

FOREST FRAGMENTATION AND IMPACTS ON THE BIRD COMMUNITY¹

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ABSTRACT – The study aimed at verifying the patterns of bird community related to different land-use/land-cover. The study area was a Conservation Unit and its buffer area. We used the fixed-point method, visiting 80 points in five times, through one year. The points were plotted in lands agriculture (AGR) and planted forest (FP) and, in areas covered by native forest (NF). The diversity index (H'), abundance (IPA), richness (X^2) and categories of species-trophic were calculated, as well as the difference between H' and X^2 according to land-use/land-cover was verified by an ANOVA. We also evaluated the taxonomic and functional similarity of the bird community, based in IPA and bird presence/absence. There were significant differences for both X^2 and H' , comparing NF and FP; NF and AGRP and; AGRP and FP. Concerning the trophic categories, the significant differences were between NF and AGRP and; FP and AGRP, because AGRP is a homogeneous environment with less diversity of resources. Conversely, NF and FP presented similarities as a consequence of the heterogeneity of its structures that subsidize greater avifauna stability than other land-use/land-cover. We conclude that the bird diversity and richness is related to the complexity of the landscape structure.

Keywords: *Forest Conservation, Connectivity, Birds diversity.*

A FRAGMENTAÇÃO FLORESTAL E OS IMPACTOS NA COMUNIDADE DE AVES

RESUMO – O estudo teve por objetivo verificar os padrões da comunidade de aves associados a diferentes usos e cobertura do solo. A área de estudo foi uma unidade de conservação e faixa de entorno, utilizando-se o método dos pontos fixos para detecção das espécies de aves em 80 pontos visitados cinco vezes, durante o período de um ano. As observações foram realizadas em áreas utilizadas por usos classificados como agricultura (AGR) e floresta plantada (FP) e, também, cobertos por mata nativa (MNA) da região. Calculou-se os índices diversidade (H'), pontual de abundância (IPA), riqueza (X^2) e as categorias tróficas das espécies, verificando-se a diferença entre H' e X^2 , em função dos usos e cobertura do solo, por meio de uma ANOVA. A partir dos dados de IPA e presença/ausência de espécies nas categorias tróficas avaliou-se, ainda, a similaridade taxonômica e funcional da comunidade de aves. MNA e FP apresentaram diferenças significativas tanto para X^2 como para H' , assim como entre MNA e AGRP e, entre AGRP e FP. Já para as categorias tróficas, obteve-se diferenças significativas entre MNA e AGRP e, entre FP e AGRP, em função de AGRP ser um ambiente homogêneo e, assim, com menor diversidade de recursos. Houve, portanto, similaridade entre MNA e FP, como consequência da heterogeneidade de suas estruturas que permite maior estabilidade da avifauna, em relação aos demais usos do solo. Conclui-se que a diversidade e riqueza de espécies de aves está relacionada à complexidade da estrutura da paisagem.

Palavras-Chave: *Conservação florestal; Conectividade; Diversidade de aves*



1. INTRODUCTION

The natural forest has been converted into modified landscapes due to the accelerated population growth and increasing demands for agricultural activity and forest products (Laurance et al., 2014). As the main consequences, we have the area reduction of affected habitats with edge increasing and clearings presence (Brummelhaus et al., 2012; Scolozzi and Geneletti, 2012).

Characterizing by a high heterogeneity level, the altered landscape presents composition and spatial configuration which are different from their original (Tschamtkke et al., 2012; Newbold et al., 2014). In this context, forest patch size, its proximity to others and, therefore, the natural vegetation structure and composition influence into species persistence as well as, in different ways, into biodiversity (Pardini et al., 2010; Vogel et al., 2011).

Related biodiversity depreciation with species, Norris et al. (2010) highlights the problems of fauna movement, while Cushman et al., (2012) the permanence of populations in the landscape.

Thus, the landscape heterogeneity and land use influence in the biodiversity of the agricultural landscapes (Fischer et al., 2011; Chiron et al., 2014). Agricultural plantations can serve as a barrier to the passage and dispersal of fauna (Villard and Haché, 2012) especially, considering that some animal species only cross these areas without using their available resources (Azevedo et al., 2010).

Antongiovanni and Metzger (2005) and Neuschulz et al. (2013) indicated the bird communities in the evaluation of forest patches connectivity, especially in the studies that investigated the matrices influence into species diversity. The birds support the knowledge about fragmentation process scale. According to Vandewalle et al. (2010) because there is a great deal knowledge about bird species biology and ecology, which have already been scientifically cataloged and compiled by forest formation.

The birds also perform functions in the forest systems, highlighting the processes of pollination and dispersion of seeds, i.e. promoting the genetic flow of plant species among forest remnants (Sethi and Howe, 2009; Anderson et al., 2011). This way, they act as connectors of landscape units, influencing the resilience of the forest under anthropic alterations (Lundberg and Moore, 2003).

In this context, the study aimed at verifying the patterns of bird community related to different land-use/land-covers. An agricultural and anthropic landscape, originally covered by Atlantic Forest, was used as the study area, showing several current vegetative types.

2. MATERIAL AND METHODS

2.1. Study area

The study area was the Capão Bonito National Forest (CBNF) and its surrounding area (Figure 1), comprising a total area of 74,575 ha, wherein the CBNF represents 4,773.83 ha and the surrounding area comprises 69,790.65 ha. Considering that the CBMF Management Plan is in elaboration because it will be supported by this work among others, we considered a surrounding area of 10 km from the perimeter protected area as a primary study.

This landscape has been studied by several groups of researchers, which consider its relevance for the biodiversity conservation, taking into account its potential for connectivity with other parks. CBNF is approximately 65 km from other relevant to conservation areas as the Intervales State Park, Carlos Botelho State Par and Ecological Station of Angatuba, which are, respectively, in South, Southeast, and Northwest from its limits.

Relating to the landscape land-use/land-cover, we produced a map by supervised digital classification (Maximum Likelihood algorithm) of SPOT satellite images (2,5m-spatial; 2009-year), having a global accuracy of 99.14% (Figure 1).

According to this map, the study area is predominantly agricultural, where cultures as corn, soy and wheat crops occupy 40% of its area, mainly out of the NF.

Native forest represents 24.45% of the landscape with remaining of Ombrophilous Dense and Seasonal Semideciduous forest formations. So, the landscape has remnants of the Atlantic Forest biome - already classified by Myers et al., (2000) as one of the five hotspots for preservation.

The planted forest occupies 20.62% of the area, which is distributed into Araucaria (2.85%), Eucalyptus (11.06%), and Pinus (6.71%) plantations. Inside the NF, however, Araucaria and Pinus plantations are predominant.

The pasture is present in the South portion, representing 10.77% of the landscape.

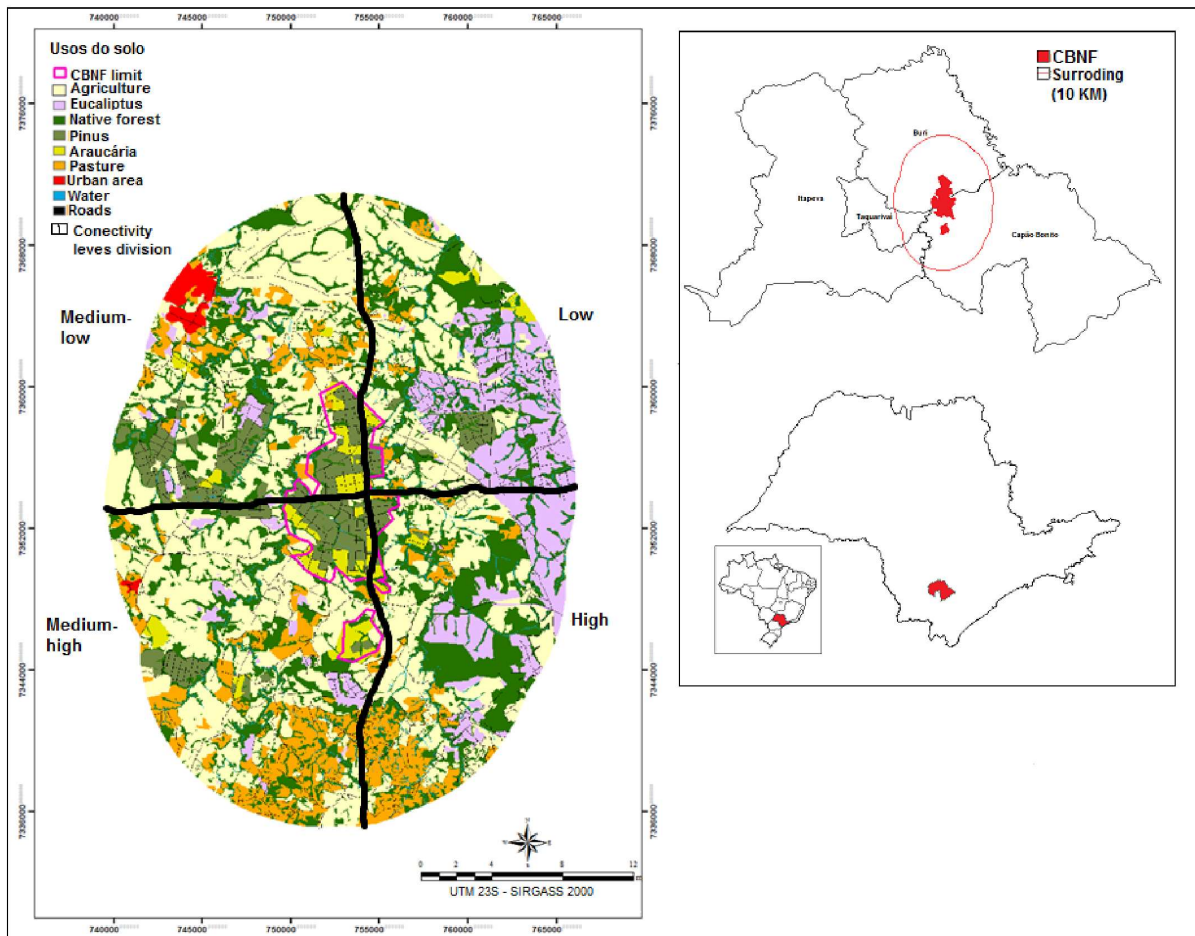


Figure 1 – Capão Bonito National Forest (CBNF) and its surrounding location (Sao Paulo state, Brazil) and land-use/land-cover with a division into quadrants, according to previous connectivity level evaluation of forest patches (low, medium-low, medium-high and high).

Figura 1 – Floresta Nacional de Capão Bonito (CBNF) e sua localização no entorno (estado de São Paulo, Brasil) e uso da terra / cobertura da terra com uma divisão em quadrantes, de acordo com a avaliação anterior do nível de conectividade dos fragmentos florestais (baixo médio-baixo, médio-alto e alto).

2.2. Sampling Design

Concerning landscape structure, similar land uses were grouped (relative to bird species diversity and distribution), resulting in the following categorical levels: Native Forests (MNA): native forest vegetation remnants; Planted Forests (FP): areas occupied with pine, eucalyptus and Araucaria planted forests; and Agriculture (AGRP): croplands like corn, soybean and wheat, and pastures.

Trails for bird survey were placed to begin and finish at the same land use level to represent the study

area. For that reason, the landscape was subdivided in four sectors (quadrants) that received the same number of trails (Figure 1).

Sample sufficiency was defined through simulation (in GENPRES software) considering the study area extension and relative densities of bird species with knowledge occurrence obtained from literature (MMA/ICMBio, 2018). Then, 80 points distributed in 16 trails were obtained, one kilometer of length each, in pairs where each trail was allocated at 500 m from the other. Each single trail had a total of five sample points 250m

distant from each other. The number of points at each land use level was 35 at MNA, 27 at FP and 18 at AGRP.

2.3. Bird Survey

Bird species detections were obtained from fixed points (Robbins, 1978), considered by Reynolds et al. (1980) as a method that permits higher uniformity in the study area evaluation.

Monthly surveys took place at the first week every month during a year (December 2013 to December 2014). Data collecting started at the first 30 minutes after sunrise and lasted for about three hours. Observation time length was stipulated to be of ten minutes (Lynch, 1995; Ralph et al., 1995).

2.4. Data Analysis

The bird species survey subsidized the calculation of Point Abundance Index (IPA) for each species, which is obtained from the ratio of number of contacts with a given species and total number of surveyed points (Donatelli et al., 2007; Vielliard et al., 2010).

Detected bird species were assigned to trophic categories as follows: carnivores (CAR), scavengers (DET), fruit-feeders (FRU), seed-feeders (GRA), insectivores (INS), nectar-feeders (NEC), omnivores (ONI) and fish-feeders (PIS) (Motta-Júnior, 1990; Donatelli et al., 2007). Taxonomic nomenclature agrees with the ninth edition of "List of Birds from Brazil" (CBRO, 2014).

Aiming to assess differences among avian community patterns of diversity (H') and richness (X^2) associated to different land-uses/land-cover, an analysis of variance (ANOVA) was performed, followed by a Tukey's post-hoc test. In order to verify the similarity amongst taxonomic and functional composition at distinct land uses and covers non-metric multidimensional scaling (NMDS) was used, with significance checked by permutational analysis of variance (PERMANOVA) (Legendre and Legendre, 2012).

Point Abundance Indexes (IPA) were evaluated through Bray-Curtis distance (Clarke and Gorley, 2006) for taxonomic component and Jaccard distance for trophic categories, computed as presence-absence matrix (Dorazio et al., 2011).

3. RESULTS

Avian community in the landscape, composed by the Capão Bonito National Forest (CBNF) and its surrounding varied in function of land-use/land-cover.

A total number of 109 species was sighted, distributed in 44 families and 17 orders (Table 1).

Species listed as Near threatened in IUCN are *Eleoscytalopus indigoticus* (Wied, 1831) (White-Breasted Tapaculo), *Leptasthenura setaria* (Temminck, 1824) (Araucaria Tit-Spinetail) and *Hemitriccus orbitatus* (Wied, 1831) (Eye-Ringed Tody-Tyrant). *Procnias nudicollis* (Vieillot, 1817) (Bare-Throated Bellbird) is listed as Vulnerable. The first three species were detected exclusively in native forest areas, with an IPA value of 0.0057 in MNA, whereas the former species was detected in land uses and covers, with a global IPA of 0.0045 and 0.0743 in MNA, 0.0593 in AGRP and, 0.0333 in FP.

Species with higher IPA were *Patagioenas picazuro* (Temminck, 1813) (Picazuro Pigeon) (0.1075), *Leptotila verreauxi* (Bonaparte, 1855) (White-Tipped Dove) (0.0850), *Basileuterus culicivorus* (Deppe, 1830) (Golden-Crowned Warbler) (0.0850) (Table 1).

Although, not in the same order, same species had higher IPA in MNA when the index was considered separately for each land use and cover. At AGRP, the species with higher global rank, Picazuro Pigeon, did not appear among the highest IPAs, at FP there were three species distinct from those with higher IPA, one of which *Zonotrichia capensis*, Rufous-Collared Sparrow was common to AGRP.

Therefore, species ranked for MNA were: *Leptotila verreauxi* (0.2629), *Patagioenas picazuro* (0.1943) and *Basileuterus culicivorus* (0.1200). For AGRP species there were *Basileuterus culicivorus* (0.1481), a *Leptotila verreauxi* (0.0889) e *Zonotrichia capensis* (0.0741), which were not ranked before and had the higher IPA at FP (0.2), followed by *Serpophaga subcristata* (Vieillot, 1817) (White-Crested Tyrannulet) (0.1667) and *Caracara plancus* (Southern Caracara) (Miller, 1777) (0.1111).

Concerning to the distribution of species in trophic category levels, 86% belonged to one of three main levels: insectivores (47%), omnivores (29%) and seed-feeders (10%) (Figure 2).

Species diversity (H') and richness (X^2) were found to be different, especially amongst MNA and FP, even when values of H' ($n=3$, $F=6.95E-02$, $p<0.05$) and X^2 ($n=3$, $F=0.001017$, $p<0.05$) were modeled in function of quality and availability of resources from land uses and covers (Figure 3).

Table 1 – Bird species, trophic categories (CT) and Punctual Index of Abundance (IPA) obtained in CBNF and its surrounding (SP, Brazil).

Table 1 – Espécies de aves, categorias tróficas (CT) e Índice Pontual de Abundância (IPA) obtidos na CBNF e seus arredores (SP, Brasil).

Família	Espécie	CT	IPA			
			Global	MNA	AGRP	FP
TINAMIDAE	<i>Rhynchotus rufescens</i> (Temminck, 1815)	ONI	0,0300	0,0286	0,0074	0,0666
	<i>Crypturellus obsoletus</i> (Temminck, 1815)	ONI	0,0025	0	0,0074	0
CRACIDAE	<i>Penelope superciliaris</i> (Temminck, 1815)	FRU	0,0050	0,0114	0,0074	0
THRESKIORNITHIDAE	<i>Theristicus caudatus</i> (Boddaert, 1783)	ONI	0,0050	0	0	0,0333
ARDEIDAE	<i>Egretta thula</i> (Molina, 1782)	PIS	0,0025	0	0	0,0222
CATHARTIDAE	<i>Coragyps atratus</i> (Bechstein, 1793)	DET	0,0175	0,0343	0,0074	0,0333
ACCIPITRIDAE	<i>Elanus leucurus</i> (Vieillot, 1818)	CAR	0,0025	0,0057	0	0
	<i>Rupornis magnirostris</i> (Gmelin, 1788)	CAR	0,0150	0,0171	0,0074	0,0333
FALCONIDAE	<i>Caracara plancus</i> (Miller, 1777)	CAR	0,0225	0,0114	0,0074	0,1111
	<i>Milvago chimachima</i> (Vieillot, 1816)	CAR	0,0300	0,0229	0,037	0,0444
RALLIDAE	<i>Aramides saracura</i> (Spix, 1825)	ONI	0,0075	0	0	0
	<i>Pardirallus nigricans</i> (Vieillot, 1819)	ONI	0,0050	0	0	0,0222
CARIAMIDAE	<i>Cariama cristata</i> (Linnaeus, 1766)	INS	0,0175	0,0057	0	0,0777
CHARADRIIDAE	<i>Vanellus chilensis</i> (Molina, 1782)	ONI	0,0375	0,0286	0,0074	0,0233
COLUMBIDAE	<i>Columbina talpacoti</i> (Temminck, 1810)	GRA	0,0150	0,0343	0	0,0222
	<i>Patagioenas picazuro</i> (Temminck, 1813)	FRU	0,1075	0,1943	0,2000	0,0155
	<i>Patagioenas cayennensis</i> (Bonnaterre, 1792)	GRA	0,0100	0,0171	0	0,0111
	<i>Zenaida auriculata</i> (Des Murs, 1847)	GRA	0,0500	0,0286	0,0222	0,0266
	<i>Leptotila rufaxilla</i> (Richard; Bernard, 1792)	GRA	0,0275	0,0343	0,0296	0,0111
	<i>Leptotila verreauxi</i> (Bonaparte, 1855)	FRU	0,0850	0,2629	0,0889	0,0222
PSITTACIDAE	<i>Pionus maximiliani</i> (Kuhl, 1820)	FRU	0,0200	0,0171	0,0148	0,0333
CUCULIDAE	<i>Tapera naevia</i> (Linnaeus, 1766)	INS	0,0075	0,0057	0,0148	0
	<i>Piaya cayana</i> (Linnaeus, 1766)	INS	0,0100	0,0114	0,0074	0,0111
	<i>Guirra guirra</i> (Gmelin, 1788)	INS	0,0025	0	0	0,0111
STRIGIDAE	(Molina, 1782) <i>Athene cunicularia</i>	CAR	0,0050	0	0	0,0222

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TROCHILIDAE	<i>Thalurania glaucopis</i> (Gmelin, 1788)	NEC	0,0150	0,0229	0,0148	0
	<i>Leucochloris albicollis</i> (Vieillot, 1818)	NEC	0,0125	0,0343	0	0,0111
	<i>Amazilia láctea</i> (Lesson, 1832)	NEC	0,0275	0,0571	0,0222	0,0111
RAMPHASTIDAE	<i>Ramphastos toco</i> (Statius Muller, 1776)	ONI	0,0025	0	0	0,0222
PICIDAE	<i>Picumnus temminckii</i> (Lafresnaye, 1845)	INS	0,0100	0,0114	0,0074	0,0111
	<i>Melanerpes candidus</i> (Otto, 1796)	INS	0,0075	0,0057	0,0074	0,0111
	<i>Veniliornis spilogaster</i> (Wagler, 1827)	INS	0,0025	0,0057	0	0
	<i>Colaptes campestris</i> (Vieillot, 1818)	INS	0,0250	0,0229	0,0074	0,1000
	<i>Colaptes melanochloros</i> (Gmelin, 1788)	INS	0,0025	0	0,0074	0
	<i>Celeus flavescens</i> (Gmelin, 1788)	INS	0,0075	0,0114	0	0,0111
XENOPIDAE	<i>Xenops rutilans</i> (Temminck, 1821)	INS	0,0025	0,0057	0	0
RHINOCRYPTIDAE	<i>Eleoscytalopus indigoticus</i> (Wied, 1831)	INS	0,0025	0,0057	0	0
THAMNOPHILIDAE	<i>Mackenziaena severa</i> (Lichtenstein, 1823)	INS	0,0050	0,0114	0	0,0111
	<i>Dysithamnus mentalis</i> (Temminck, 1823)	INS	0,0075	0,0114	0,0074	0
	<i>Thamnophilus caerulescens</i> (Vieillot, 1816)	INS	0,0450	0,1086	0,0296	0
	<i>Pyriglena leucoptera</i> (Vieillot, 1818)	INS	0,0175	0,0343	0,0148	0
	<i>Drymophila malura</i> (Temminck, 1825)	INS	0, 0125	0,0114	0,0222	0
CONOPOPHAGIDAE	<i>Conopophaga lineata</i> (Wied, 1831)	INS	0,0050	0,0114	0	0
SCLERURIDAE	<i>Sclerurus scansor</i> (Ménétrières, 1835)	INS	0,0025	0,0057	0	0
DENDROCOLAPTIDAE	<i>Sittasomus griseicapillus</i> (Vieillot, 1818)	INS	0,0100	0,0229	0	0
	<i>Xiphorhynchus fuscus</i> (Vieillot, 1818)	INS	0,0075	0,0057	0,0074	0,0111
FURNARIIDAE	<i>Furnarius rufus</i> (Gmelin, 1788)	INS	0,0125	0,0057	0	0,0444
	<i>Automolus leucophthalmus</i> (Wied, 1821)	INS	0,0075	0,0171	0	0
	<i>Syndactyla rufosuperciliata</i> (Lafresnaye, 1832)	INS	0,0025	0,0057	0	0
	<i>Leptasthenura setaria</i> (Temminck, 1824)	INS	0,0025	0,0057	0	0
	<i>Synallaxis ruficapilla</i> (Vieillot, 1819)	INS	0,0050	0,0057	0,0074	0
	<i>Synallaxis spixi</i>	INS	0,0050	0,0057	0	0,0111

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PIPRIDAE	(Sclater, 1856) <i>Chiroxiphia caudata</i>	ONI	0,0525	0,0857	0,0667	0,0111
TITYRIDAE	(Shaw; Nodder, 1793) <i>Schiffornis virescens</i>	ONI	0,0175	0,0229	0,0148	0,0111
COTINGIDAE	(Lafresnaye, 1838) <i>Procnias nudicollis</i>	FRU	0,0450	0,0743	0,0593	0,0333
TYRANNOIDEA	(Vieillot, 1817) <i>Platyrinchus mystaceus</i>	INS	0,0050	0,0057	0,0074	0
RYNCHOCYCLIDAE	<i>Corythopsis delalandi</i>	INS	0,0050	0,0114	0	0
	(Lesson, 1830)					
	<i>Tolmomyias sulphurescens</i>	INS	0,0125	0,0171	0,0296	0
	(Spix, 1825)					
	<i>Hemitriccus orbitatus</i>	INS	0,0025	0,0057	0	0
	(Wied, 1831)					
TYRANNIDAE	<i>Todirostrum poliocephalum</i>	INS	0,0050	0,0114	0,0074	0
	(Wied, 1831)					
	<i>Todirostrum cinereum</i>	INS	0,0025	0,0057	0	0
	(Linnaeus, 1766)					
	<i>Poecilatriccus plumbeiceps</i>	INS	0,0025	0,0057	0	0
	(Lafresnaye, 1846)					
TYRANNIDAE	<i>Myiarchus tyrannulus</i>	INS	0,0075	0,0057	0	0,0222
	(Statius Muller, 1776)					
	<i>Camptostoma obsoletum</i>	INS	0,0100	0,0343	0	0
	(Temminck, 1824)					
	<i>Elaenia flavogaster</i>	ONI	0,0125	0,0286	0	0,0111
	(Thunberg, 1822)					
	<i>Elaenia mesoleuca</i>	ONI	0,0075	0,0286	0	0
	(Deppe, 1830)					
	<i>Serpophaga subcristata</i>	INS	0,0150	0,0171	0	0,1667
	(Vieillot, 1817)					
	<i>Myiodynastes maculatus</i>	ONI	0,0150	0,0400	0,0074	0
	(Statius Muller, 1776)					
	<i>Pitangus sulphuratus</i>	INS	0,0375	0,0629	0,0074	0,0778
	(Linnaeus, 1766)					
<i>Machetornis rixosa</i>	ONI	0,0075	0,0171	0	0	
(Vieillot, 1819)						
<i>Megarynchus pitangú</i>	ONI	0,0075	0,0229	0	0	
(Linnaeus, 1766)						
<i>Tyrannus melancholicus</i>	INS	0,0050	0,0057	0,0222	0	
(Vieillot, 1819)						
<i>Myiophobus fasciatus</i>	INS	0,0050	0,0114	0	0	
(Statius Muller, 1776)						
<i>Myiarchus swainsoni</i>	INS	0,0025	0,0057	0	0	
(Cabanis; Heine, 1859)						
<i>Lathrotriccus euleri</i>	INS	0,0050	0	0,0074	0	
(Cabanis, 1868)						
VIREONIDAE	<i>Cyclarhis gujanensis</i>	INS	0,0475	0,0857	0,0593	0,0111
	(Gmelin, 1789)					
	<i>Vireo chivi</i>	INS	0,0475	0,1143	0,0444	0,0222
(Vieillot, 1817)						
<i>Hylophilus poicilotis</i>	INS	0,0050	0,0057	0,0222	0	
(Temminck, 1822)						
CORVIDAE	<i>Cyanocorax cristatellus</i>	ONI	0,0025	0	0	0,0111
	(Temminck, 1823)					
	<i>Cyanocorax chrysops</i>	ONI	0,0025	0	0	0,0111
	(Vieillot, 1818)					

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TROGLODYTIDAE	<i>Troglodytes musculus</i> (Naumann, 1823)	INS	0,0125	0,0114	0	0,0222
TURDIDAE	<i>Turdus amaurochalinus</i> (Cabanis, 1850)	ONI	0,0250	0,0286	0,0296	0,0111
	<i>Turdus subalaris</i> (Seebohm, 1887)	ONI	0,0025	0,0057	0	0
	<i>Turdus rufiventris</i>	ONI	0,0275	0,0343	0,0296	0,0222
	<i>Turdus leucomelas</i> (Vieillot, 1818)	ONI	0,0225	0,0286	0,0370	0,0111
	<i>Turdus albicollis</i> (Vieillot, 1818)	ONI	0,0150	0,0229	0,0296	0
MOTACILLIDAE	<i>Anthus lutescens</i> (Pucheran, 1855)	INS	0,0075	0	0	0,0333
THRAUPIDAE	<i>Coereba flaveola</i> (Linnaeus, 1758)	ONI	0,0075	0,0114	0,0074	0
	<i>Tachyphonus coronatus</i> (Vieillot, 1822)	ONI	0,0275	0,0457	0,0222	0,0111
	<i>Lanio melanops</i> (Vieillot, 1818)	GRA	0,0025	0	0,0074	0
	<i>Tangara sayaca</i> (Linnaeus, 1766)	ONI	0,0150	0,0229	0,0148	0
	<i>Tangara cayana</i> (Linnaeus, 1766)	ONI	0,0150	0,0171	0	0,0444
	<i>Saltator similis</i> (d'Orbigny; Lafresnaye, 1837)	ONI	0,0200	0,0286	0,0370	0
	EMBERIZIDAE	<i>Ammodramus humeralis</i> (Bosc, 1792)	GRA	0,0200	0,0171	0,0074
	<i>Zonotrichia capensis</i> (Statius Muller, 1776)	GRA	0,0575	0,0800	0,0741	0,2000
	<i>Sicalis citrina</i> (Pelzeln, 1870)	GRA	0,0100	0,0114	0	0,0555
	<i>Sicalis flaveola</i> (Linnaeus, 1766)	GRA	0,0025	0	0	0,0111
	<i>Volatinia jacarina</i> (Linnaeus, 1766)	GRA	0,0375	0,0400	0,0370	0,1000
	<i>Sporophila caerulescens</i> (Vieillot, 1823)	GRA	0,0075	0	0,0074	0,0222
CARDINALIDAE	<i>Habia rubica</i> (Vieillot, 1817)	ONI	0,0050	0,0057	0	0,0222
PARULIDAE	<i>Setophaga pitiayumi</i> (Vieillot, 1817)	INS	0,0125	0,0229	0	0,0111
	<i>Geothlypis aequinoctialis</i> (Gmelin, 1789)	INS	0,0050	0,0114	0	0
	<i>Basileuterus culicivorus</i> (Deppe, 1830)	INS	0,0850	0,1200	0,1481	0,0222
	<i>Myiothlypis leucoblephara</i> (Vieillot, 1817)	INS	0,0350	0,1029	0,0222	0
ICTERIDAE	<i>Gnorimopsar chopi</i> (Vieillot, 1819)	ONI	0,0025	0	0	0,0111
	<i>Pseudoleistes guirahuro</i> (Vieillot, 1819)	ONI	0,0025	0	0	0,0111
	<i>Molothrus bonariensis</i> (Gmelin, 1789)	ONI	0,0025	0	0	0,0111
	<i>Psarocolius decumanus</i> (Pallas, 1769)	ONI	0,0050	0,0057	0	0,0111

Where: CAR: carnivores; DET: scavenger; FRU: fruit-feeders; GRA: seed-feeders; INS: insectivores; NEC: nectar-feeders; ONI: omnivores e PIS: fish-feeders. MNA: native; AGR: agriculture; PAS: pasture; FPP: Pinus planted forest; FPE: Eucalyptus planted forest e FPA: Araucária planted forest.

In contrast with patterns observed for H' and X^2 , values of IPA at MNA and FP were highly similar ($p=0.0124$), as for MNA and AGRP ($p=0.0001$) and, AGRP and FP ($p=0.0001$) (Figure 3A). In opposition, trophic categories were significantly different between MNA and AGRP ($p=0.0001$) as for AGRP and PF ($p=0.0043$) (Figure 3B).

4. DISCUSSION

The agricultural landscape matrix influenced the bird community, with MNA, FP, and AGRP showing species with several IPA values, considering their different ability to provide resources. Therefore, the patterns of bird abundance were influenced by the landscape heterogeneity (Mcgarigal and Cushman, 2002).

The MNA, which has the greatest ability to provide resources, presents three species, having intrinsic characteristics and, classified as “Near Threatened” of extinction. They have the forest, especially Atlantic Forest, as the natural habitat. Among them, the *Eleoscytalopus indigoticus* (White-Breasted Tapaculo) and the *Leptasthenura setariave* (Araucaria Tit-Spintail) can also be associated with the Araucaria forest (Sigrist, 2013; Antunes et al., 2013).

The third species (i.e. *Procnias nudicollis*; Bare-Throated Bellbird) show the highest IPA value for MNA (among the three species), belong to “Vulnerable” category, and has the Atlantic Forest as habitat. Although, we also registered its presence in FP and AGRP, having IPA value higher than the two first species and, occupying the seventh highest IPA value, when we evaluated the three categories together (MNA, FP, and AGRP).

On the other side, the highest IPA value obtained for MNA as well as the FP, and the AGR is related to species with general habits, that adapt to environments with different conditions.

Amongst them, are the *Leptotila verreauxi* (White-Tipped Dove) and the *Basileuterus culicivorus* (Golden-Crowned Warbler), which are registered in MNA and AGRP. Normally, the first occurs in open and shrubby areas, preferring the edge of the forests, open forests, and forests surrounded by agriculture (Sigrist, 2013). The second species inhabits several environments, from forest areas, Restinga, to areas suffering from anthropic actions, but its population has been suffering a decline due to the destruction of forest habitats (Sigrist, 2013).

In turn, the *Patagioenas picazuro* (Picazuro Pigeon) was observed only in MNA. According to Del Hoyo et al., (1997), the species have increased its population due to the expansion of the forest degradation, that provides a favorable environment for this species.

Associated with the AGRP and FP, we obtained the *Zonotrichia capensis* (Rufous-Collared Sparrow), which have been found in several habitats, from forest to pastures, rural, and urban areas. In the case of forest, although, the species prefers the clearings and the edge areas (Class and Moore, 2010; Class et al., 2011).

In FP, we highlight the species (Vulnerable; with the highest IPA value) *Serpophaga subcristata* and *Caracara plancus*. The first requires areas with shrub, favoring its presence in several environmental (Vogel et al., 2011). This requirement is in accordance with the study area, where the most part of FP has understory of native species. The same way, the *Caracara plancus* can occur in several habitats, from open fields, forest

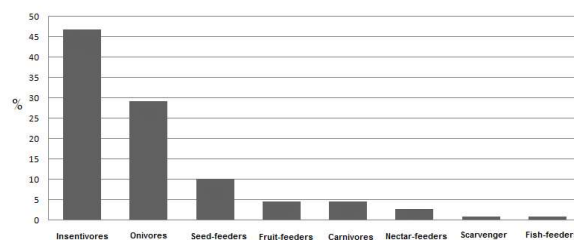


Figure 2 – Bird species per trophic categories in Capão Bonito National Forest and its surrounding (SP, Brazil).
Figura 2 – Espécies de aves por categorias tróficas e Floresta Nacional de Capão Bonito e seus arredores (SP, Brasil).

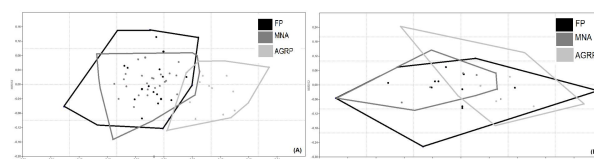


Figure 3 – Similarity among native forest (NF), planted forest (FP) and, agriculture and pasture (AGRP) relates to: (A) the Abundance Index (IPA); and categories of species-trophic, for bird species in Capão Bonito National Forest and its surrounding (SP, Brazil).
Figura 3 – Similaridade entre floresta nativa (NF), floresta plantada (PF) e agricultura e pastagem (AGRP) para: (A) o Índice de Abundância (IPA); e categorias de espécies-tróficas, para espécies de aves em Floresta Nacional de Capão Bonito e seus arredores (SP, Brasil).

edges, savannahs, river banks, to urban areas (Sick, 1997; Antunes et al., 2013).

In this context, landscape patches that have a similar structure, as MNA and FP, present similar species abundance (Figure 3), that are superior to homogeneous patches, as AGR. Therefore, they contribute to increment of avifauna stability in the landscape (Jiang and Pu, 2009; Downing et al., 2014), supporting better conditions of species surviving and, being adequate places for nesting, resources stabilization, and refuge for environmental stressors (Brown, 2007).

Considering the patches structure, MNA and FP also present similarity for their trophic categories, that are dissimilar of AGR (Figure 3B). So, differences in structure, availability of food resources, and land-uses/land-covers were responsible for the differences, in the species occurrence and trophic categories.

The insectivorous and the omnivorous are the trophic categories present in MNA, which were also predominant at small remains forest (Southeastern São Paulo), wherein frugivores decreased (Willis, 1979). Similarly, Ruiz-Gutierrez et al., (2008) obtained the smaller abundance for frugivores, in landscapes tropical, fragmented, and anthropized. According to Sodhi et al. (2014) because there are not fruits during the year and, because these species present a specialized diet, being more vulnerable to anthropic alterations and food availability (Donatelli et al., 2007).

The insectivorous also were the most representative trophic category in the FP and AGR (Figure 2), which is a characteristic pattern of tropical regions (Telino-Júnior et al., 2005; Donatelli et al., 2007).

Conversely, the carnivorous species showed the lesser representativeness (Figure 2) in the landscape, because they are larger than others, have a population with lower density, have lower survival rate, and need larger area (extension) to survive (Sieving and Karr, 1997).

The bird richness and diversity were also influenced by the environment structure and availability of resources, having MNA the greatest richness of species (total of 90). This cover has availability of trees, which usually increases the resources availability (nesting and foraging) and, consequently, increasing the bird wealth and abundance.

On the other hand, FP showed richness and abundance values lower than MNA, reflecting a general pattern associated to monoculture plantations, independently of the tree species

(Barlow et al., 2007). Consequently, we observed a significant difference, in terms of bird diversity, between MNA and FP.

So, the fragmentation process, that causes land-use/land-cover alterations modify the bird community (in terms of species composition) and alters the trophic categories of habitats. According to Ries et al., (2004) during this process, a habitat as the native forest has the reduction of its quality. The study area species, associated with MNA, have usually searched for other land-uses to resources compensation, characterizing several changes in the bird community.

5. CONCLUSION

In the study area, the forest fragmentation process influences directly the bird community in term of their abundance, richness, and diversity. These three variables are intrinsically related to landscape structure and composition, in terms of land-use/land-cover.

So, the species diversity is related to the land-use/land-cover complexity, which presents the pattern of trophic categories that is typical of tropical and fragmented regions.

In this context, we conclude that the native forest (i.e. MNA category), despite its high level of fragmentation, is the category that preserves greater biodiversity, in terms of species richness and diversity.

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