	48	187	8.985	0.852	3.299	2370
EC1	15	35	3.938	0.913	2.473	770
EC2	6	15	1.846	0.957	1.714	630
Per habitats						
Cerrado	67	319	11.448	0.859	3.612	3750
Cerradão	66	486	10.507	0.824	3.451	6010
Gallery	48	187	8.985	0.852	3.299	2370
Eucalyptus	19	50	4.601	0.917	2.701	1400

of each species was considered. The species most closely associated with a specific habitat were determined for each habitat using an "indicator-species analysis" with a Monte Carlo test of significance ($P = 0.05$). Species with 30% or more of perfect indication and significant value of P were considered indicators of a given habitat. Cluster and indicator analyses were performed using PCORD 4.01 (McCune & Mefford 1997). We classified species as dependent, semi-dependent or independent of forest habitats when they were sampled only in forests, in forest and in open areas, and only in open areas, respectively. We considered cerradões and gallery forest as forest vegetation. For species with less than five captures, we followed forest-dependence patterns proposed by Silva (1995a).

We defined trophic guilds according to the principal vegetation stratum where a species feeds, the kind of food and the principal foraging mode and substratum of the species (Willis 1979, Sick 1997, Pearman 2002). Birds were also categorized as residents, wet or dry-season species according to their presence/absence during the year. Chi-square tests were used to examine differences in captures for each species between wet and dry seasons.

RESULTS

We captured 1306 birds, including 264 recaptures (20.2%) in 13,468 net-h; captures represented 99 species and 21 families. These 99 species accounted for 11.8% off all species recorded in the Cerrado region by Silva (1995a) and included one species, *Poecilurus scutatus*, not reported by Silva (1995a). Only

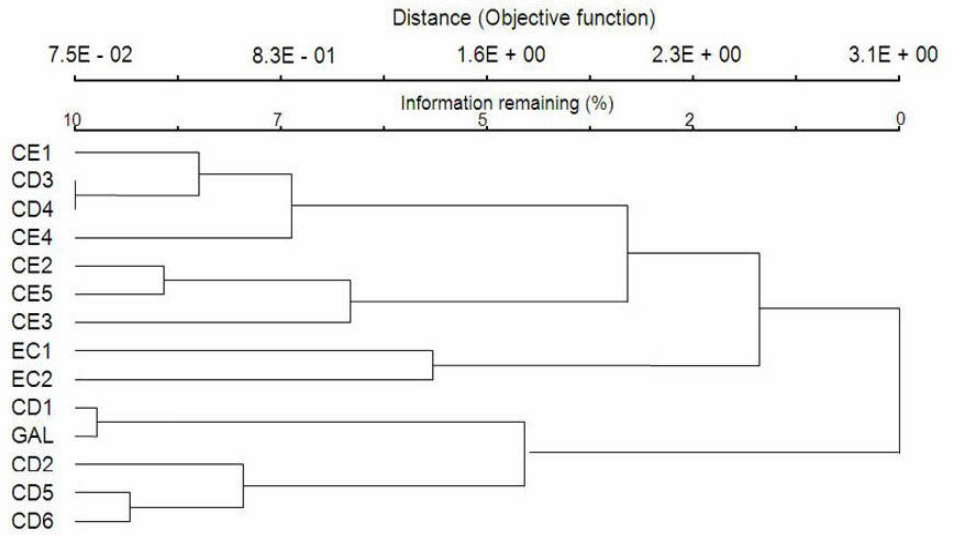

FIG. 1. Cluster analysis based on species abundance and richness for 14 sample sites in eastern Mato Grosso do Sul state, Brazil, using Bray-Curtis distance and flexible-ß as linkage method (ß = -0.250). CD = cerrados, CE = cerradões, GAL = gallery forest, and EC = *Eucalyptus* plantations.

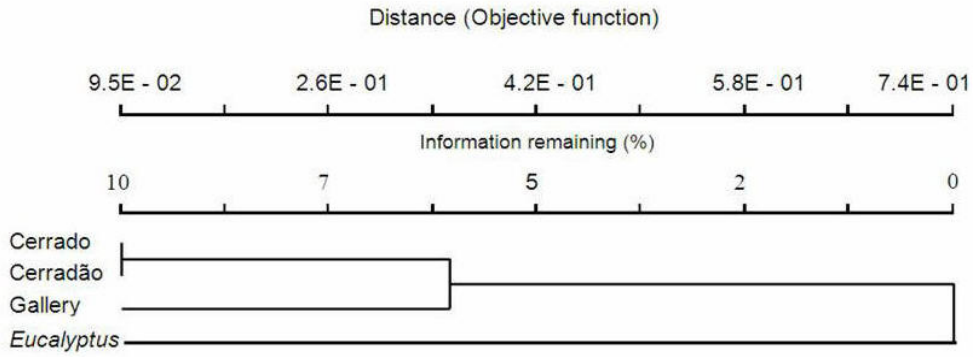

FIG. 2. Cluster analysis based on species abundance and richness for four sample habitats in eastern Mato Grosso do Sul state, Brazil, using Bray-Curtis distance and flexible-ß as linkage method (ß = -0.250).

one species (*Antilophia galeata*) is considered endemic to Cerrado. Most frequently captured species included *Basileuterus flaveolus* (n = 85; 8.2%), *Cnemotriccus fuscatus* (n = 71; 6.8%) and *Saltator similis* (n = 67; 6.4%). Tyrannidae (24 species; 23.5%) and Emberizidae (18 species; 17.5%) were the most species-rich families. First-order and second-order jackknife estimates of species richness were 134.4 and 151.8, respectively. Total ß-diversity was 18.46 and evenness was 0.97. The highest alpha diversity index was observed in cerrados, followed by cerradões, gallery forest, and *Eucalyptus* (Table 1).

Study sites formed 4 main clusters (Figs 1 and 2): 1) cerrados and cerradões, a set of landscapes with more canopy cover and/or dense understory, 2) cerrados *sensu stricto*, 3) *Eucalyptus* plantations, and 4) forest habitats, including gallery forest and cerradões. In this last cluster, there is a subgroup including gallery forest and one cerradão. The cerradões in the fourth cluster differed from those in the first by having more canopy cover and less disturbance. There was a significant difference in capture rates among habitats (Friedman Statistic = 8.6; $P < 0.05$; d.f. = 3), but not differ across seasons (Friedman Statistic = 4.2; $P < 0.24$; d.f. = 3).

Most species (82 of 99) were dependent (29 species) or semi-dependent (53) on forest habitats; 17 species were considered independent of such habitats. Seven species used mostly dry forests, and two (*Momotus momota* and *Pipra fasciicauda*) mainly used gallery forest. Six forest species also were found in savannas: *Momotus momota, Nonnula rubecula, Dendrocolaptes platyrostris, Pipra fasciicauda, Cyclarhis gujanensis* and *Eucometis penicilata. Platyrhinchus mystaceus* and *Elaenia mesoleuca* were considered specialized in cerradão and cerrado, respectively.

Species selected as indicators of specific habitats were *Thamnophilus punctatus* (31%), *Cnemotriccus fuscatus* (29%) and *Casiornis rufa* (35%) for cerrado; *Basileuterus hypoleucus* (68%), *Tachyphonus coronatus* (34%) and *Saltator similis* (54%) for cerradão; *Momotus momota* (63%), *Leptopogon amaurocephalus* (31%) and *Pipra fasciicauda* (44%) for gallery forest, and *Coryphospingus cucullatus* (31%) for *Eucalyptus.*

Of 41 species with six or more captures, 2 (4.2%) were found only in one habitat (*P. mystaceus* in cerradão and *Elaenia mesoleuca* in cerrado), 13 (27.6%) were captured in two habitats, 17 (36.2%) used three habitats, and 9 species (19.4%) were found in all four habitats (see Table 2). Eight species (19%) were captured more in the wet season: *Columbina talpacoti, Claravis pretiosa, Camptostoma obsoletum*, *Poecilurus scutatus, Coryphospingus cucullatus, Vireo chivi, Piaya cayana,* and *Myiodynastes maculatus.* Thirty-four species (81%) were resident in the study area for the entire year (e.g., *Momotus momota*, *Tachyphonus rufus*). *Thamonophilus punctatus* was captured more in cerradão than in cerrado in the dry season and in cerrado in the wet season (Table 2). No species were captured only or mostly in the dry season.

Insectivores accounted for 53.5% of all captured species (n = 54) and for the greatest number of species and individuals in each habitat. Leaf-insectivores (n = 20; 20.2%) and omnivores (n = 16; 16.2%) were the most species-rich guilds (Table 3).

DISCUSSION

Results of this study agree in many respects with previous studies and provide further evidence of the importance of cerrado as habitat for birds. Silva (1995a) ranked Tyrannidae (14.9%) and Emberizidae (12.0%) as the most species-rich families for the Cerrado region, and that was true in our study as well. These two families did, however, represent a higher proportion of the total in our study (23.5% for Tyrannidae and 17.5% for Emberizidae). This difference may partially be because mist nets likely underestimated the occurrence of some large non-passeriformes, thereby leading to a higher relative importance of these two families. Similarly, we found that cerradão and cerrado were the most similar habitats (see Fig. 1), as previously stressed by Silva (1995a) as well.

Species richness, abundance and diversity of birds typically are thought to increase in areas with more shrubs and trees (Tubelis & Cavalcanti 2000, 2001), presumably as a consequence of the increased complexity of the vegetation (MacArthur & MacArthur 1961; see also Fry 1970). In this study, however,

TABLE 2. Species captured (more than five captures) in wet and dry season in eastern Mato Grosso do Sul, Brazil (recaptures included), trophic guilds and percentage of perfect indication. CE = cerrado, CD = cerradão, GAL = gallery forest and EUC = *Eucalyptus*. Wet = wet-season migrants, Res = residents. Forest dependency: D = dependent, I = independent, Sd = semi-dependent. Chi-square test for comparing capture number between wet and dry season and Monte Carlo test of significance of observed maximum indicator value for species (* = significance for $P < 0.05$).

	Season	CE	CD	GAL	EUC	Total	χ^2	Status	Forest dep	Perfect indication (%)
Claravis pretiosa	Dry	0	0	2	0	2	0.002*	Wet	Sd	-
	Wet	3	9	1	2	15				
Columbina talpacoti	Dry	1	0	0	0	1	0.001*	Wet	Sd	-
	Wet	9	3	1	0	13				
Leptotila rufaxilla	Dry	1	4	2	1	8	0.491	Res	Sd	-
	Wet	1	2	6	2	11				
Leptotila verreauxi	Dry	1	3	2	0	6	0.225	Res	Sd	-
	Wet	2	0	5	4	11				
Piaya cayana	Dry	0	0	0	0	0	0.008	Wet	Sd	-
	Wet	1	5	0	1	7				
Amazilia fimbriata	Dry	1	1	0	0	2	0.096	Res	Sd	-
	Wet	5	1	1	0	7				
Momotus momota	Dry	1	10	22	0	33	0.352	Res	D	63* GAL
	Wet	2	14	25	0	41				
Nystalus maculatus	Dry	4	2	0	0	6	0.157	Res	Sd	-
	Wet	2	0	0	0	2				
Nonnula rubecula	Dry	1	5	2	0	8	0.405	Res	D	-
	Wet	0	0	5	0	5				
Taraba major	Dry	0	0	3	0	3	0.083	Res	D	-
	Wet	1	3	5	0	9				
Thamnophilus doliatus	Dry	3	0	1	0	4	0.109	Res	Sd	31* CE
	Wet	2	4	4	0	10				
Thamnophilus punctatus	Dry	23	12	2	4	41	0.745	Res	Sd	-
	Wet	13	26	1	4	44				
Dysithamnus mentalis	Dry	0	5	4	0	9	0.394	Res	Sd	-
	Wet	0	10	3	0	13				
Poecilurus scutatus	Dry	0	3	0	0	3	0.033*	Wet	Sd	-
	Wet	2	8	1	0	11				
Automolus leucophthalmus	Dry	0	1	5	0	6	0.527	Res	D	-
	Wet	0	0	4	0	4				
Sittasomus griseicapillus	Dry	2	5	4	0	11	0.549	Res	Sd	-
	Wet	4	9	1	0	14				
Dendrocolaptes platyrostris	Dry	0	0	5	0	5	0.134	Res	D	-
	Wet	1	5	5	0	11				
Lepidocolaptes angustirostris	Dry	3	1	0	0	4	0.248	Res	Sd	-
	Wet	1	7	0	0	8				
Campylorhamphus trochilirostris	Dry	0	0	6	0	6	0.157	Res	D	-
	Wet	0	0	2	0	2				

TABLE 2. Continued.

	Season	CE	CD	GAL	EUC	Total	χ^2	Status	Forest dep	Perfect indication (%)
Camptostoma obsoletum	Dry	0	1	0	0	1	0.007*	Wet	Sd	-
	Wet	7	2	0	1	10				
Elaenia mesoleuca	Dry	3	0	0	0	3	0.206	Res	I	-
	Wet	7	0	0	0	7				
Leptopogon amaurocephalus	Dry	0	2	8	0	10	0.197	Res	D	31* CD
	Wet	0	1	4	0	5				
Corythopis delalandi	Dry	0	4	0	0	4	1	Res	D	-
	Wet	0	4	0	0	4				
Hemitriccus margaritaceiventer	Dry	3	2	0	0	5	0.197	Res	Sd	-
	Wet	8	2	0	0	10				
Platyrinchus mystaceus	Dry	0	5	0	0	5	0.564	Res	D	-
	Wet	1	6	0	0	7				
Pipra fasciicauda	Dry	0	17	15	0	32	0.547	Res	D	44* CD
	Wet	2	15	20	0	37				
Cnemotriccus fuscatus	Dry	16	15	3	0	34	0.122	Res	Sd	-
	Wet	19	26	3	0	48				
Casiornis rufa	Dry	9	5	0	1	15	0.194	Res	Sd	35* CE
	Wet	16	6	1	0	23			Sd	-
Myiarchus tyrannulus	Dry	7	1	2	1	11	0.04*	Wet	D	-
	Wet	11	8	1	3	23				
Myiodynastes maculatus	Dry	0	0	0	0	0	0.003*	Wet	I	-
	Wet	4	4	1	0	9				
Cyanocorax chrysops	Dry	1	1	1	2	5	0.763	Res	D	-
	Wet	1	1	0	4	6				
Turdus amaurochalinus	Dry	14	13	0	3	30	0.157	Res	D	-
	Wet	8	8	3	1	20				
Turdus leucomelas	Dry	4	16	13	2	35	0.264	Res	Sd	-
	Wet	12	21	10	2	45				
Cyclarhis gujanensis	Dry	1	8	0	0	9	0.819	Res	Sd	-
	Wet	5	5	0	0	10				
Vireo chivi	Dry	2	1	0	0	3	0.052*	Wet	Sd	-
	Wet	4	6	0	0	10				
Basileuterus flaveolus	Dry	11	47	1	0	59	0.014	Res	D	68* CD
	Wet	26	62	1	0	89				
Basileuterus hypoleucus	Dry	0	2	1	0	3	1	Res	Sd	-
	Wet	0	3	0	0	3				
Eucometis penicillata	Dry	1	5	2	0	8	1	Res	Sd	-
	Wet	0	3	5	0	8				
Tachyphonus rufus	Dry	4	10	0	0	14	0.853	Res	D	34* CD
	Wet	5	10	0	0	15				
Arremon flavirostris	Dry	3	0	0	0	3	0.317	Res	Sd	-
	Wet	4	1	1	0	6				
Coryphospingus cucullatus	Dry	0	0	0	1	1	0.002*	Wet	I	31* EUC
	Wet	4	0	0	8	12				
Saltator similis	Dry	6	27	0	1	34	0.149	Res	Sd	54* CD
	Wet	12	34	0	1	47				

TABLE 3. Number of individuals and species of bird communities in trophic guilds in the four study habitats in eastern Mato Grosso do Sul state, Brazil.

Guilds		Cerrado	Cerradões	Gallery	*Eucalyptus*
Aerial insectivores	Individuals	31	14	11	0
	Species	7	5	4	0
Generalists Insectivores	Individuals	116	178	13	6
	Species	9	9	5	3
Ground insectivores	Individuals	11	11	3	0
	Species	2	2	1	0
Leaf insectivores	Individuals	65	119	51	9
	Species	14	15	9	3
Trunk insectivores	Individuals	14	33	26	1
	Species	5	8	7	1
Carnivores	Individuals	1	0	3	0
	Species	1	1	1	0
Frugivores	Individuals	4	36	35	0
	Species	2	4	3	0
Granivores	Individuals	30	25	21	20
	Species	9	9	6	6
Nectarivores	Individuals	11	4	6	1
	Species	5	3	5	1
Omnivores	Individuals	87	172	78	19
	Species	14	11	7	6

species richness and diversity were highest in cerrados *sensu stricto*. Higher species richness in cerrados than in gallery forests and cerradões, as found in this study, might have three major causes: 1) mist nets may have underestimated the number of species from midlevel and canopy, 2) some of our forested habitats had suffered severe disturbance, and 3) sites dominated by savanna vegetation may have sufficient shrubs and trees to protect and attract birds. The first two potential factors may be the most likely. Although we do not have data on vegetation structure, we do know that some of the cerradões sites were very disturbed (DCRDAO, DCRDAO2, DCRDAO3 and CRDAO3). These sites, based on cluster analyses, were similar to some cerrados (open habitats) and even *Eucalyptus* sites (see Fig. 1).

Forested habitats occupy less than 20% of Cerrado (Silva & Bates 2002) but are used by a majority of species, at least to some degree (see Radford & Fonseca 1996 for mammals, and Silva 1995b for birds). Forested habitats are thus very important for birds in Cerrado, particularly because forest birds usually have very restricted ranges in this region. According to Silva & Bates (2002), 83% of Cerrado birds require forests to some extent, meaning that gallery forests are responsible for maintaining an important proportion of regional biodiversity. Gallery forests have been considered as natural habitat features that historically favored wildlife dispersal through Cerrado (e.g., Redford & Fonseca 1986), introducing Amazonian (202 species) and Atlantic (79 species) bird taxa into the Cerrado region (Silva 1996). This importance is particularly impressive given that such forests occupy a relatively small portion of the landscape (Eiten 1993).

In peripheral depressions in Cerrado

region, dry forests and cerradões occupy larger areas than gallery forests and offer more opportunities for survival of forest-dependent or semi-dependent organisms. In the depression of Paraná River, dry forests are thought to support more species than gallery forests and cerrado, and almost all species found in gallery forests can also be found in dry forests (Silva 1995a), although these last two can have significant differences in species composition (Silva 1995c). Nonetheless, gallery forests play an important role in maintenance of regional biodiversity. These forests, because of their higher humidity, offer food resources year-round (fruits, insects), and can provide refuges for particular bird fauna, including large frugivores such as *Crax fasciolata* and *Pteroglossus castanotis* (A. Piratelli pers. observ.).

The disappearance of gallery forests in Paraná river basin is a reality, primarily because of the creation of dams for hydroelectric power plants, which have flooded large areas of those forests. This phenomenon likely has had a negative impact on the regional avifauna, and could lead to significant reductions of populations of some typical forest species, such as *Momotus momota*, *Leptogopon amaurocephalus*, and *Pipra fasciicauda.* The last huge hydroelectric power plant in this region (Porto Primavera) flooded over 2000 km^2 after 1999 (Travasssos 2001) but the environmental impacts are still barely known.

Most of species captured in this study occurred both in open and forested areas, while 30.3% were typical forest species. In general, 52% of bird species that reproduce in Cerrado region are strongly dependent on forests and 551 species (approximately 70%) depend on these habitats, at least partially (Silva 1995a). Habitat specialization in cerrado habitats is considered extremely uncommon (Stotz *et al.* 1996); forest species also need savanna habitats to live, and they can move up to 300 m from forests (Tubelis *et al.* 2004). Similarly, there are seasonal movements between gallery forests and cerrado *sensu stricto* (Cavalcanti 1999 and this study), sometimes as mixed-species flocks (Tubelis 2004). For effective conservation, Tubelis *et al.* (2004) have suggested that at least a 60 m-wide band of savanna should always be maintained close to gallery forests to provide enough habitat supplementation for most bird species. This distance is only a guide, as the distance to which forest birds move into savannas to forage varies with the density of vegetation. We also emphasize that even typical forest species (e.g., *M. momota, L. amaurocephalus* and *P. fasciicauda*) are able to move into open areas such as cerrados (see Table 2). Even *Trichothraupis melanops*, which Bagno & Marinho (2001) considered restricted to forests, was found well into cerrado.

Insectivores were the most common guild throughout the year; fruits were more important as a food resource, in the rainy season (Piratelli & Pereira 2002), when they are likely to be more available. The strongly seasonal rainfall regime and the mosaic distribution of habitats apparently lead some birds from cerrado to move among habitats to obtain seasonally available resources (Tubelis & Cavalcanti 2001, Tubelis 2004, Tubelis *et al.* 2004). In our study, this typically was the case of *Thamnophilus punctatus,* a leaf-insectivore that was captured alternatively and seasonally between cerradão and cerrado.

In this study, only 6 and 14 species were captured in *Eucalyptus* plantations without and with understory, respectively. Only *Coryphospingus cuculatus*, a generalist species that feeds even in agricultural areas, was common in *Eucalyptus* plantations, reflecting its capacity to exploit human-made habitats. Previous studies have shown that *Eucalyptus* plantations are very poor habitats for birds (Motta-Júnior 1990, Machado & Lamas 1996, Marsden *et al.* 2001). Marsden *et al.* (2001) found only eight species in *Eucalyptus* plantations in Espirito

Santo state, including *C. obsoletum*, which we also captured.

Therefore, even though *Eucalyptus* plantations are forest habitats, they were not of sufficient quality to attract and sustain complex bird communities. Plantations with well developed understory likely are better habitat but still inferior to native forest. This and previous studies have shown that birds in Cerrado need a mosaic of habitats, and that opportunities to move among them is a crucial premise for maintaining bird populations. Conversion of large areas of Cerrado into plantations causes loss of native habitats and connectivity among them and, of course, losses of biodiversity.

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