

Bird communities in two fragments of Cerrado in Itirapina, Brazil

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(With 4 figures)

Abstract

The Cerrado domain is a mosaic of vegetation types at the local scale, and this environmental heterogeneity leads to high regional bird diversity. Therefore, we aimed to survey quantitative and qualitatively the bird fauna of two fragments of Cerrado and to compare them with an adjacent protected area (Estação Ecológica de Itirapina), in order to assess the heterogeneity of bird diversity in the region. The present study was conducted during 12 months from October 2006 to September 2007 in the municipality of Itirapina, Southeastern Brazil. Altogether we recorded 210 bird species. Fifty-six of them had never been detected in Estação Ecológica de Itirapina, and eleven species are new records for the whole Itirapina region. The list also includes six species that are endangered in São Paulo State and five endemic species of the Cerrado domain. Most species were recorded in less than 50% of the visits and exhibited low relative abundance. Primarily insectivorous species were the most common, followed by omnivores. Frugivorous birds were poorly represented. Carnivores were more abundant than usually observed in fragments. The similarity among fragments was higher than between fragments and the protected area. Considering the vegetation heterogeneity in the Cerrado domain, our results reinforce the importance of conserving fragments in order to sample this diversity.

Keywords: avifauna, forest fragmentation, environmental heterogeneity.

Comunidades de aves em dois fragmentos de Cerrado em Itirapina, Brasil

Resumo

O mosaico de tipos vegetacionais que formam o Cerrado contribui para a alta diversidade de aves deste domínio. O presente trabalho teve como objetivo principal realizar os levantamentos qualitativo e quantitativo da avifauna de dois fragmentos de Cerrado e compará-los aos resultados encontrados em uma área adjacente de Cerrado (Estação Ecológica de Itirapina). O trabalho foi realizado entre outubro de 2006 e setembro de 2007, no município de Itirapina, região central do Estado de São Paulo, Brasil. Registramos um total de 210 espécies de aves. Destas, 56 ainda não haviam sido registradas na Estação Ecológica e onze espécies são novos registros para a região de Itirapina. A lista dos fragmentos inclui seis espécies ameaçadas no Estado de São Paulo e cinco espécies endêmicas de Cerrado. A maioria das espécies foi detectada em menos de 50% das visitas e apresentou baixa abundância relativa. A classificação em categorias tróficas indicou a prevalência de espécies predominantemente insetívoras, seguidas pelas onívoras. Os frugívoros foram pouco representados e a quantidade de carnívoros foi superior à geralmente encontrada em fragmentos. A similaridade encontrada entre os fragmentos foi maior que a encontrada entre os fragmentos e Estação Ecológica. Os resultados reforçam a importância da conservação dos fragmentos de Cerrado, uma vez que a heterogeneidade de tipos vegetacionais é importante para a conservação da biodiversidade local.

Palavras-chave: avifauna, fragmentação florestal, heterogeneidade ambiental.

1. Introduction

Detecting environmental quality and monitoring biodiversity is important for the conservation of natural areas. In that sense, bird inventories are commonly used for this purpose (Vielliard, 2000; Marini, 2001; Antunes, 2005; Piratelli et al., 2008). Conservation strategies of natural areas require knowledge on the distribution and abundance of species, and studies on bird communities can provide suitable data (Naeve et al., 1996).

Studies on Cerrado demonstrate high biodiversity (Klink and Machado, 2005). The domain is formed of a mosaic of different vegetation forms that varies from grasslands ('campo limpo') to forests ('cerradão'), including gallery forests (Coutinho, 2006). This environmental heterogeneity is important to keep high levels of species richness and endemic species (Machado et al., 2004). However, the Cerrado is one of the world's threatened biodiversity

hotspots (Myers et al., 2000). About 60% of its vegetation has already been removed (Machado et al., 2004) and the remaining areas are isolated in forest fragments (Durigan et al., 2007).

Nowadays, Sao Paulo State has only 7% of its original Cerrado vegetation (Durigan et al., 2007), and only 18% is inside protected areas (São Paulo, 1999). The Estação Ecológica de Itirapina (EEI) is one of these areas and has been studied by ornithologists since the 80's (Willis, 2004). It has already 231 bird species registered (Willis, 2004; Motta-Junior et al., 2008), including endemic and threatened ones (Silva and Bates, 2002; IBAMA, 2008; IUCN, 2008; São Paulo, 2008). That makes the area important for bird biodiversity conservation (Bencke et al., 2006). Close to the EEI there is another protected area, the Estação Experimental de Itirapina, which has two fragments of Cerrado poorly studied in terms of its avifauna (Willis and Oniki, 2003).

While grasslands are predominant in EEI (Motta-Junior et al., 2008; Granzinoli, 2009) more forested areas prevail in these two fragments. Therefore, this paper aimed to accomplish qualitative and quantitative bird surveys of the two fragments, as well as to compare the results with those from EEI. Such outcomes could be used in future wildlife monitoring and to better understand the influence of fragmentation on bird communities (Palmer et al., 2008). This study also proposes some local management strategies for biodiversity conservation.

2. Material and Methods

2.1. Study area

We have studied two fragments: A (22° 13' S and 47° 48' W) and B (22° 14' S and 47° 49' W), inside the Estação Experimental de Itirapina. This area is basically used for the extraction of *Eucalyptus* spp. (Myrtaceae) and resin from *Pinus* spp. (Pinaceae). Fragment A, of 150 ha, is composed predominantly of 'cerrado sensu stricto', 'cerradão' (a tall woodland) and gallery forest (Delgado et al., 2004). Fragment B, of 350 ha, is more heterogeneous, concerning the vegetation. It is a more forested fragment than A, being composed of 'cerradão', 'cerrado sensu stricto', gallery forests (Delgado et al., 2004), *Eucalyptus* spp. with native understory and regeneration areas with native and exotic species (pers. obs.). Fragments A and B are about 1.5 km and 2 km, respectively, distant from EEI, that is of 2,300 ha. Both fragments are surrounded by pine and eucalyptus plantations and are 750 m apart from each other.

Itirapina region has a Cwa climate according to the Köppen system (Zanchetta, 2006), with annual rainfall average of 1,459 mm. The rainy season is usually from October to March and the dry period occurs from April to September. The average annual temperature is 21.9 °C. The hottest months are January and February and the coolest, June and July. The altitude of the region is about 740 m (Zanchetta, 2006).

2.2. Methods

Qualitative and quantitative methods were performed. The qualitative survey was done to generate the fullest species list possible that occur in the area (Vielliard and Silva, 1990) and was conducted during 12 months (October 2006 to September 2007). For this purpose we walked on pre-existent tracks during mornings (6:00 to 11:00 AM), evenings (3:00 to 6:00 PM) and nights (6:00 to 9:00 PM) recording all bird species, through auditory and/or visual contacts, without standardising the vegetation types. Sampling effort during the qualitative survey in fragment B (61 visits) was higher than in fragment A (30 visits) because of its size and vegetation heterogeneity. Rarefaction curves were plotted using the statistical package EstimateS 8.0 (Colwell, 2006). The same program was used to estimate fragment richness using the first-order Jackknife richness estimator (Heltsh and Forrester, 1983). Species composition in the fragments, compared with that from EEI, was analysed using Jaccard's similarity index (Krebs, 1999). Bird lists from EEI were extracted from data review by Motta-Junior et al. (2008). Species frequency of occurrence (FO) was calculated from Vielliard and Silva (1990) and the analysis of trophic structure was done using species groups based on Motta-Junior (1990) and Sick (1997).

The quantitative survey was also carried out over 12 months (October 2006 to September 2007) using the point counts method, developed by Blondel et al. (1970) and adapted by Vielliard and Silva (1990) for Neotropical studies. For this purpose, 18 sampling points were chosen in each fragment in pre-existing tracks, each containing four or five points, with the minimum distance of 200 m from each other (Vielliard and Silva, 1990). In each of these sampling places all auditory and/or visual contacts with individuals within a 100 m range were recorded over 20 minutes. Points were visited during morning (6:00 to 11:00 PM), starting minutes before sunrise. On each day, eight to ten random points were visited in each fragment, totalising 216 samples in each area (18 points visited for 12 months).

Through quantitative surveys the Punctual Index of Abundance (PIA) was calculated (Vielliard and Silva, 1990; Aleixo and Vielliard, 1995). The Shannon diversity index (H') and Pielou's evenness (J') (Krebs, 1999) were calculated using PAST statistical package (Hammer et al., 2001). We used Bootstrap ($p < 0.05$) to reduce bias (Hammer et al., 2001). Scientific nomenclature adopted here follows the Brazilian Committee of Ornithological Records (CBRO, 2008).

3. Results

During the qualitative survey, 210 species of birds distributed in 51 families, were recorded (see Table 1). In 91 days of field visits (476 hours of observation) 158 species in the fragment A and 201 in B were recorded (see Table 1). First-order Jackknife estimated a richness of 186 ± 7.22 species to fragment A and 223.61 ± 5.3 species

to fragment B. Rarefaction curves from both fragments indicate a similar pattern (see Figures 1 and 2). The similarity among species composition of fragments was 70.95%, while the similarity between fragments and EEI was 53.66%.

Species frequency of occurrence ranged from 3.1% (one contact) to 96.9% (31 contacts) in fragment A and 1.5% (one contact) to 90.8% (59 contacts) in B (see Table 1). In both fragments, most of the species were recorded in up to 50% of the field visits (see Table 2), namely 119 species in A (75.3% of the total recorded in the fragment) and 158 species in B (78.61%), however some species were recorded in only one visit. This occurred with 30 species (18.9%) in A and 22 (13.92%) in B. Species with frequency of occurrence over 75% were considered residents in the studied areas (Almeida et al., 1999). This frequency was 19 species (12.03%) for fragment A and 14 species (6.97%) for B (see Table 1).

In both fragments, results were similar in relation to the distribution of trophic categories (see Table 3). Predominantly insectivorous birds were more representative both in A and B (49.37 and 48.26% respectively), followed by predominantly

omnivorous (17.72 and 16.42%, respectively). The other categories, in order of prevalence piscivores, detritivores, malacophages, carnivores, nectarivores and gramnivores - were poorly represented and together summed only 27.21% of birds in fragment A and 29.36% in B. The predominantly frugivorous birds were represented by only 5.70% of species in A and 5.97% in B.

During quantitative surveys, 111 species of birds in A and 120 in B were recorded, in 3,647 and 3,474 contacts, respectively (see Table 1). PIA ranged from 0.005 (one contact) to 1.282 (277 contacts) in A and 0.005 (one contact) to 1.023 (221 contacts) in B (see Figures 3 and 4). In A, 26 species (23.42% of the total registered during quantitative survey) had PIA values lower than 0.019 (less than four contacts), and the same occurred with 36 species (29.75%) in B, where values lower than 0.014 represent less than three contacts.

The Shannon diversity index was $H' = 3.9$ for both fragments and Pielou's evenness was $J' = 0.85$ for fragment A and $J' = 0.84$ for fragment B. Data indicate high similarity in community structure among fragments.

Table 1. Bird species recorded during qualitative and quantitative surveys in two Brazilian Cerrado fragments in Itirapina, Sao Paulo. PIA – Punctual Index of Abundance, FO - Frequency of Occurrence given in percentage, A (fragment A), B (fragment B). The nine trophic categories are represented by: ONI (omnivores), FRU (frugivores), PIS (piscivores), INS (insectivores), DET (detritivores), CAR (carnivores), MAL (malacophages), GRA (gramnivores) and NEC (nectarivores) - based on Motta-Junior (1990) and Sick (1997).

Taxon	FO (%)		PIA		Trophic categories
	A	B	A	B	
TINAMIDAE					
<i>Crypturellus parvirostris</i> (Wagler, 1827)	46.9	33.8	0.111	0.054	ONI
ANATIDAE					
<i>Amazonetta brasiliensis</i> (Gmelin, 1789)	-	41.5	-	-	ONI
CRACIDAE					
<i>Penelope superciliaris</i> Temminck, 1815	25	16.9	0.019	0.037	FRU
PHALACROCORACIDAE					
<i>Phalacrocorax brasilianus</i> (Gmelin, 1789)	3.1	46.2	-	-	PIS
ARDEIDAE					
<i>Tigrisoma lineatum</i> (Boddaert, 1783)	-	9.2	-	-	PIS
<i>Nycticorax nycticorax</i> (Linnaeus, 1758) *	3.1	7.7	-	-	PIS
<i>Butorides striata</i> (Linnaeus, 1758)	-	3.1	-	-	PIS
<i>Bubulcus ibis</i> (Linnaeus, 1758)	25	23.1	-	-	PIS
<i>Ardea cocoi</i> Linnaeus, 1766	15.6	33.8	-	-	PIS
<i>Ardea alba</i> Linnaeus, 1758	18.8	66.2	-	-	PIS
<i>Syrigma sibilatrix</i> (Temminck, 1824)	37.5	6.2	-	-	PIS
<i>Egretta thula</i> (Molina, 1782)	3.1	49.2	-	-	PIS
THRESKIORNITHIDAE					
<i>Mesembrinibis cayennensis</i> (Gmelin, 1789)	12.5	33.8	-	0.023	INS
<i>Theristicus caudatus</i> (Boddaert, 1783)	-	1.5	-	-	INS
CATHARTIDAE					
<i>Cathartes aura</i> (Linnaeus, 1758)	-	3.1	-	-	DET
<i>Coragyps atratus</i> (Bechstein, 1793)	43.8	47.7	-	-	DET

* Species that had not been recorded in EEI (n = 56) (review by Motta-Junior et al., 2008); § Atlantic Forest endemic species (n = 16) (Brooks et al., 1999); † Species registered for the first time for the whole Itirapina region (n = 11) (Willis, 2003a; Willis and Oniki 2003; Motta-Junior et al., 2008); and ‡ Fragments resident species (n = 23) (Almeida et al., 1999).

Table 1. Continued...

Taxon	FO (%)		PIA		Trophic categories
	A	B	A	B	
ACCIPITRIDAE					
<i>Elanus leucurus</i> (Vieillot, 1818)	3.1	1.5	-	-	CAR
<i>Rostramus sociabilis</i> (Vieillot, 1817) * †	6.3	3.1	-	-	MAL
<i>Ictinia plumbea</i> (Gmelin, 1788)	21.9	30.8	-	-	INS
<i>Geranospiza caerulescens</i> (Vieillot, 1817) *	-	13.8	-	-	CAR
<i>Buteogallus urubitinga</i> (Gmelin, 1788)	6.3	-	-	-	CAR
<i>Heterospizias meridionalis</i> (Latham, 1790)	-	1.5	-	-	CAR
<i>Rupornis magnirostris</i> (Gmelin, 1788) ‡	81.3	69.2	-	-	CAR
<i>Buteo albicaudatus</i> Vieillot, 1816	3.1	10.8	-	-	CAR
<i>Buteo brachyurus</i> Vieillot, 1816 *	3.1	13.8	-	-	CAR
FALCONIDAE					
<i>Caracara plancus</i> (Miller, 1777)	71.9	40	-	-	CAR
<i>Milvago chimachima</i> (Vieillot, 1816)	43.8	38.5	-	-	CAR
<i>Herpetotheses cachinnans</i> (Linnaeus, 1758)	9.4	4.6	-	-	CAR
<i>Micrastur semitorquatus</i> (Vieillot, 1817) * †	-	13.8	-	-	CAR
<i>Falco sparverius</i> Linnaeus, 1758	-	3.1	-	-	INS
<i>Falco femoralis</i> Temminck, 1822	6.3	6.2	-	-	CAR
RALLIDAE					
<i>Aramides cajanea</i> (Statius Muller, 1776)	-	4.6	-	-	ONI
CARIAMIDAE					
<i>Cariama cristata</i> (Linnaeus, 1766) ‡	84.4	61.5	-	-	INS
CHARADRIIDAE					
<i>Vanellus chilensis</i> (Molina, 1782)	68.8	70.8	-	-	ONI
SCOLOPACIDAE					
<i>Tringa solitaria</i> Wilson, 1813 *	-	3.1	-	-	INS
COLUMBIDAE					
<i>Columbina talpacoti</i> (Temminck, 1811)	46.9	33.8	0.125	0.046	GRA
<i>Columbina squammata</i> (Lesson, 1831)	53.1	33.8	0.144	0.079	GRA
<i>Patagioenas picazuro</i> (Temminck, 1813) ‡	96.9	89.2	1.282	1.023	FRU
<i>Patagioenas cayennensis</i> (Bonnaterre, 1792)	53.1	36.9	0.125	0.069	FRU
<i>Zenaida auriculata</i> (Des Murs, 1847)	9.4	9.2	0.005	-	GRA
<i>Leptotila verreauxi</i> Bonaparte, 1855 ‡	84.4	70.8	0.444	0.375	FRU
<i>Leptotila rufaxilla</i> (Richard & Bernard, 1792) * †	-	3.1	-	-	FRU
PSITTACIDAE					
<i>Aratinga leucophthalma</i> (Statius Muller, 1776)	68.8	58.5	-	-	FRU
<i>Aratinga aurea</i> (Gmelin, 1788)	-	1.5	-	-	FRU
<i>Forpus xanthopterygius</i> (Spix, 1824)	25	52.3	-	-	FRU
<i>Brotogeris chiriri</i> (Vieillot, 1818)	65.6	52.3	-	-	FRU
CUCULIDAE					
<i>Piaya cayana</i> (Linnaeus, 1766)	34.4	40	0.028	0.065	INS
<i>Crotophaga ani</i> Linnaeus, 1758	31.3	27.7	0.037	0.037	INS
<i>Guira guira</i> (Gmelin, 1788)	3.1	3.1	0.005	-	INS
<i>Tapera naevia</i> (Linnaeus, 1766)	9.4	13.8	0.009	0.009	INS
TYTONIDAE					
<i>Tyto alba</i> (Scopoli, 1769)	-	1.5	-	-	CAR
STRIGIDAE					
<i>Glaucidium brasilianum</i> (Gmelin, 1788)	-	1.5	-	-	CAR
<i>Athene cunicularia</i> (Molina, 1782)	-	1.5	-	-	CAR
<i>Rhinoptynx clamator</i> (Vieillot, 1808)	-	4.6	-	-	CAR

* Species that had not been recorded in EEI (n = 56) (review by Motta-Junior et al., 2008); § Atlantic Forest endemic species (n = 16) (Brooks et al., 1999); † Species registered for the first time for the whole Itaipina region (n = 11) (Willis, 2003a; Willis and Oniki 2003; Motta-Junior et al., 2008); and ‡ Fragments resident species (n = 23) (Almeida et al., 1999).

Table 1. Continued...

Taxon	FO (%)		PIA		Trophic categories
	A	B	A	B	
<i>Asio stygius</i> (Wagler, 1832)	-	3.1	-	-	CAR
NYCTIBIIDAE					
<i>Nyctibius griseus</i> (Gmelin, 1789)	3.1	9.2	-	-	INS
CAPRIMULGIDAE					
<i>Podager nacunda</i> (Vieillot, 1817) *	-	1.5	-	-	INS
<i>Nyctidromus albicollis</i> (Gmelin, 1789)	50	56.9	-	-	INS
<i>Caprimulgus rufus</i> Boddaert, 1783 *	6.3	15.4	-	-	INS
<i>Hydropsalis torquata</i> (Gmelin, 1789)	12.5	9.2	-	-	INS
APODIDAE					
<i>Streptoprocne zonaris</i> (Shaw, 1796)	-	1.5	-	-	INS
<i>Chaetura meridionalis</i> Hellmayr, 1907	6.3	3.1	-	-	INS
TROCHILIDAE					
<i>Phaethornis pretrei</i> (Lesson & Delattre, 1839)	9.4	9.2	-	0.019	NEC
<i>Eupetomena macroura</i> (Gmelin, 1788)	25	23.1	0.023	0.032	NEC
<i>Aphantochroa cirrochloris</i> (Vieillot, 1818) §	3.1	10.8	0.005	0.009	NEC
<i>Florisuga fusca</i> (Vieillot, 1817) §	46.9	36.9	0.111	0.111	NEC
<i>Anthracothorax nigricollis</i> (Vieillot, 1817) *	-	1.5	0.130	-	NEC
<i>Chlorostilbon lucidus</i> (Shaw, 1812)	34.4	47.7	-	0.111	NEC
<i>Thalurania glaucopsis</i> (Gmelin, 1788) * §	-	1.5	-	-	NEC
<i>Hylocharis sapphirina</i> (Gmelin, 1788) * †	6.3	3.1	0.014	0.005	NEC
<i>Hylocharis chrysura</i> (Shaw, 1812)	46.9	43.1	0.162	0.120	NEC
<i>Leucochloris albicollis</i> (Vieillot, 1818) * §	12.5	9.2	0.023	0.005	NEC
<i>Amazilia versicolor</i> (Vieillot, 1818)	3.1	3.1	0.005	0.005	NEC
<i>Amazilia lactea</i> (Lesson, 1832)	56.3	60	0.278	0.130	NEC
<i>Heliomaster squamosus</i> (Temminck, 1823) *	34.4	26.2	0.065	0.023	NEC
<i>Calliphlox amethystina</i> (Boddaert, 1783) *	-	1.5	-	0.005	NEC
ALCEDINIDAE					
<i>Megaceryle torquata</i> (Linnaeus, 1766)	3.1	29.2	0.005	0.032	PIS
<i>Chloroceryle amazona</i> (Latham, 1790)	3.1	50.8	0.005	0.005	PIS
MOMOTIDAE					
<i>Baryphthengus ruficapillus</i> (Vieillot, 1818) * §	9.4	43.1	0.014	0.088	ONI
GALBULIDAE					
<i>Galbula ruficauda</i> Cuvier, 1816	3.1	-	-	-	INS
BUCCONIDAE					
<i>Nystalus chacuru</i> (Vieillot, 1816)	-	1.5	-	0.005	INS
<i>Malacoptila striata</i> (Spix, 1824) * §	-	1.5	-	0.005	INS
RAMPHASTIDAE					
<i>Ramphastos toco</i> Statius Muller, 1776	-	21.5	-	0.014	FRU
PICIDAE					
<i>Picumnus albosquamatus</i> d'Orbigny, 1840	59.4	69.2	0.144	0.185	INS
<i>Melanerpes candidus</i> (Otto, 1796)	18.8	15.4	0.051	0.056	INS
<i>Veniliornis passerinus</i> (Linnaeus, 1766)	43.8	41.5	0.097	0.069	INS
<i>Colaptes melanochlorus</i> (Gmelin, 1788)	53.1	47.7	0.106	0.097	INS
<i>Colaptes campestris</i> (Vieillot, 1818) ‡	84.4	49.2	0.255	0.088	INS
<i>Dryocopus lineatus</i> (Linnaeus, 1766)	50	38.5	0.106	0.032	INS
MELANOPAREIIDAE					
<i>Melanopareia torquata</i> (Wied, 1831)	-	1.5	-	-	INS
THAMNOPHILIDAE					
<i>Taraba major</i> (Vieillot, 1816)	15.6	7.7	0.032	-	INS

* Species that had not been recorded in EEI (n = 56) (review by Motta-Junior et al., 2008); § Atlantic Forest endemic species (n = 16) (Brooks et al., 1999); † Species registered for the first time for the whole Itirapina region (n = 11) (Willis, 2003a; Willis and Oniki 2003; Motta-Junior et al., 2008); and ‡ Fragments resident species (n = 23) (Almeida et al., 1999).

Table 1. Continued...

Taxon	FO (%)		PIA		Trophic categories
	A	B	A	B	
<i>Thamnophilus doliatus</i> (Linnaeus, 1764)	34.4	12.3	0.065	0.014	INS
<i>Thamnophilus ruficapillus</i> Vieillot, 1816	-	3.1	-	0.009	INS
<i>Thamnophilus torquatus</i> Swainson, 1825	-	1.5	-	-	INS
<i>Thamnophilus pelzelni</i> Hellmayr, 1924 * ‡	81.3	47.7	0.361	0.204	INS
<i>Thamnophilus caerulescens</i> Vieillot, 1816	50	66.2	0.083	0.222	INS
<i>Dysithamnus mentalis</i> (Temminck, 1823) *	3.1	4.6	-	0.005	INS
<i>Formicivora rufa</i> (Wied, 1831)	28.1	4.6	0.097	0.005	INS
<i>Drymophila ferruginea</i> (Temminck, 1822) * §	6.3	4.6	-	-	INS
CONOPOPHAGIDAE					
<i>Conopophaga lineata</i> (Wied, 1831) §	34.4	55.4	0.065	0.134	INS
DENDROCOLAPTIDAE					
<i>Sittasomus griseicapillus</i> (Vieillot, 1818) *	9.4	12.3	0.014	0.023	INS
<i>Lepidocolaptes angustirostris</i> (Vieillot, 1818)	62.5	47.7	0.231	0.079	INS
FURNARIIDAE					
<i>Furnarius rufus</i> (Gmelin, 1788)	31.3	41.5	0.046	0.079	INS
<i>Synallaxis ruficapilla</i> Vieillot, 1819 * §	-	4.6	-	-	INS
<i>Synallaxis frontalis</i> Pelzelni, 1859 ‡	81.3	64.6	0.190	0.083	INS
<i>Synallaxis albescens</i> Temminck, 1823	3.1	-	-	-	INS
<i>Synallaxis spixi</i> Sclater, 1856	40.6	66.2	0.069	0.116	INS
<i>Certhiaxis cinnamomeus</i> (Gmelin, 1788)	-	27.7	-	-	INS
<i>Phacellodomus ferrugineigula</i> (Pelzelni, 1858) §	6.3	3.1	0.005	-	INS
<i>Automolus leucophthalmus</i> (Wied, 1821) * §	12.5	41.5	0.005	0.079	INS
<i>Xenops rutilans</i> Temminck, 1821 *	6.3	6.2	0.005	-	INS
TYRANNIDAE					
<i>Leptopogon amaurocephalus</i> Tschudi, 1846 *	6.3	30.8	-	0.074	INS
<i>Hemitriccus orbitatus</i> (Wied, 1831) * §	-	1.5	-	-	INS
<i>Hemitriccus margaritaceiventer</i> (d'Orbigny & Lafresnaye, 1837)	21.9	-	0.023	0.005	INS
<i>Todirostrum poliocephalum</i> (Wied, 1831) * §	-	1.5	-	-	INS
<i>Todirostrum cinereum</i> (Linnaeus, 1766)	-	1.5	-	0.005	INS
<i>Elaenia flavogaster</i> (Thunberg, 1822)	71.9	66.2	0.579	0.282	ONI
<i>Elaenia spectabilis</i> Pelzelni, 1868 * †	3.1	6.2	0.019	-	ONI
<i>Elaenia mesoleuca</i> (Deppé, 1830)	18.8	7.7	0.037	0.037	ONI
<i>Elaenia chiriquensis</i> Lawrence, 1865	34.4	24.6	0.153	0.093	ONI
<i>Elaenia obscura</i> (d'Orbigny & Lafresnaye, 1837)	43.8	43.1	0.167	0.120	ONI
<i>Camptostoma obsoletum</i> (Temminck, 1824) ‡	87.5	81.5	0.444	0.287	INS
<i>Serpophaga nigricans</i> (Vieillot, 1817)	3.1	-	-	-	INS
<i>Serpophaga subcristata</i> (Vieillot, 1817)	34.4	26.2	0.125	0.037	INS
<i>Phaeomyias murina</i> (Spix, 1825) *	31.3	16.9	0.106	0.056	INS
<i>Euscarthmus meloryphus</i> Wied, 1831 *	21.9	29.2	0.046	0.028	INS
<i>Tolmomyias sulphurescens</i> (Spix, 1825) * ‡	40.6	83.1	0.069	0.306	INS
<i>Platyrinchus mystaceus</i> Vieillot, 1818 *	3.1	6.2	-	-	INS
<i>Myiophobus fasciatus</i> (Statius Muller, 1776)	6.3	10.8	-	0.009	INS
<i>Lathrotriccus euleri</i> (Cabanis, 1868)	34.4	46.2	0.037	0.116	INS
<i>Cnemotriccus fuscatus</i> (Wied, 1831) *	40.6	24.6	0.102	0.051	INS
<i>Knipolegus cyanirostris</i> (Vieillot, 1818) *	-	9.2	-	0.014	INS
<i>Satrapa icterophrys</i> (Vieillot, 1818)	3.1	4.6	0.009	-	INS
<i>Xolmis velatus</i> (Lichtenstein, 1823)	3.1	-	0.009	-	INS
<i>Fluvicola nengeta</i> (Linnaeus, 1766) *	-	32.3	-	-	INS
<i>Colonia colonus</i> (Vieillot, 1818) *	25	33.8	0.028	0.037	INS

* Species that had not been recorded in EEI (n = 56) (review by Motta-Junior et al., 2008); § Atlantic Forest endemic species (n = 16) (Brooks et al., 1999); † Species registered for the first time for the whole Itaipava region (n = 11) (Willis, 2003a; Willis and Oniki 2003; Motta-Junior et al., 2008); and ‡ Fragments resident species (n = 23) (Almeida et al., 1999).

Table 1. Continued...

Taxon	FO (%)		PIA		Trophic categories
	A	B	A	B	
<i>Machetornis rixosa</i> (Vieillot, 1819)	-	1.5	-	-	INS
<i>Legatus leucophaius</i> (Vieillot, 1818) * †	9.4	13.8	0.005	0.028	INS
<i>Myiozetetes similis</i> (Spix, 1825)	65.6	61.5	0.134	0.116	ONI
<i>Pitangus sulphuratus</i> (Linnaeus, 1766) ‡	84.4	90.8	0.634	0.556	ONI
<i>Myiodynastes maculatus</i> (Statius Muller, 1776)	34.4	38.5	0.153	0.231	ONI
<i>Megarynchus pitangua</i> (Linnaeus, 1766) ‡	84.4	86.2	0.329	0.370	ONI
<i>Empidonomus varius</i> (Vieillot, 1818)	40.6	44.6	0.120	0.167	INS
<i>Tyrannus albogularis</i> Burmeister, 1856	9.4	3.1	-	-	INS
<i>Tyrannus melancholicus</i> Vieillot, 1819 ‡	78.1	61.5	0.759	0.454	INS
<i>Tyrannus savana</i> Vieillot, 1808	28.1	32.3	0.153	0.037	INS
<i>Casiornis rufus</i> (Vieillot, 1816) *	62.5	35.4	0.264	0.056	INS
<i>Myiarchus swainsoni</i> Cabanis & Heine, 1859	31.3	26.2	0.037	0.014	INS
<i>Myiarchus ferox</i> (Gmelin, 1789)	68.8	46.2	0.241	0.093	INS
<i>Myiarchus tyrannulus</i> (Statius Muller, 1776)	18.8	3.1	0.023	-	INS
PIPRIDAE					
<i>Antilophia galeata</i> (Lichtenstein, 1823)	40.6	44.6	0.069	0.069	FRU
<i>Chiroxiphia caudata</i> (Shaw & Nodder, 1793) * §	3.1	36.9	-	0.065	FRU
TITYRIDAE					
<i>Pachyramphus castaneus</i> (Jardine & Selby, 1827) * †	-	1.5	-	-	INS
<i>Pachyramphus polychopterus</i> (Vieillot, 1818) *	40.6	36.9	0.125	0.093	INS
<i>Pachyramphus validus</i> (Lichtenstein, 1823) *	40.6	55.4	0.144	0.148	INS
VIREONIDAE					
<i>Cyclarhis gujanensis</i> (Gmelin, 1789) ‡	93.8	89.2	0.782	0.972	INS
<i>Vireo olivaceus</i> (Linnaeus, 1766)	43.8	60	0.204	0.412	ONI
CORVIDAE					
<i>Cyanocorax criStatellus</i> (Temminck, 1823) ‡	87.5	58.5	-	-	ONI
<i>Cyanocorax chrysops</i> (Vieillot, 1818) ‡	62.5	76.9	-	-	ONI
HIRUNDINIDAE					
<i>Pygochelidon cyanoleuca</i> (Vieillot, 1817)	46.9	36.9	0.046	0.093	INS
<i>Stelgidopteryx ruficollis</i> (Vieillot, 1817)	46.9	46.2	0.074	0.042	INS
<i>Progne chalybea</i> (Gmelin, 1789)	-	1.5	-	-	INS
TROGLODYTIDAE					
<i>Troglodytes musculus</i> Naumann, 1823	46.9	61.5	0.079	0.102	INS
<i>Cantorchilus leucotis</i> (Lafresnaye, 1845) * †	18.8	6.2	0.023	0.009	INS
DONACOBIIDAE					
<i>Donacobius atricapilla</i> (Linnaeus, 1766)	-	3.1	-	-	INS
POLIOPTILIDAE					
<i>Polioptila dumicola</i> (Vieillot, 1817) * †	-	1.5	-	-	INS
TURDIDAE					
<i>Turdus rufiventris</i> Vieillot, 1818	31.3	61.5	0.097	0.176	ONI
<i>Turdus leucomelas</i> Vieillot, 1818 ‡	96.9	90.8	0.676	0.852	ONI
<i>Turdus amaurochalinus</i> Cabanis, 1850	65.6	64.6	0.194	0.185	ONI
<i>Turdus albicollis</i> Vieillot, 1818 *	-	4.6	-	0.005	ONI
MIMIDAE					
<i>Mimus saturninus</i> (Lichtenstein, 1823)	15.6	24.6	0.019	0.005	INS
COEREBIDAE					
<i>Coereba flaveola</i> (Linnaeus, 1758)	46.9	49.2	0.102	0.083	NEC
THRAUPIDAE					
<i>Schistochlamys ruficapillus</i> (Vieillot, 1817)	31.3	21.5	0.032	0.005	ONI

* Species that had not been recorded in EEI (n = 56) (review by Motta-Junior et al., 2008); § Atlantic Forest endemic species (n = 16) (Brooks et al., 1999); † Species registered for the first time for the whole Itirapina region (n = 11) (Willis, 2003a; Willis and Oniki 2003; Motta-Junior et al., 2008); and ‡ Fragments resident species (n = 23) (Almeida et al., 1999).

Table 1. Continued...

Taxon	FO (%)		PIA		Trophic categories
	A	B	A	B	
<i>Nemosia pileata</i> (Boddaert, 1783)	12.5	9.2	0.009	-	INS
<i>Thlypopsis sordida</i> (d'Orbigny & Lafresnaye, 1837)	3.1	21.5	0.005	0.028	INS
<i>Trichothraupis melanops</i> (Vieillot, 1818) *	-	4.6	-	0.005	ONI
<i>Piranga flava</i> (Vieillot, 1822)	18.8	13.8	0.042	0.014	ONI
<i>Habia rubica</i> (Vieillot, 1817) *	-	6.2	-	-	INS
<i>Eucometis penicillata</i> (Spix, 1825) * †	3.1	10.8	0.005	0.009	INS
<i>Tachyphonus coronatus</i> (Vieillot, 1822) * §	3.1	10.8	0.005	0.014	ONI
<i>Ramphocelus carbo</i> (Pallas, 1764)	68.8	46.2	0.153	0.181	ONI
<i>Thraupis sayaca</i> (Linnaeus, 1766) ‡	87.5	86.2	0.648	0.625	ONI
<i>Tangara cayana</i> (Linnaeus, 1766) ‡	84.4	84.6	0.815	0.907	ONI
<i>Tersina viridis</i> (Illiger, 1811) *	-	6.2	-	0.023	ONI
<i>Dacnis cayana</i> (Linnaeus, 1766)	37.5	63.1	0.097	0.171	ONI
<i>Hemithraupis ruficapilla</i> (Vieillot, 1818) * §	-	1.5	-	0.006	INS
<i>Conirostrum speciosum</i> (Temminck, 1824)	3.1	12.3	-	0.014	INS
EMBERIZIDAE					
<i>Zonotrichia capensis</i> (Statius Muller, 1776) ‡	96.9	87.7	0.440	0.389	GRA
<i>Ammodramus humeralis</i> (Bosc, 1792)	15.6	12.3	0.023	0.005	GRA
<i>Haplospiza unicolor</i> Cabanis, 1851 * § †	-	1.5	-	-	GRA
<i>Emberizoides herbicola</i> (Vieillot, 1817)	-	3.1	-	0.002	GRA
<i>Volatinia jacarina</i> (Linnaeus, 1766)	43.8	50.8	0.125	0.255	GRA
<i>Sporophila lineola</i> (Linnaeus, 1758)	12.5	13.8	0.009	0.014	GRA
<i>Sporophila nigricollis</i> (Vieillot, 1823) *	-	3.1	-	-	GRA
<i>Sporophila caerulescens</i> (Vieillot, 1823)	34.4	40	0.176	0.157	GRA
<i>Sporophila angolensis</i> (Linnaeus, 1766) *	3.1	-	-	-	GRA
<i>Arremon flavirostris</i> Swainson, 1838	3.1	46.2	0.005	0.079	INS
<i>Coryphospingus cucullatus</i> (Statius Muller, 1776) ‡	81.3	64.6	0.366	0.144	GRA
CARDINALIDAE					
<i>Saltator similis</i> d'Orbigny & Lafresnaye, 1837	-	4.6	-	-	GRA
<i>Saltator atricollis</i> Vieillot, 1817	3.1	-	-	-	GRA
PARULIDAE					
<i>Parula pitayumi</i> (Vieillot, 1817)	62.5	69.2	0.148	0.278	INS
<i>Geothlypis aequinoctialis</i> (Gmelin, 1789)	50	27.7	0.074	0.028	INS
<i>Basileuterus hypoleucus</i> Bonaparte, 1830 ‡	71.9	84.6	0.370	0.731	INS
<i>Basileuterus flaveolus</i> (Baird, 1865) ‡	90.6	89.2	0.505	0.620	INS
<i>Basileuterus leucophrys</i> Pelzeln, 1868	25	-	0.032	-	INS
ICTERIDAE					
<i>Icterus cayanensis</i> (Linnaeus, 1766)	3.1	3.1	-	-	ONI
<i>Gnorimopsar chopi</i> (Vieillot, 1819)	-	7.7	-	0.005	GRA
<i>Chrysomus ruficapillus</i> (Vieillot, 1819) *	-	9.2	-	-	INS
FRINGILLIDAE					
<i>Euphonia chlorotica</i> (Linnaeus, 1766) ‡	62.5	78.5	0.157	0.259	ONI
<i>Euphonia violacea</i> (Linnaeus, 1758) *	3.1	3.1	0.005	0.005	ONI

* Species that had not been recorded in EEI (n = 56) (review by Motta-Junior et al., 2008); § Atlantic Forest endemic species (n = 16) (Brooks et al., 1999); † Species registered for the first time for the whole Itirapina region (n = 11) (Willis, 2003a; Willis and Oniki 2003; Motta-Junior et al., 2008); and ‡ Fragments resident species (n = 23) (Almeida et al., 1999).

4. Discussion

4.1. Species richness

Species richness corresponded to 27.27% of all birds of Sao Paulo State (Willis and Oniki, 2003) and 25.08% of all birds recorded in Cerrado (Marini and Garcia, 2005). Of the 210 species recorded, six (*Hylocharis sapphirina*,

Melanopareia torquata, *Eucometis penicillata*, *Sporophila angolensis*, *Saltator atricollis* and *Basileuterus leucophrys*) are threatened in Sao Paulo State (São Paulo, 2008), five (*M. torquata*, *S. atricollis*, *B. leucophrys*, *Antilophia galeata* and *Cyanocorax cristatellus*) are endemic to the Cerrado (Silva and Bates, 2002) and sixteen are Atlantic Forest endemics (Brooks et al., 1999) (see Table 1). Two

registered species (*Chiroxiphia caudata* and *Habia rubica*) are bioindicators (Piratelli et al., 2008). According to these authors, both species have some ecological characteristics (e.g. needs for nesting and foraging in mixed flocks) that lead them to prefer less altered areas.

Some species (n = 56) had never been registered in EEI (review by Motta-Junior et al., 2008) (see Table 1), but one (*Leucochloris albicollis*) had already been registered during a brief visit to fragment B (Willis and Oniki, 2003). This number represents a considerable increase to the bird list for the protected areas (EEI and Estação Experimental de Itirapina), now with a total of 287 species. Some species may not have been previously recorded as they are difficult to detect or even occur in the region in low relative abundance (low FO and/or low PIA values). This is the case, for example, of the five records of hummingbirds (*Anthracothorax nigricollis*, *Thalurania glaucopis*, *Hylocharis sapphirina*, *Heliomaster squamosus*, *Calliphlox amethystina*).

However, some of the new species recorded were found only in forested habitats, which are scarce in EEI (Granzinolli, 2009) and very important for birds in Cerrado (Piratelli and Blake, 2006). These species possibly would not be detected in more open vegetation areas, which prevail in EEI. In this group there are thirteen Atlantic Forest endemics (Brooks et al., 1999) (see Table 1). There were also, while not restricted, other species associated with forest habitats (Sick, 1997), like *Eucometis penicillata*, *Habia rubica*, *Leptopogon amaurocephalus* and *Pachyramphus polychopterus*. These results reinforce the importance of keeping forest fragments and environmental heterogeneity for the conservation of local biodiversity, especially for Cerrado. This contributes to bird conservation in a landscape scale (Bakker et al., 2002).

Within the list, there are eleven species (see Table 1) registered for the first time for the whole Itirapina region (Willis, 2003a; Willis and Oniki, 2003; Motta-Junior et al., 2008): *Rostramus sociabilis*, *Micrastur semitorquatus*, *Leptotila rufaxilla*, *Hylocharis sapphirina*, *Elaenia spectabilis*, *Legatus leucophaeus*, *Pachyramphus castaneus*, *Cantorchilus leucotis*, *Polioptila dumicola*, *Eucometis penicillata* and *Haplospiza unicolor*. Even when a specific area is visited for a long time, recording new species is common in bird surveys, as shown by some other authors (Rodrigues et al., 2005; Motta-Junior et al., 2008). Despite the intensive sampling effort, rarefaction curves did not stabilize (see Figures 1 and 2). Jackknife estimator data indicate that bird richness is probably higher than observed for both studied areas. In light of that, new visits to the fragments are likely to allow for additional records.

4.2. Similarities among areas

The similarity among bird communities of fragments is probably explained by the similarities in vegetation and proximity between areas, which may favour the displacement of individuals. The matrix can also play an important role, since the occurrence of a similar matrix in distinct areas selects similar communities (Sisk et al., 1997). In addition, a considerable portion of the species common to both areas is often found in forest fragments

(Gimenes and Anjos, 2003; Antunes, 2005; Manica et al., 2010). They are less demanding species in relation to food, nesting and other surviving conditions, such as *Elaenia flavogaster*, *Camptostoma obsoletum*, *Lathrotriccus euleri*, *Pitangus sulphuratus*, *Myiodynastes maculatus*, *Megarynchus pitangua*, *Tyrannus melancholicus*, *Cyclarhis gujanensis*, *Troglodytes musculus* and *Turdus leucomelas* (Sick, 1997). The similarity of 70.95% among fragment bird communities and the probable reasons for this index, suggest that an ecological corridor to link these areas would be an important management strategy. Moreover, total fragment isolation should be avoided (Tabarelli and Gascon, 2005). In this way, corridors are proposed by some authors (Tubelis and Cavalcanti, 2000; Tubelis et al., 2004) and are, indeed, priorities for the conservation of Cerrado (Azevedo, 1998).

Lower similarity between fragments and EEI, compared to the similarity among fragments, may be related to size and vegetation differences among areas and also the presence of a large number of exclusive bird species in each one of them. The fragments have 56 exclusive species, which happens to 77 species recorded only in EEI. Belonging to this group of birds apparently sensitive to environmental changes, there is a group that includes endemic species to the Cerrado and/or threatened ones, occurring in more open vegetation forms, as *Rhea americana*, *Culicivora caudacuta*, *Alectrurus tricolor* and *Polystictus pectoralis*. Differences between study duration, frequency of visits and sampling method may also explain the disparity of results. For example Willis's survey (2004) was conducted over 21 years in contrast to the 12 months of this study.

4.3. Frequency of occurrence

The high percentage of species with low FO is commonly found in other studies (Almeida et al., 1999; Donatelli et al., 2007). Almeida et al. (1999) attribute the results to the occurrence of wandering, occasional or migratory species. Concerning the fragments studied, especially due to the considerable species number recorded in up to 25% of visits, this explanation can be attributed to some groups, such as diurnal raptors, represented by nine of the 11 species with low frequency in A and 13 of the 14 species in B. Low FO values can also be related to the reduced detection of certain species. This was true to some hummingbird species: nine of the 11 species showed low frequencies (seven species with up to 25% of frequency) in fragment A and the same happened with 13 of the 14 species recorded (9 species below 25% of frequency) in B. Species with inconspicuous vocalisations (*Conirostrum speciosum*, *Eucometis penicillata*, *Piranga flava* and *Nemosia pileata*) and/or which were recorded in low relative abundance in study areas (*Penelope superciliaris*, *Piaya cayana* and *Tapera naevia*) may also explain these results (Aleixo and Vielliard, 1995). Only 26 species (see Table 1) are resident (FO values higher than 75%, according to Almeida et al., 1999) to the studied areas and ten of them occur in both fragments. *Turdus leucomelas*, *Pitangus sulphuratus*, *Patagioenas picazuro*, *Cyclarhis gujanensis* and *Zonotrichia capensis* can be included in this group because they are species adapted to disturbed

areas and also occurred in high frequencies in other studies (Donatelli et al., 2007).

4.4. Trophic categories

Almost 50% of registered species were classified as predominantly insectivores and omnivores represented just over 15% of species (see Table 3). The percentage of birds considered frugivores was low for both fragments, corroborating studies conducted in fragments in Sao Paulo State (Motta-Junior, 1990; Manica et al., 2010). Frugivores are among the most sensitive groups to forest fragmentation (Willis, 1979) because they need large areas to reach their food needs (Pizo, 2001). The higher percentage of predominantly insectivorous birds was also recorded by Motta-Junior (1990), Donatelli et al. (2004, 2007); and Manica et al. (2010). However Motta-Junior

(1990) and Donatelli et al. (2007) found frugivores as the second more representative category. Omnivores were more abundant than frugivores, as observed in Motta-Junior (1990) and Manica et al. (2010) and this appears to be a common pattern in fragments (Willis, 1979). Apparently, a more varied diet (e.g. omnivory) tends to be favoured in disturbed environments.

Despite the low number of predominantly frugivores species (n = 12), small (*Forpus xanthopterygius*, *Brotogeris chiriri*, *Antilophia galeata* and *Chiroxiphia caudata*), medium (*Aratinga leucophthalma*, *Aratinga aurea*, *Leptotila verreauxi*, *Leptotila rufaxilla*, *Patagioenas picazuro* and *Patagioenas cayennensis*) and large (*Ramphastos toco* and *Penelope superciliaris*) size animals were found, which indicates the wide range of food items availability (Manica et al., 2010). Frugivores are important to natural

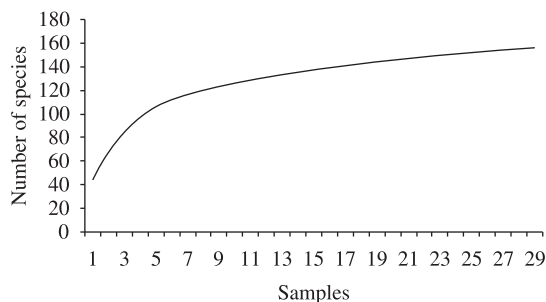


Figure 1. Rarefaction curve from fragment A during the qualitative survey conducted between October 2006 and September 2007 in Itirapina, Sao Paulo State, Brazil.

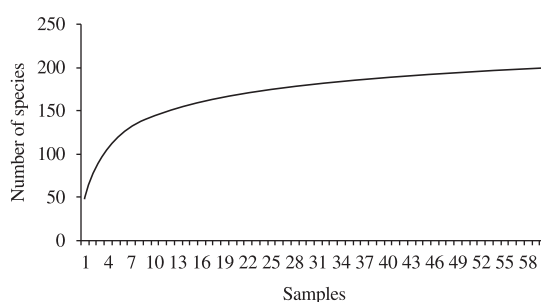


Figure 2. Rarefaction curve from fragment B during the qualitative survey conducted between October 2006 and September 2007 in Itirapina, Sao Paulo State, Brazil.

Table 2. Frequency of occurrence (FO) classes percentage of bird species in fragments A and B, Itirapina, Sao Paulo State, during 91 visits to areas in 12 months of study (October 2006 to September 2007).

		FO classes (%)				Total
		1-25	25.1-50	50.1-75	75.1-100	
Frag A	species (%)	46.83	28.48	12.66	12.03	
	species number	74	45	20	19	158
Frag B	species (%)	52.24	26.37	14.43	6.97	
	species number	105	53	29	14	201

Table 3. Number of species and relative percentage of nine trophic categories to the fragments studied (A and B) and analysed for both overall (total). INS - insectivores; ONI - omnivores; NEC - nectarivores; CAR - carnivores; GRA - granivores; PIS - piscivores; FRU - frugivores; DET - detritivores; MAL - malacophages. Categories based on Motta-Junior (1990) and Sick (1997).

		Trophic categories									Total
		INS	ONI	NEC	CAR	GRA	PIS	FRU	DET	MAL	
Frag A	species	78	28	12	9	11	9	9	1	1	158
	%	49.37	17.72	7.59	5.70	6.96	5.70	5.70	0.63	0.63	
Frag B	species	97	33	15	16	14	11	12	2	1	201
	%	48.26	16.42	7.46	7.96	6.97	5.47	5.97	1.00	0.50	
Total	species	103	33	15	17	16	11	12	2	1	210
	%	49.05	15.71	7.14	8.10	7.62	5.24	5.71	0.95	0.48	

areas because some species are related to seed dispersal (Pizo, 2001).

Although with low values, the importance of carnivores in both fragments was high when compared to other studies (Motta-Junior, 1990; Donatelli et al., 2007; Manica et al., 2010). Raptor birds have a large range (Del Hoyo et al., 1994) and probably the proximity to EEI allowed the record of most species. Therefore, these birds must use both Itirapina protected areas, which again highlight the importance of the fragments to the local avifauna. The presence of 17 carnivore species in the fragments can indicate its quality. They are top predators (Sick, 1997) and thus need a structured environment, concerning trophic chains.

Gramnivores were ranked in the fourth position, probably because both fragments have large amounts of exotic herbaceous species, used by these birds (pers.

obs). Nectarivores occupied the fifth place, which can be partially attributed to the presence of *Pyrostegia venusta* (Ker Gawl.) Miers (Bignoniaceae), which produces flowers visited by this category (hummingbirds, mainly). However, the importance of this plant species for nectarivorous birds must be observed in other areas. Flowers of *Eucalyptus* spp. were also apparently important for these birds, but also requires more observations, although Willis (2002, 2003b) has already reported the importance of the resource. Nectarivores are important in natural areas because some species are flower pollinators. Impacts on pollinator populations can affect all communities' structure (Murcia, 1996).

4.5. Ponctual index of abundance

For the PIA values, a pattern similar to other studies that have used the same methodological standards (e.g. time in each sampling point) was observed (Vielliard and Silva, 1990; Aleixo and Vielliard, 1995; Almeida et al., 1999). The results indicated the presence of few species with high values and many species with medium to low values. Some birds had high and similar values in both fragments, such as *Patagioenas picazuro*, *Tangara cayana*, *Cyclarhis gujanensis*, *Turdus leucomelas*, *Thraupis sayaca* and *Pitangus sulphuratus*, common species in disturbed environments (Sick, 1997) and with long or constant vocalisation scope (Almeida et al., 1999). The PIA of *P. picazuro* was higher than 1.0, data also found by Almeida et al. (1999) and Donatelli et al. (2007). This species has been expanding in Sao Paulo State, aided by deforestation (Willis and Oniki, 1987) and is currently one of the most common birds in eastern Brazil (Oniki and Willis, 2000).

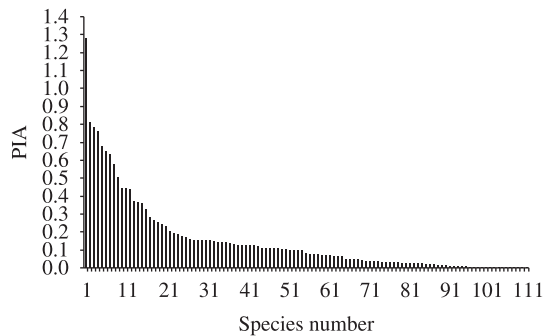


Figure 3. Ponctual Index of Abundance (PIA) in descending order of the bird species recorded during the quantitative survey conducted between October 2006 and September 2007 in fragment A in Itirapina, Sao Paulo State, Brazil.

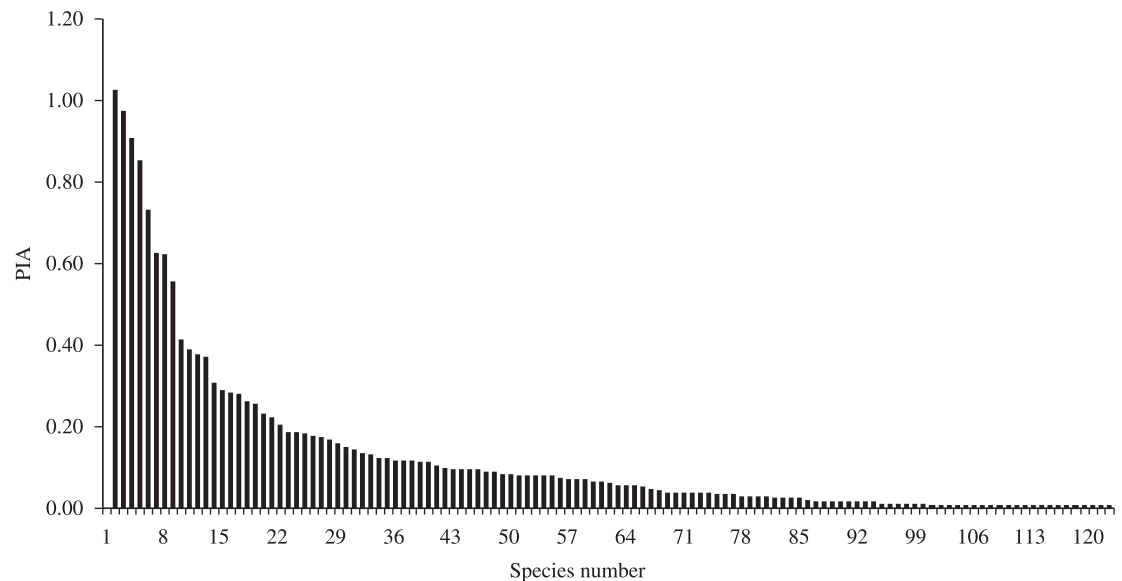


Figure 4. Ponctual Index of Abundance (PIA) in descending order of the bird species recorded during the quantitative survey conducted between October 2006 and September 2007 in fragment B in Itirapina, Sao Paulo State, Brazil.

There is difference in PIA values of some species when the fragments are compared (see Table 1). This is the case, for example, of *Tolmomyias sulphurescens*, *Thamnophilus caerulescens*, *Euphonia chlorotica*, *Turdus rufiventris*, *Conopophaga lineata* and *Lathrotriccus euleri*, which occurred in higher relative abundance in B, and to *Coryphospingus cucullatus*, *Casiornis rufa*, *Colaptes campestris*, *Synallaxis frontalis* and *Tyrannus savanna*, which occurred at higher relative abundance in A. These differences may be related to the occurrence of certain birds in forest vegetation areas, which occur in B, and species associated with more open environments, such as those with highest relative abundance in A. This highlights the importance of keeping the Cerrado mosaic, since species are related to certain vegetation types (Boecklen, 1986).

5. Final Considerations and Recommendations

To improve the quality of the studied areas, this paper suggests the establishment of an ecological corridor between fragments, given the short distance that separates them, and the similarity among bird communities. It includes the use of native plant species that produce fruits. Frugivorous birds, including the largest ones, still occur within Sao Paulo State, but they need large areas to reach their food needs. So, in addition to these corridors between fragments, it could also attract frugivorous bird species, currently rare, to these fragments. Moreover, these fragments can act as a damping area to the Estação Ecológica de Itirapina, reducing the disruption in this area.

This paper also proposes discussing the withdrawal of native understory in *Pinus* spp. plantation, used by birds. Certain areas of forest adjacent to the fragments show native understory which is, at least apparently, important for certain bird populations. The testing of this hypothesis is therefore suggested. In case of positive results, lack of removal of native vegetation can be a simple way of management in areas of planting pine species.

6. Conclusion

Our results reinforce the importance of forest fragments for certain populations of birds and therefore for the conservation of birds locally. Environmental heterogeneity is an important factor for the conservation of biodiversity and therefore, is essential to the maintenance of forest fragments in areas of activities affecting the soil cover. Moreover, the results also highlight that forest fragments are important to research, since they contribute to understanding species distribution on a landscape scale, providing data for management strategies.

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