Bird assembly of Gurupi Forest: who is who in the last continuous forest remnant in south-eastern Amazonia

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Keywords: Belém Center of Endemism; bird communities; bird conservation; forest fragmentation.

ABSTRACT – We sampled bird species occurrence along two trails with 12 points each, over four counts: two in the dry season and two in the rainy season, between June 2010 and December 2013, on the southern edge of the Gurupi Biological Reserve (GBR), Maranhão, in the Belém Endemism Center (BCE), which is the easternmost and one of the most threatened regions of the Amazon. The primary goal was to study the composition of the bird assembly in the area. We recorded 182 species from 41 families, with the total estimated species richness for the continuous terra firme forest patch at 250 species. Total Shannon diversity was 4.253, remaining similar across locations and seasons. Six taxa were considered endemic to the BCE, and fifteen were deemed threatened either in Brazil or globally. The assembly was primarily typical of primary tropical forest, with many species highly sensitive to habitat alterations and indicative of preserved Amazon rainforest, though with a few species indicative of disturbed habitats. Several understory thamnophilid species were among the most frequently recorded, while the Psittacidae was the family with the highest total number of species. *Psophia obscura*, classified as critically endangered, was observed multiple times during sampling. Some BCE-endemic taxa were also among the most frequently sampled species, indicating a notably idiosyncratic community composition. Our findings reinforce the extreme importance of the GBR as a strategic region for the conservation of both threatened bird species and bird communities in the BCE. We recommend a complete halt to deforestation in Maranhão to preserve bird species and communities.

Assembleia de aves da Floresta do Gurupi: quem é quem no último remanescente florestal contínuo no sudeste da Amazônia

Palavras-chave: Centro de Endemismo Belém; comunidades de aves; conservação das aves; fragmentação de florestas.

RESUMO – Amostramos a ocorrência de espécies de aves em duas trilhas com 12 pontos cada, durante quatro contagens: duas na estação seca e dois na chuvosa, entre junho de 2010 e dezembro de 2013, na borda sul da Reserva Biológica do Gurupi (GBR nas siglas em inglês), Maranhão, no Centro de Endemismo Belém (BCE nas siglas em inglês), a mais oriental e uma das mais ameaçadas das regiões da Amazônia. O objetivo principal foi estudar a composição da assembleia de aves da área. Registramos 182 espécies de 41 famílias, sendo que a riqueza total em espécies da mancha contínua de floresta de terra firme foi estimada em 250 espécies. A diversidade total Shanon foi de 4,253, sendo similar entre locais e estações do ano. Seis *taxa* foram considerados endêmicos do BCE. Quinze foram considerados ameaçados, ora no Brasil ou globalmente. A assembleia foi principalmente típica de floresta tropical primária, com muitas espécies altamente sensíveis a alterações do *habitat*, e indicadoras de floresta amazônica preservada, mas também com umas poucas espécies indicadoras de *habitat* alterados. Várias espécies de tamnofilídeos de sub-bosque estiveram entre as espécies mais frequentes, e os psitacídeos foram a família com o maior número total de espécies. *Psophia obscura,* classificado como criticamente ameaçado, foi encontrado várias vezes durante as amostragens. Alguns *taxa* endêmicos do BCE estiveram também entre as espécies mais frequentemente amostradas, indicando uma composição da comunidade notavelmente idiossincrática. Os nossos resultados reforçam a extrema importância da GBR como uma região estratégica para a conservação tanto das espécies de aves ameaçadas quanto das comunidades de aves do BCE. Recomendamos terminar completamente o desmatamento no Maranhão para preservar as espécies e comunidades de aves.

Asamblea de aves del Bosque de Gurupí: quién es quién en el último remanente forestal continuo del sudeste de la Amazonia

Palabras clave: Centro de Endemismo Belém; comunidades de aves; conservación de las aves; fragmentación de bosques.

RESUMEN – Muestreamos la presencia de especies de aves en dos senderos con 12 puntos cada uno, durante cuatro conteos, dos en la estación seca y dos en la lluviosa, entre junio de 2010 y diciembre de 2013, en el borde sur de la Reserva Biológica de Gurupí (GBR en las siglas en inglés), Maranhão, en el Centro de Endemismo Belém (BCE en inglés), la más oriental y una de las más amenazadas regiones de la Amazonia. El objetivo principal fue estudiar la composición de la asamblea de aves del área. Registramos un total de 182 especies de 41 familias, y la riqueza total en especies de la mancha continua de bosque de tierra firme fue estimada en 250 especies. La diversidad total Shannon fue de 4,523, siendo similar entre sitios y estaciones del año. Seis taxones fueron considerados endémicos del BCE. Quince fueron considerados amenazados en Brasil o globalmente. La asamblea fue principalmente típica de bosque tropical primario, con muchas especies altamente sensibles a alteraciones del hábitat, e indicadoras de bosque amazónico preservado, pero también con unas pocas especies indicadoras de hábitat alterados. Varias especies de tamnofílidos de sotobosque estuvieron entre las especies más frecuentes, y los psitácidos fueron la familia con el mayor número total de especies. *Psophia obscura*, clasificado como críticamente en peligro, fue encontrado varias veces durante los muestreos. Algunos taxones endémicos del BCE estuvieron también entre las especies más frecuentemente muestreadas, indicando una composición de la

comunidad notablemente idiosincrática. Nuestros resultados refuerzan la extrema importancia de la GBR como una región estratégica para la conservación tanto de las especies de aves amenazadas como de las comunidades de aves del BCE. Recomendamos suspender completamente la deforestación en Maranhão para preservar las especies y comunidades de aves.

Introduction

The Gurupi Biological Reserve (hereafter GBR), created by the Brazilian Federal Government in 1988 (Decree n. 95614), is an area of utmost importance for bird conservation in the lowland Amazon (IUCN category Ia). It is the only strictly protected area located in the Belém Center of Endemism (hereafter BCE), which is the smallest and most threatened of the eight endemism centers extant in the Amazon Basin [1][2]. The BCE is by far the most heavily deforested region in the entire Brazilian Amazon [3] [4], with only a few scattered fragments remaining, primarily located within reserves and indigenous lands [5].

The main threats to this center include disorderly land occupation, illegal logging, forest fires, and illegal deforestation driven by the expansion of agricultural activities *e.g.* [6][7][8]. About 80% of the BCE's original tropical forest has been lost or severely degraded [3][8][9][10][11][12][13]. The best preserved remaining areas correspond to the GBR and several Indigenous Lands in the same region, in the south-central part of BCE, in the state of Maranhão [3]. However, even these areas face ongoing threats from illegal logging and land occupation *e.g.* [6][7], and specially forest fires, which are often deliberate [4][8].

Although some relevant information about GBR is already available in the literature [12], the avifauna of this last remnant of continuous forest in BCE still requires to be more extensively studied. To date, no quantitative studies have been published on bird communities in the southern GBR, although a quantitative baseline study has been conducted in Paragominas, a neighboring area inside the BCE, [14]. However, Lima *et* al. [12] carried out a comprehensive survey of the GBR's avifauna, reporting the occurrence of 424 bird species for the entire region. Additionally, Pinheiro *et* al. [15] recorded 79 new species in the region, raising the total number to 503 species, making the GBR the site with the highest species richness in the entire BCE, even when compared to more diverse and better sampled areas, such as Grande Belém, with 490 species [16] or Paragominas, with 460 species [14][17]. Pinheiro *et* al. [15] also conducted a quantitative study of avifauna in the northern GBR.

The fieldwork for the present study was conducted largely concurrently with that of Lima *et* al. [12], so estimating the total species richness of the southern GBR was not our objective, as this was already being assessed by those authors. Instead, this study focused on the quantitative structure and composition of bird communities in the studied area.

Assessing the composition of the GBR's avifauna will help to better understand the original avifaunal composition of the entire BCE [18], as much of the Center's original forest cover has been lost. Thus, the last forest remnants in Gurupi offer one of the last opportunities to carry out such samplings across the BCE. Furthermore, a biogeographical question can be addressed through these samplings: a decline in forest bird species richness is expected [19] [20] from the better-preserved central regions of the BCE to the more peripheral areas, which suffer higher levels of deforestation and fragmentation [3][13][21].

Thus, the Gurupi avifauna can serve as a reference for comparison with avifaunas from more peripheral aras in BCE, and then assess to what extent either the geographical location of a given site, or its degree of habitat loss, affect the composition and diversity of its avifauna. Data obtained in this study may also be used in the future to compare trends of forest loss or preservation *in situ*.

This study aimed to describe the patterns of bird species occurrence in the southern GBR by sampling the area during different seasons and across different forest spots. This region of the Amazonia is increasingly threatened, and soon it may be too late to gather such data [3], especially given that deforestation rates in Brazilian Amazonia have significantly increased since 2018 [13][22][23], from 6900 km^2 in 2017, to between 10100 and 13000 km^2 per year between 2019 and 2022 [24]. Thus, GBR arises as a high-priority area for the conservation of amazonian avifauna [18].

Methods

Study area

The study was conducted in the southernmost sector of the GBR. The GBR is a strictly Protected Area, known in Brazil as a Conservation Unity of Integral Protection. Entirely within the BCE, it has a north-south elongated shape and covers 271,197.51 ha (Figure 1). The GBR was created in 1988 as part of a larger, continuous forest region, along with three indigenous lands: Alto Turiaçu to the north, and Caru and Awá to the east. The entire complex was initially protected as a Forest Reserve in 1961. However, the GBR's forests have faced several serious threats since before its creation, continuing to the present. These threats include illegal occupation of parts of its territory for cattle ranches, illegal poaching, and illegal logging in some preserved sectors, which together have reduced the original forest cover by about 30% over the last 30 years [3][7][8].

The GBR's primary forests are typical Dense Ombrophile Amazon Rainforests with continuous canopies about 35-40 m tall, and emerging trees reaching 50 m [12]. Below the canopy, there are stratified layers typical of the Amazon Forest vegetation, including epiphytes, lianas, trees and shrubs, forming an understory 4-7 m tall, denser in clearings, whether natural or human-induced [*e.g.* 12].

The samplings were conducted along two trails in a large continuous area of primary *terra firme* forest that was mostly pristine, with only a few illegally logged trunks. A few patches with secondary vegetation, dominated by *Cecropia* spp. were found along the trails, mainly near their southern ends, close to the southern border of GBR, but these covered less than 5% of the total forest surface on each trail.

Field data

Four surveys were carried out during the study: two of them in the dry season (June 2010 and September 2011, and two in the rainy season (March 2011 and December 2013). Data were collected in point samples along two 4 km-long trails (Figure 1). Each survey sampled 12 point counts per trail [25], totaling 24 point counts per survey, or 96 point counts over the whole study (24 per trail in a given season).

Walking inside the forest was very difficult due to the scarcity of trails, so the surveys followed the few pre-existing trails, with irregular paths. The trails were located within adjacent 5x5 km quadrats. Trails were divided into 300-m segments, and a point sample was located in the center of every segment. All sampling points were georeferenced using a Garmin Etrex Vista, Datum SAD 69 handheld GPS. The coordinates of the trail endpoints were:

- West trail: from 4° 00'10"S, 46° 50'44"W to 3° 58'05"S, 46° 49'23"W.
- East trail: from 3° 59'35"S, 46° 48'22"W to 3° 57'54"S, 46° 46'35"W (Figure 1).

The study area thus covered approximately 50 km^2 inside a larger continuous forest cover.

Surveys began at 05:50 hours. The researcher remained for 5 minutes in each point count, and walked rapidly to the next point to complete the entire trail in a single morning. No point counts were sampled after 09:00 hours.

During the 5-minute period, all bird species detected within an estimated distance of less than 50 m from the observer, whether by sight or sound, were recorded. Birds were identified using field guides [26][27][28] and sound recordings [29][30]. The presence of each species in the study area was quantified by the number of point samples where it was recorded.

Data analyses

For comparison purposes, species accumulation curves (collector curves) and sample-based rarefaction curves (1000 permutations) were constructed per trail and per season. The Chao 1 and the first-order jackknife richness estimators for incidence data were used. Comparisons between the curves were carried out by overlapping the confidence intervals between the curves, with a high or total overlap implying that there is no difference in species richness between areas or between seasons [31].

To investigate possible differences in species compositions between trails and between seasons, similarity matrices were constructed based on the Sorensen index [32]. A non-metric multidimensional scaling (NMDS) analysis was performed to verify the possible formation of groups in the multidimensional space and a permutational multivariate analysis of variance (PERMANOVA) was performed to assess the statistical significance of differences between groups ($\alpha = 0.05$; 9999 permutations) [33].

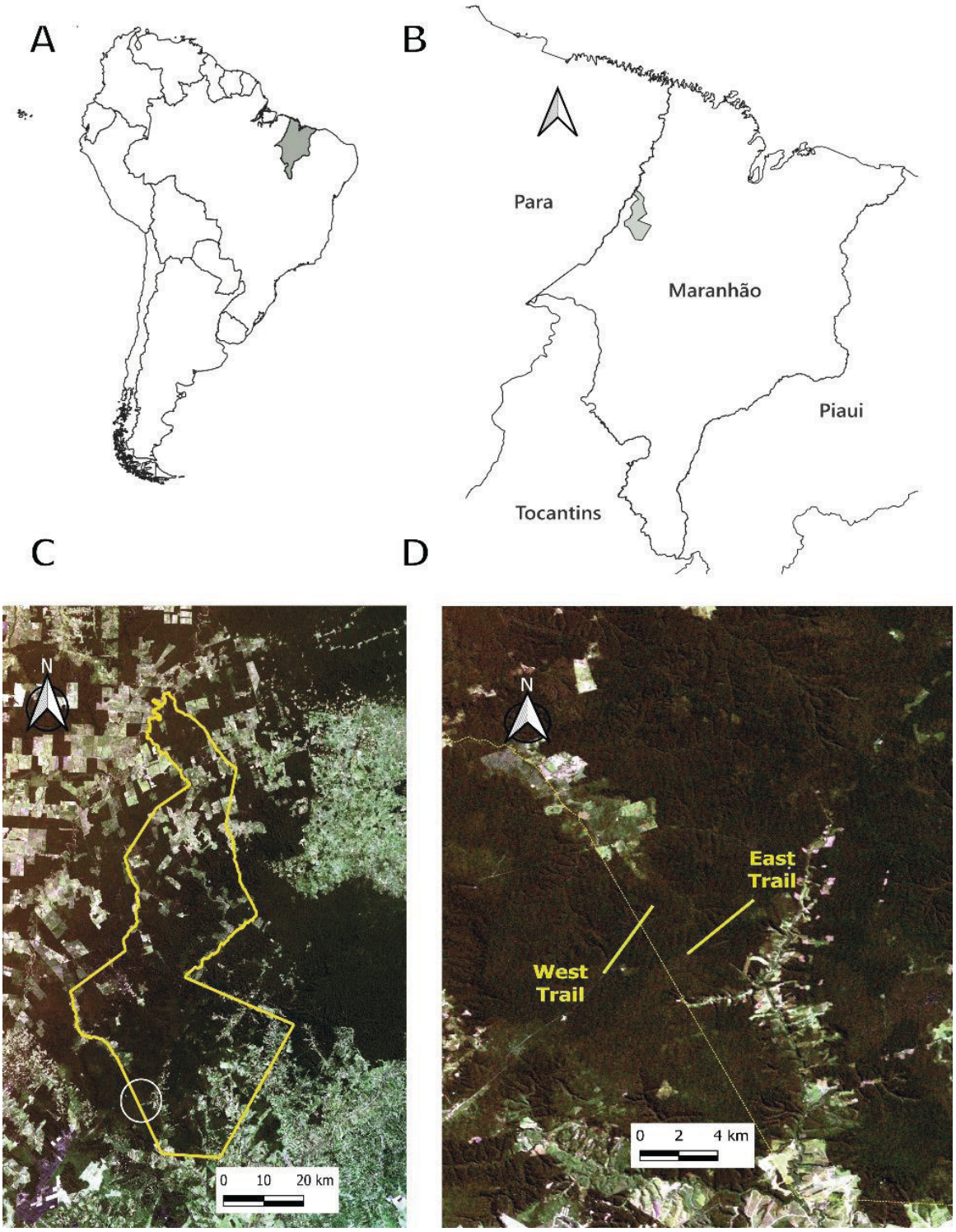

Figure 1 – Map of the GBR, with the sampling trails from June 2010 to December 2013.

To identify differences potentially obscured by using all the species, parallel analyses were performed for specific groups: only species recorded in 10 or more point counts (30 species); only Psittacidae (20 species); only Thamnophilidae (16 species); and only species classified by Stotz *et al*. [34], as highly ecologically sensitive and exclusive to the Amazon Forest (56 species).

The Shannon-Wiener diversity index [*e.g.* 35] was calculated for each season and trail, as well as for the entire study area. In addition, we identified which bird families were most represented in GBR fauna, and which taxa were classified as endemic, or threatened in Brazil [36] or worldwide [37].

Finally, we classified the recorded species based on environmental sensitivity and identified their more or less specialized relationship with the Amazon Forest (adapted from [34]). We followed the taxonomic standard proposed by Pacheco *et al.* [38] updated by Stopiglia *et al.* [39].

Results

A total of 182 species were recorded during the samplings (Table 1), belonging to 41 families. The five most represented families were: Psittacidae (20 species), Thamnophilidae (16 species), Thraupidae and Tyrannidae (12 species each), and Trochilidae (11 species). The overall diversity for all samples was 4.523 (Shannon) (Table 2). Partial samplings (West trail at the dry season, East dry, West rainy and East rainy), showed between 97 and 107 species, and diversity ranged from 4.220 to 4.299 (Table 2).

Table 1 – List of the 182 bird species recorded in the Gurupi Biological Reserve at systematically sampled points, during four surveys between June 2010 and December 2013. [1]High Sensitivity and endemic to Amazon Forest [34]. [2]Endangered in national and/or international (IUCN) lists; VU = vulnerable; EN = endangered; CR = critically endangered [36, 37]. [3]Endemic only to BCE, or to BCE and small neighboring regions [12, 40, 41, 42].

TAXON	High Sensitivity[1]	Endangered[2]	Endemic[3]
Tinamidae Gray, 1840			
Tinamus tao Temminck, 1815	X	VU	
Crypturellus cinereus (Gmelin, 1789)	X		
Crypturellus strigulosus (Temminck, 1815)			
Crypturellus parvirostris (Wagler, 1827)			
Cracidae Rafinesque, 1815			
Ortalis superciliaris (Gray, 1867)			X
Penelope superciliaris Temminck, 1815			
Aburria cujubi (Pelzeln, 1858)	X	VU	
Pauxi tuberosa (Spix, 1825)	X		
Cathartidae Lafresnaye, 1839			
Cathartes melambrotus Wetmore, 1964			
Coragyps atratus (Bechstein, 1793)			
Sarcoramphus papa (Linnaeus, 1758)			
Accipitridae Vigors, 1824			
Elanoides forficatus (Linnaeus, 1758)			
Rupornis magnirostris (Gmelin, 1788)			
Pseudastur albicollis (Latham, 1790)			
Buteo nitidus (Latham, 1790)			
Psophiidae Bonaparte, 1831			
Psophia obscura Pelzeln, 1857	X	CR	X
Columbidae Leach, 1820			
Claravis pretiosa (Ferrari-Perez, 1886)			
Patagioenas speciosa (Gmelin, 1789)			
Patagioenas plumbea (Vieillot, 1818)	X		
Patagioenas subvinacea (Lawrence, 1868)	X		

Leptotila rufaxilla (Richard & Bernard, 1792)			
Geotrygon montana (Linnaeus, 1758)			
Cuculidae Leach, 1820			
Piaya cayana (Linnaeus, 1766)			
Coccyzus americanus (Linnaeus, 1758)			
Caprimulgidae Vigors, 1825			
Nyctiprogne leucopyga (Spix, 1825)	X		
Nyctidromus albicollis (Gmelin, 1789)			
Apodidae Olphe-Galliard, 1887			
Chaetura chapmani Hellmayr, 1907			
Chaetura brachyura (Jardine, 1846)			
Tachornis squamata (Cassin, 1853)			
Trochilidae Vigors, 1825			
Glaucis hirsutus (Gmelin, 1788)			
Phaethornis ruber (Linnaeus, 1758)			
Phaethornis superciliosus (Linnaeus, 1766)	X		
Phaethornis maranhaoensis Grantsau, 1968			
Campylopterus obscurus Gould, 1848			
Florisuga mellivora (Linnaeus, 1758)			
Chlorestes notata (Reich, 1793)			
Chlorestes cyanus (Vieillot, 1818)			
Thalurania furcata (Gmelin, 1788)			
Chionomesa fimbriata (Gmelin, 1788)			
Heliothryx auritus (Gmelin, 1788)			
Trogonidae Lesson, 1828			
Trogon melanurus Swainson, 1838			
Trogon viridis Linnaeus, 1766			
Trogon ramonianus Deville & DesMurs, 1849			
Momotidae Gray, 1840			
Momotus momota (Linnaeus, 1766)			
Bucconidae Horsfield, 1821			
Notharchus tectus (Boddaert, 1783)			
Monasa morphoeus (Hahn & Küster, 1823)	X		
Ramphastidae Vigors, 1825			
Ramphastos tucanus Linnaeus, 1758	X		
Ramphastos vitellinus Lichtenstein, 1823	X		
Pteroglossus inscriptus Swainson, 1822			
Pteroglossus bitorquatus bitorquatus Vigors, 1826		VU	X
Pteroglossus aracari (Linnaeus, 1758)			
Picidae Leach, 1820			
Piculus flavigula (Boddaert, 1783)	X		

Celeus elegans (Statius Muller, 1776)			
Celeus ochraceus (Spix, 1824)			
Celeus torquatus pieteroyensi Oren, 1992	X	VU	X
Dryocopus lineatus (Linnaeus, 1766)			
Campephilus rubricollis (Boddaert, 1783)	X		
Falconidae Leach, 1820			
Ibycter americanus (Boddaert, 1783)	X		
Milvago chimachima (Vieillot, 1816)			
Herpetotheres cachinnans (Linnaeus, 1758)			
Micrastur mintoni Whittaker, 2003	X		
Psittacidae Rafinesque, 1815			
Ara macao (Linnaeus, 1758)			
Ara chloropterus Gray, 1859	X		
Ara severus (Linnaeus, 1758)			
Diopsittaca nobilis (Linnaeus, 1758)			
Guaruba guarouba (Gmelin, 1788)	X	VU	
Aratinga jandaya (Gmelin, 1788)			
Eupsittula aurea (Gmelin, 1788)			
Pyrrhura coerulescens Neumann, 1927	X	VU	
Pyrrhura amazonum Hellmayr, 1906	X	VU	
Forpus xanthopterygius (Spix, 1824)	X		
Brotogeris chiriri (Vieillot, 1818)			
Brotogeris chrysoptera (Linnaeus, 1766)			
Touit huetii (Temminck, 1830)	X		
Pionites leucogaster (Kuhl, 1820)	X	VU	
Pionus menstruus (Linnaeus, 1766)			
Pionus fuscus (Statius Muller, 1776)	X		
Amazona farinosa (Boddaert, 1783)			
Amazona amazonica (Linnaeus, 1766)			
Amazona ochrocephala (Gmelin, 1788)			
Deroptyus accipitrinus (Linnaeus, 1758)	X		
Thamnophilidae Swainson, 1824			
Pygiptila stellaris (Spix, 1825)	X		
Myrmornis torquata (Boddaert, 1783)	X		
Myrmotherula longipennis Pelzeln, 1868	X		
Myrmotherula axillaris (Vieillot, 1817)			
Myrmotherula menetriesii (d'Orbigny, 1837)	X		
Formicivora grisea (Boddaert, 1783)			
Isleria hauxwelli (Sclater, 1857)	X		
Thamnomanes caesius (Temminck, 1820)	X		
Dysithamnus mentalis (Temminck, 1823)			

Thamnophilus palliatus (Lichtenstein, 1823)			
Thamnophilus aethiops incertus Pelzeln, 1868	X		X
Thamnophilus amazonicus Sclater, 1858			
Taraba major (Vieillot, 1816)			
Pyriglena leuconota leuconota (Spix, 1824)			X
Cercomacra cinerascens (Sclater, 1857)	X		
Cercomacroides laeta Todd, 1920			
Phlegopsis nigromaculata paraensis Hellmayr, 1904		VU	X
Conopophagidae Sclater & Salvin, 1873			
Conopophaga roberti Hellmayr, 1905			
Grallariidae Sclater & Salvin, 1873			
Hylopezus paraensis Snethlage, 1910		VU	
Formicariidae Gray, 1840			
Formicarius analis (d'Orbigny & Lafresnaye, 1837)			
Scleruridae Swainson, 1827			
Sclerurus rufigularis Pelzeln, 1868	X		
Sclerurus caudacutus (Vieillot, 1816)	X		
Dendrocolaptidae Gray, 1840			
Dendrocincla fuliginosa (Vieillot, 1818)	X		
Deconychura longicauda zimmeri Pinto, 1974	X		
Glyphorynchus spirurus (Vieillot, 1819)			
Xiphorhynchus guttatoides (Lafresnaye, 1850)			
Dendroplex picus (Gmelin, 1788)			
Lepidocolaptes layardi (Sclater, 1873)	X		
Dendrocolaptes medius Todd, 1920	X	VU	
Xenopidae Bonaparte, 1854			
Xenops minutus (Sparrman, 1788)			
Furnariidae Gray, 1840			
Automolus paraensis Hartert, 1902	X		
Automolus rufipileatus (Pelzeln, 1859)			
Dendroma erythroptera (Sclater, 1856)	X		
Philydor pyrrhodes (Cabanis, 1848)	X		
Synallaxis frontalis Pelzeln, 1859			
Pipridae Rafinesque, 1815			
Tyranneutes stolzmanni (Hellmayr, 1906)	X		
Ceratopipra rubrocapilla (Temminck, 1821)	X		
Lepidothrix iris (Schinz, 1851)		EN	
Chiroxiphia pareola (Linnaeus, 1766)	X		
Onychorhynchidae Tello, Moyle, Marchese & Cracraft, 2009			
Myiobius atricaudus Lawrence, 1863			

Tityridae Gray, 1840			
Schiffornis turdina (Wied, 1831)			
Iodopleura isabellae Parzudaki, 1847			
Tityra inquisitor (Lichtenstein, 1823)			
Tityra cayana (Linnaeus, 1766)			
Tityra semifasciata (Spix, 1825)			
Pachyramphus minor (Lesson, 1830)	X		
Pachyramphus validus (Lichtenstein, 1823)			
Cotingidae Bonaparte, 1849			
Lipaugus vociferans (Wied, 1820)	X		
Xipholena lamellipennis (Lafresnaye, 1839)	X	VU	
Cotinga cotinga (Linnaeus, 1766)			
Querula purpurata (Statius Muller, 1776)			
Rhynchocyclidae Berlepsch, 1907			
Mionectes macconnelli (Chubb, 1919)	X		
Tolmomyias flaviventris (Wied, 1831)			
Todirostrum maculatum (Desmarest, 1806)			
Todirostrum cinereum (Linnaeus, 1766)			
Poecilotriccus sylvia (Desmarest, 1806)			
Hemitriccus striaticollis (Lafresnaye, 1853)			
Lophotriccus galeatus (Boddaert, 1783)			
Tyrannidae Vigors, 1825			
Myiopagis gaimardii (d'Orbigny, 1839)			
Attila spadiceus (Gmelin, 1789)			
Myiarchus tuberculifer (d'Orbigny & Lafresnaye, 1837)			
Pitangus sulphuratus (Linnaeus, 1766)			
Myiodynastes maculatus (Statius Muller, 1776)			
Megarynchus pitangua (Linnaeus, 1766)			
Myiozetetes cayanensis (Linnaeus, 1766)			
Myiozetetes similis (Spix, 1825)			
Tyrannus melancholicus Vieillot, 1819			
Empidonomus varius (Vieillot, 1818)			
Contopus nigrescens (Sclater & Salvin, 1880)	X		
Sirystes sibilator (Vieillot, 1818)			
Vireonidae Swainson, 1837			
Cyclarhis gujanensis (Gmelin, 1789)			
Hylophilus pectoralis Sclater, 1866			
Hirundinidae Rafinesque, 1815			
Progne chalybea (Gmelin, 1789)			

Troglodytidae Swainson, 1831			
Microcerculus marginatus (Sclater, 1855)	X		
Campylorhynchus turdinus (Wied, 1831)			
Pheugopedius genibarbis (Swainson, 1838)			
Cantorchilus leucotis (Lafresnaye, 1845)			
Polioptilidae Baird, 1858			
Polioptila paraensis Todd, 1937	X		
Passerellidae Cabanis & Heine, 1850			
Arremon taciturnus (Hermann, 1783)			
Icteridae Vigors, 1825			
Psarocolius viridis (Statius Muller, 1776)	X		
Psarocolius decumanus (Pallas, 1769)			
Cacicus solitarius (Vieillot, 1816)			
Cacicus haemorrhous (Linnaeus, 1766)			
Molothrus oryzivorus (Gmelin, 1788)			
Mitrospingidae Barker, Burns, Klicka, Lanyon & Lovette, 2013			
Lamprospiza melanoleuca (Vieillot, 1817)	X		
Thraupidae Cabanis, 1847			
Coereba flaveola (Linnaeus, 1758)			
Parkerthraustes humeralis (Lawrence, 1867)	X		
Tachyphonus rufus (Boddaert, 1783)			
Ramphocelus carbo (Pallas, 1764)			
Loriotus luctuosus (d'Orbigny & Lafresnaye, 1837)			
Loriotus cristatus pallidigula Goeldi, 1903			X
Thraupis episcopus (Linnaeus, 1766)			
Thraupis palmarum (Wied, 1821)			
Dacnis lineata (Gmelin, 1789)			
Hemithraupis guira (Linnaeus, 1766)			
Conirostrum speciosum (Temminck, 1824)			
Cardinalidae Ridgway, 1901			
Granatellus pelzelni paraensis Rothschild, 1906		VU	X
Caryothraustes canadensis (Linnaeus, 1766)			
Cyanoloxia rothschildii (Bartlett 1890)			
Fringillidae Leach, 1820			
Euphonia violacea (Linnaeus, 1758)			

Table 2 – Number of species and diversity (Shannon index) for the entire set of samples, for the whole West trail, the whole East trail, each season (dry and rainy), and for each case (West dry, West rainy, East dry and East rainy).

Case	Number of species	Diversity (Shannon)
West Dry	98	4.220
West Rainy	107	4.299
East Dry	97	4.261
East Rainy	106	4.299
Dry Season	132	4.522
Rainy Season	150	4.330
West Trail	138	4.407
East Trail	140	4.441
Total	**182**	**4.523**

With the cumulative species curve reaching a total of 182 species (Figure 2), the estimated total number of species in the continuous forest area sampled in this study was about 250 species, as calculated by both Chao 1 and first-order jack-knife estimators (Figure 2). By seasons, the rainy season showed a slightly higher number of species than the rainy season (150 to 132 species in 48 samples per season), and the rarefaction curve showed that those differences were significant (Figure 3). By trails, the differences were not significant, with each trail showing around 140 species for 48 samples (Figure 4).

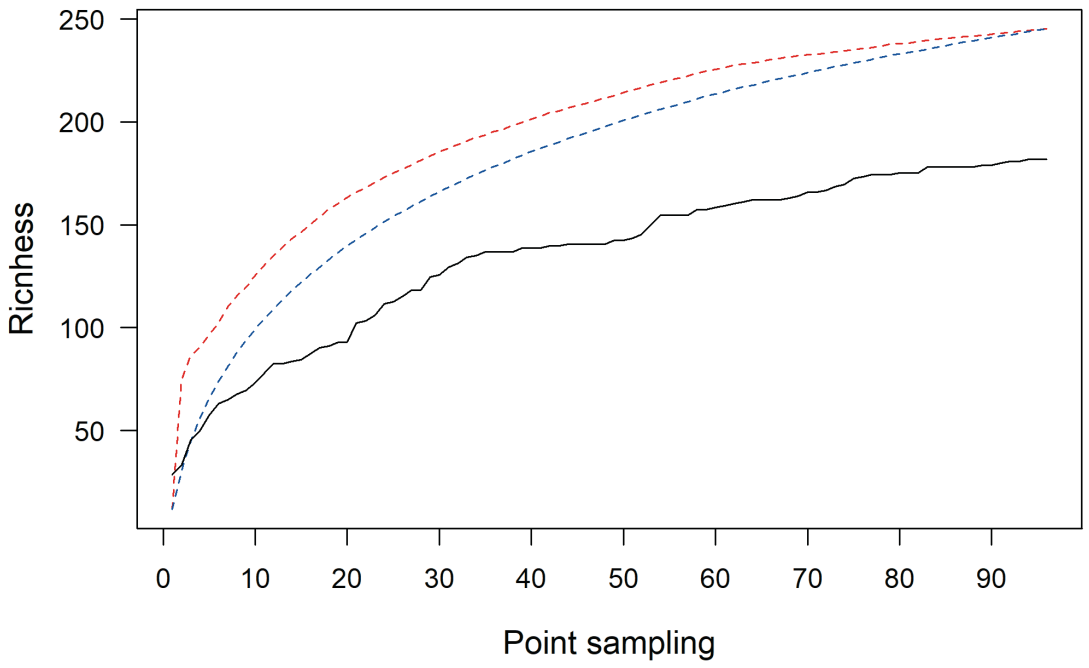

Figure 2 – Species richness estimators for the total set of data. Solid black line: species accumulation curve. Blue dashed line: first-order jackknife. Red dashed line: Chao 1.

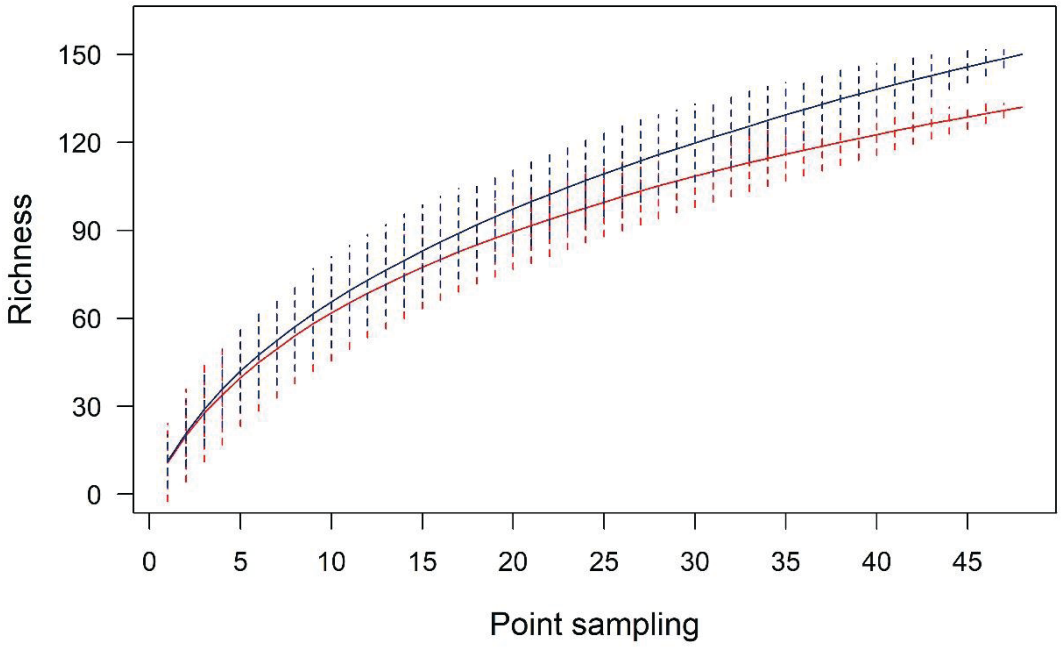

Figure 3 – Comparation of species richness between seasons. Solid lines: sample-based rarefaction curve (Chao 1 index). Blue line: rainy season. Red line: dry season. Dashed transversal (vertical) lines: confidence intervals.

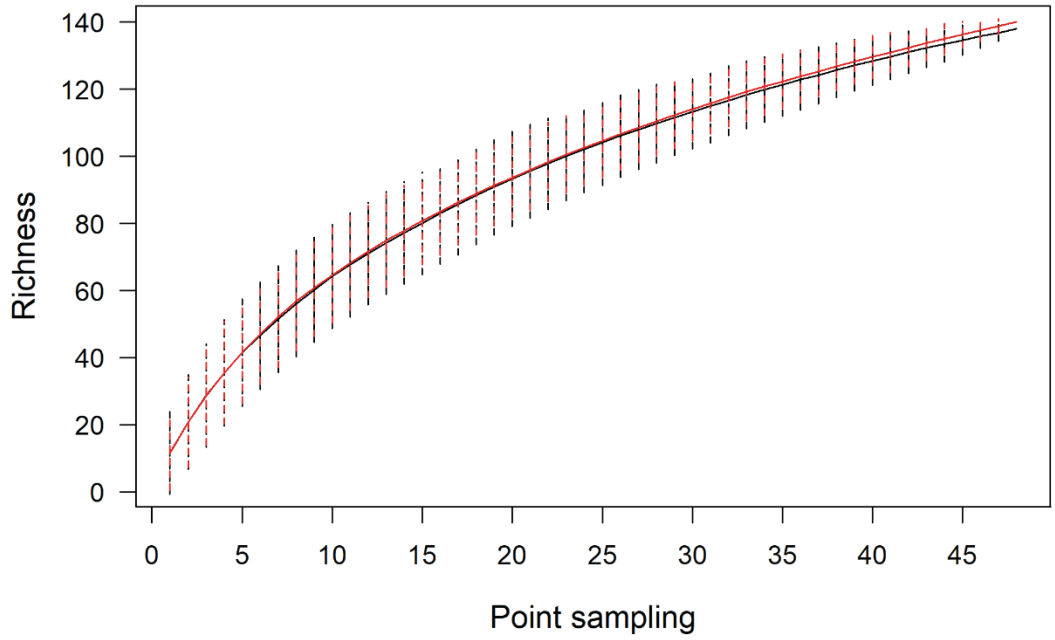

Figure 4 – Comparation of species richness between trails. Solid lines: sample-based rarefaction curve (Chao 1 index). Black line: West trail. Red line: East trail. Dashed transversal (vertical) lines: confidence intervals.

Regarding community composition, there were no significant differences (F= 0.9078; p-value = 0.7) between trails or seasons when all the species were used in the analyses (Figure 5). The same pattern was found when the analyses were run only for specific groups of birds: only the 30 most common species, only Psittacidae, only Thamnophilidae, and only the most sensitive 56 species (F = 0.8868; p-value = 0.62); the NMDS for the most sensitive species is shown in Figure 6.

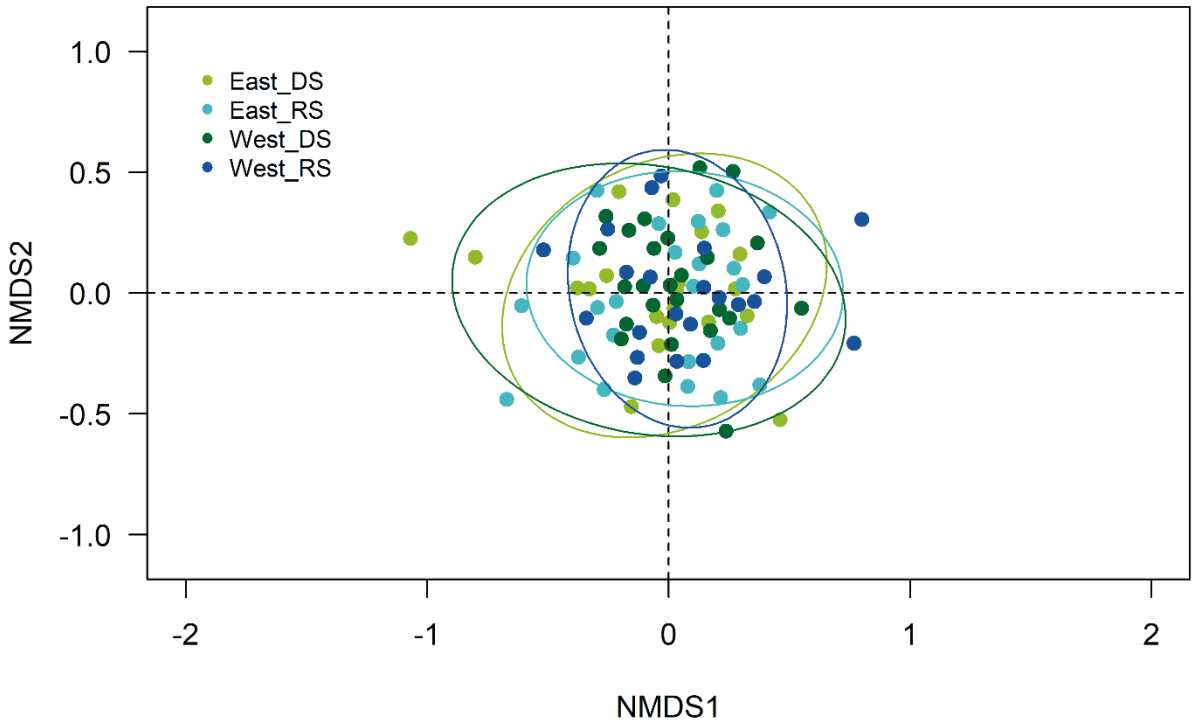

Figure 5 – Non-metric multidimensional scaling for the whole set of species.

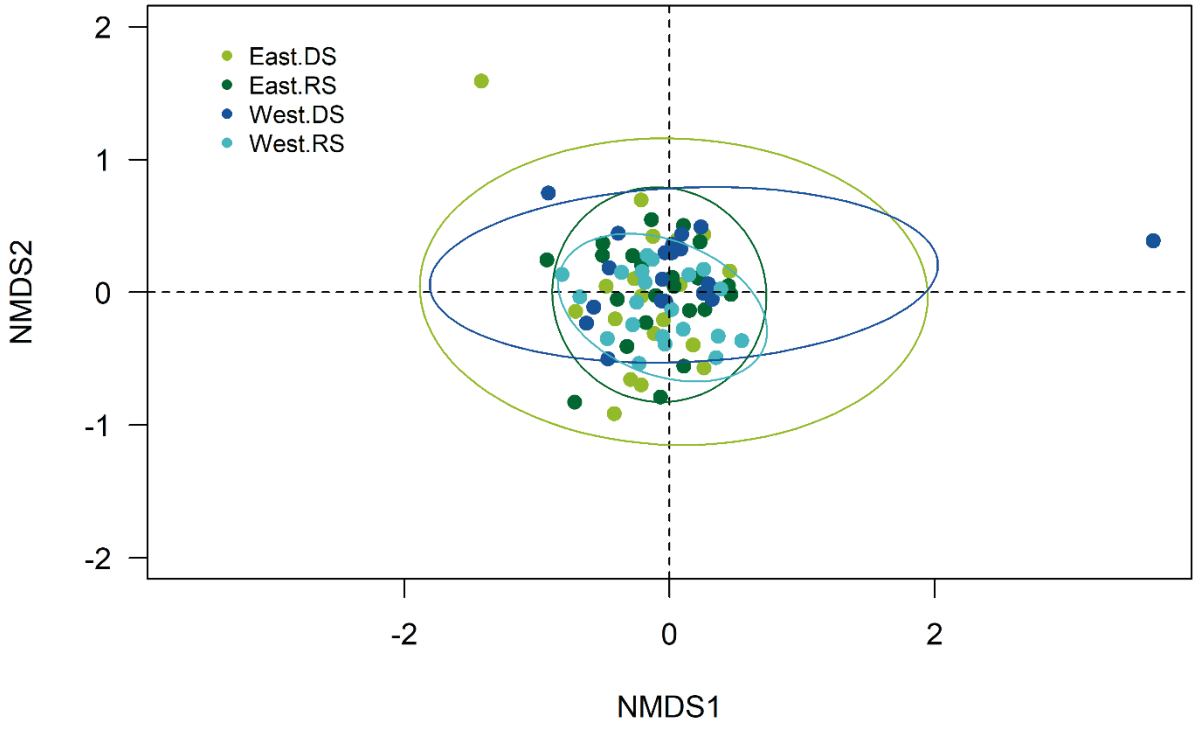

Figure 6 – Non-metric multidimensional scaling for the 56 most sensitive species.

The species with the highest occurrence across all samples was *Cercomacra cinerascens*, a highly sensitive forest species. That was the only species recorded in more than 50% of all samples (49 samples, 51.0%) The 30 most common species were found in 10 (10.4%) or more of all the sampled spots. Results for those 30 species are shown in Table 3, both for the global results, and for each of the four

cases (West trail dry season, East trail dry season, West rainy and East rainy). It is remarkable that seven of those 30 species were thamnophilid birds, including five among the top 10 most frequent species (*C.cinerascens*, *Cercmacroides laeta*, *Thamnophilus amazonicus*, *Pyriglena leuconota*, *Thamnophilus aethiops*, *Thamnomanes caesius* and *Thamnophilus palliatus*, 1st, 3rd, 5th, 6th, 9th, 13th and 22nd of the 30 most frequent species). Meanwhile, five of those 30 species were psittacids, none of them among the top 10 most frequent (*Pionus menstruus*, *Amazona farinosa*, *Pionus fuscus*, *Brotogeris chrysoptera* and *Ara chloropterus*, 12th, 14th, 15th, 16th and 21st of the 30 most frequent species).

Table 3 – Occurrence of species found in 10 or more point counts throughout the study, from the highest to the lowest occurrence value. n, number of spots where a given species was recorded. WD, West trail, dry season. ED, East trail, dry season. WR, West trail, rainy season. ER, East trail, rainy season.

ORDER	SPECIES	CASE									
		ALL		WD		ED		WR		ER	
		n	%	n	%	n	%	n	%	n	%
1	*Cercomacra cinerascens*	**49**	51,0%	**13**	54,2%	**10**	41,7%	**12**	50,0%	**14**	58,3%
2	*Campylorhynchus turdinus*	**45**	46,9%	**11**	45,8%	**10**	41,7%	**14**	58,3%	**10**	41,7%
3	*Cercomacroides laeta*	**36**	37,5%	**9**	37,5%	**10**	41,7%	**10**	41,7%	**7**	29,2%
4	*Lipaugus vociferans*	**35**	36,5%	**8**	33,3%	**8**	33,3%	**10**	41,7%	**9**	37,5%
5	*Thamnophilus amazonicus*	**34**	35,4%	**9**	37,5%	**8**	33,3%	**10**	41,7%	**7**	29,2%
6	*Pyriglena leuconota*	**34**	35,4%	**5**	20,8%	**5**	20,8%	**11**	45,8%	**13**	54,2%
7	*Coereba flaveola*	**32**	33,3%	**9**	37,5%	**6**	25,0%	**6**	25,0%	**11**	45,8%
8	*Caryothraustes canadensis*	**31**	32,3%	**10**	41,7%	**7**	29,2%	**7**	29,2%	**7**	29,2%
9	*Thamnophilus aethiops*	**30**	31,3%	**11**	45,8%	**6**	25,0%	**6**	25,0%	**7**	29,2%
10	*Chiroxiphia pareola*	**27**	28,1%	**6**	25,0%	**6**	25,0%	**11**	45,8%	**4**	16,7%
11	*Pheugopedius genibarbis*	**27**	28,1%	**6**	25,0%	**10**	41,7%	**5**	20,8%	**6**	25,0%
12	*Pionus menstruus*	**25**	26,0%	**5**	20,8%	**6**	25,0%	**9**	37,5%	**5**	20,8%
13	*Thamnomanes caesius*	**22**	22,9%	**4**	16,7%	**6**	25,0%	**4**	16,7%	**8**	33,3%
14	*Amazona farinosa*	**19**	19,8%	**7**	29,2%	**3**	12,5%	**5**	20,8%	**4**	16,7%
15	*Pionus fuscus*	**19**	19,8%	**6**	25,0%	**3**	12,5%	**3**	12,5%	**7**	29,2%
16	*Brotogeris chrysoptera*	**17**	17,7%	**5**	20,8%	**4**	16,7%	**4**	16,7%	**4**	16,7%
17	*Phaethornis ruber*	**17**	17,7%	**5**	20,8%	**4**	16,7%	**4**	16,7%	**4**	16,7%
18	*Hemithraupis guira*	**15**	15,6%	**5**	20,8%	**4**	16,7%	**2**	8,3%	**4**	16,7%
19	*Cyclarhis gujanensis*	**15**	15,6%	**3**	12,5%	**6**	25,0%	**2**	8,3%	**4**	16,7%
20	*Monasa morphoeus*	**14**	14,6%	**2**	8,3%	**5**	20,8%	**4**	16,7%	**3**	12,5%
21	*Ara chloropterus*	**14**	14,6%	**2**	8,3%	**3**	12,5%	**4**	16,7%	**5**	20,8%
22	*Thamnophilus palliatus*	**14**	14,6%	**3**	12,5%	**4**	16,7%	**4**	16,7%	**3**	12,5%
23	*Cacicus haemorrhous*	**14**	14,6%	**4**	16,7%	**5**	20,8%	**0**	0,0%	**5**	20,8%
24	*Psarocolius viridis*	**14**	14,6%	**5**	20,8%	**4**	16,7%	**2**	8,3%	**3**	12,5%
25	*Leptotila rufaxilla*	**13**	13,5%	**4**	16,7%	**2**	8,3%	**3**	12,5%	**4**	16,7%
26	*Ramphocelus carbo*	**12**	12,5%	**5**	20,8%	**2**	8,3%	**3**	12,5%	**2**	8,3%
27	*Ibycter americanus*	**12**	12,5%	**5**	20,8%	**0**	0,0%	**4**	16,7%	**3**	12,5%
28	*Loriotus luctuosus*	**11**	11,5%	**2**	8,3%	**6**	25,0%	**3**	12,5%	**0**	0,0%
29	*Poecilotriccus sylvia*	**11**	11,5%	**2**	8,3%	**6**	25,0%	**1**	4,2%	**2**	8,3%
30	*Tyranneutes stolzmanni*	**10**	10,4%	**2**	8,3%	**1**	4,2%	**4**	16,7%	**3**	12,5%
TOTAL		**96**	100,0%	**24**	100,0%	**24**	100,0%	**24**	100,0%	**24**	100,0%

Regarding habitat sensitivity, as said above, 56 species were listed by Stotz et al. [34] as occurring exclusively in Amazon Forest and showing high ecological sensitivity (see Table 1). Sixty additional species from this study are also restricted to the Amazon Forest but show medium or low ecological sensitivity, according to the same work. And the remaining 66 species occur both in Amazon Forest and in more open habitats.

Twenty-one species from this study were listed by that same work as indicator species of tropical forest habitats, with 17 as indicators of Tropical Lowland Evergreen Forest, one of Flooded Forest, and three of River-Edge Forest. On the other hand, 22 species were indicators of disturbed habitats. Among the 30 most abundant species (occurrence in 10% or more points), 11 were considered by Stotz et al. [34] as highly sensitive, with four among the top 10 most frequent (*C. cinerascens*, *Lipaugus vociferans*, *T. aethiops*, *Chiroxiphia pareola*, *T. caesius*, *P. fuscus*, *Monasa morphoeus*, *A. chloropterus*, *Psarocolius viridis*, *Ibycter americanus* and *Tyranneutes stolzmanni*, 1st, 4th, 9th, 10th, 13th, 15th, 20th, 21st, 24th, 27th and 30th most frequent species). Three of those 11 species were considered indicators of Tropical Forest by the same work (*T. aethiops*, *C. pareola* and *T. caesius*), and four of the 30 were indicators of disturbed habitats, being two among the top 10 most frequent (*Campylorhynchus turdinus*, *Coereba flaveola*, *T. palliatus* and *Ramphocelus carbo*, 2nd, 7th, 22nd and 26th most frequent species).

Among the identified taxa, 14 were considered endangered according to the National List of Brazilian Fauna Species Threatened with Extinction [36]. These included: *Tinamus tao* (Vulnerable – VU; also internationally), *Aburrria cujubi* (Vulnerable – VU; also internationally) , *Psophia obscura* (Critically Endangered – CR; also internationally), *Celeus torquatus pieteroyensis* (Vulnerable – VU), *Guaruba guarouba* (Vulnerable – VU; also internationally), *Pyrrhura coerulescens* (Vulnerable – VU; also internationally), *Pyrrhura amazonum* (Vulnerable – VU), *Pteroglossus bitorquatus bitorquatus* (Vulnerable – VU), *Phlegopsis nigromaculata paraense* (Vulnerable – VU), *Hylopezus paraensis* (Vulnerable – VU), *Dendrocolaptes medius* (Vulnerable – VU), *Lepidothrix iris* (Endangered – EN; Vulnerable internationally), *Xipholena lamellipennis* (Vulnerable – VU), and *Granatellus pelzelni paraensis* (Vulnerable – VU). In addition, *Pionites leucogaster* is classified as threatened internationally (Vulnerable – VU) [37]. (Table 1).

There were six taxa endemic to the BCE: *Psophia obscura*, *Pteroglossus bitorquatus bitorquatus*, *Thamnophilus aethiops incertus*, *Phlegopsis nigromaculata paraensis*, *Loriotus cristatus pallidigula*, and *Granatellus pelzelni paraensis*. Other taxa previously considered endemic [12], have recently been found in neighboring areas. That is the case of *Ortalis superciliaris* [40], *Celeus torquatus pieteroyensis* [41] and *Pyriglena leuconota leuconota* [42]. However, the distributions of these three taxa remain largely restricted to BCE. In any case, it is worth noting that two of these nine taxa were among the top 10 most frequent species in the samplings (*P. leuconota leuconota* and *T. aethiops incerta*, 6th and 9th most frequent).

Discussion

Habitat conservation status

The bird species assembly found in the sampled areas of southern GBR comprises a large number of forest specialists, many of them highly sensitive to ecological conditions. The diversity values are typical of a highly diverse ecosystem, which was expected as well. On the other hand, the values of diversity remained similar when only specific subsets of data were considered (Table 2), indicating high levels of α-diversity at a given forest spot. These results suggest also that these high levels of α-diversity could be found consistently throughout the forest cover. In other words: as expected, the bird assembly in the region was mostly a primary forest assembly.

However, several species indicator of disturbed habitats were also recorded (see below), showing a mixed condition of relatively continuous primary forest, interspersed with some disturbed spots. This mixture of species was found both when all the species were considered and when only the most frequent species were taken into account.

In any case, while the composition of the local bird community indicated some degree of habitat disturbance, it is noteworthy that no completely deforested spots were found in the sampled region. Instead, the study site included zones where some trees had been previously logged, resulting in an irregular canopy layer and edge-like conditions in certain parts of the forest [C. M., pers. obs.], even beyond the few secondary small patches dominated by *Cecropia*.

Thus, for example, among the four species indicator of disturbed habitats that ranked among the 30 most common species, two (*C. flaveola* and *R. carbo*), even when they may occur in highly disturbed habitats, they are also found in primary forest; and the other two (*C. turdinus* and *T. palliatus*) though more common in forest clearings, remain confined to forest environments. In other words: despite some degree of disturbance, the forests of southern GBR remain far more preserved than disturbed, at least within the relatively large continuous areas we studied. This underscores the high conservation value of those forests.

The estimated species richness for the whole area (around 250 species) was slightly lower than that (295 species) found by Pinheiro et al. [15] for three trails in the northern and central regions of GBR. That means that the values we estimated were noticeably similar to those of that work (regardless of differences in the sampling methods between the two studies), as the samplings in this study were much less extensive, and the southern region of GBR is a little more disturbed than the forest remnants studied by Pinheiro et al. [15] in central and northern GBR [7, pers. obs.].

While Lima et al. [12] reported 424 species for the entire GBR, it should be taken into account that the present study sampled only a specific region of approximately 50 km^2 of relatively homogeneous *terra firme* forest, with almost no flooded habitats. Indeed, 17 of the 21 tropical forest indicator species we found, were specific to *terra firme* forest. The only source of spatial heterogeneity was the presence of a few disturbed spots.

In their study, Lima et al. [12] sampled both the northern and southern GBR regions, as well as the buffer zone, which included deforested areas, *terra firme* forests, flooded forest, rivers and swamps across a much larger territory. Similarly, while Pinheiro et al. [15] estimated 295 species for the trails, their total regional estimate was about 550 species, exceeding the estimate found by Lima et al. [12]. This difference reflects new species additions to the GBR check list since the earlier study.

Comparation between samples and with existing studies in the literature

We performed several comparisons between assemblies recorded in the trails (considering all the recorded species, and specific groups), and did not find significant differences between trails. Thus, the structure of the avian communities we found may reflect a more general pattern, at least within the southern GBR and for *terra firme* forest. The only difference we found between sample sets was a slightly higher number of species during the rainy season for the whole set of data (Figure 3).

In any case, since the vast majority of the species occurring in the region are residents, this seasonal difference in species richness (not reflected in community composition comparisons using NMDS, either for the whole set of species, Figure 5, or for specific groups, Figure 6) suggests a higher detectability of some species during the rainy season. In other words: the community composition would have remained the same, but our results suggest that several bird species in local communities probably remain more active during the rainy season, making them easier to observe and identify.

As stated above, compared to the work of Pinheiro et al. [15] in central and northern GBR, we found fewer species. Actually, our sampling effort was not as extensive as that of that work [C. M., pers. obs.] and we sampled a more homogeneous area of continuous *terra firme* forest, so a globally lower species richness would be expected.

Regarding community composition, *C. cinerascens* was the most frequent species both in the trails studied by those authors and in this study. Among the top 10 most frequent species, *L. vociferans* ranked 2nd in that work., and 4th in the present study. *P. leuconota* was among the 10 most frequent species on one of the trails of that work, being the 6th most common species in ths study. Meanwhile, *Phaethornis ruber*, *Pheugopedius genibarbis* and *T. caesius* were the 5th, 8th and 9th most common species in that work, respectively ranking 17th, 11th and 13th in the present study.

Thus, while the composition of bird communities in the two trails of this study, both located in close proximity in southern GBR, was almost identical, the comparison between southern and northern GBR showed several important similarities, but also some relevant differences. This points to the existence of a common baseline in the structure of bird communities within GBR, but also to the existence of local variations from that baseline.

Still, it is important to remark that we did not use sound recording devices, unlike Pinheiro et al. [15]; therefore, some species' occurrences

are expected to have been underestimated in the present work. On the other hand, our field work was conducted several years before the mentioned work; specifically, our samplings were carried out before the large number of forest fires which took place in GBR in 2015 [4][8][E.N. Mendonça, pers. com.], which seriously impacted about half of the GBR's forested area. This makes the present study not only the sole quantitative study of bird communities in the southern sector of GBR to date, but also the only quantitative study conducted across the entire GBR before the occurrence of that number of large fires.

Impacts of the 2015-2016 fires

Multiple heat focuses appeared in GBR during the final months of 2015, remaining ative until the first months of 2016 in some cases [4][8][E.N. Mendonça, pers. com.]. These fires may have been retaliatory acts against the increasing efforts to prevent the illegal extraction and trade of logs in GBR and its buffer zone [4]. The impacts of those fires were severe, affecting about 50% of the total forest area of the GBR [E.N. Mendonça, pers. com.], and affecting 4526 km^2 for the whole Amazon forest in Maranhão, about three times the annual average of burnt forest area from 2003 to 2017 [8].

The ecological consequences of those fires for the biota remain poorly understood: in any case, for example, the critically endangered Black-winged Trumpeter (*Psophia obscura*) [36, 37], was recorded seven times in the pre-fire samplings of the present study, while Pinheiro et al. [15], using a much greater sampling effort in post-fire surveys, reported the same number of occurrences. These findings indicate that, regardless of sampling method differences, *P. obscura* may have suffered a notorious decline from 2010-2013, years of sampling for the present study, to 2017-2023, years of sampling for Pinheiro et al. [15].

To present day, forest fires have been common in GBR, and most times have been deliberate and criminal, as was the case for the 2015-2016 multiple fires [4][8]. Hopefully, efforts to combat forest fires have increased in recent years, largely due to the commitment of ICMBio personnel and local community members. As of November 2024 no fires of comparable severity have occurred. However, fires remain a major threat to the preservation of GBR's forests and biodiversity [8].

Regional avifauna

According to Lima et al. [12], GBR hosts 84% of the avian species occurring in BCE, and 66% of Maranhão's bird species. Similar results were obtained by Pinheiro et al. [15]. This makes the GBR, not only essential for conservation purposes, but also a representative example of the regional avifauna. Consequently, describing GBR bird communities helps to understand a more general pattern for all this easternmost region of Amazon Forest, serving as a reference for comparison with other studies carried out in other sites in BCE [*e.g.* 14][17][21].

Threatened and endemic species

Fifteen taxa sampled in this work were classified under different degrees of threat, both in Brazil and internationally. This includes the Critically Endangered *P. obscura*, the Endangered *Lepidothrix iris*, and several Vulnerable taxa [36][37] (see Table 1). Thus, also for this reason, the southern GBR can be regarded as a critical region for the preservation of BCE avian diversity. It is important to remark that in this study we did not use occasional observational data, meaning that threatened species were only reported during systematic surveys, without any particular search effort specifically focused on those species.

A similar observation applies to BCE endemic or near-endemic taxa. Six endemic and three near-endemic taxa (previously classified as endemic) were found during the systematic surveys of this study, demonstrating that no special effort was required to detect them. Two of these taxa ranked among the 10 most common species in the surveys, meaning that GBR bird communities, were not only primary forest bird communities, but were also specifically BCE bird communities. These unique communities cannot be found outside the globally threatened BCE. Thus, GBR is one of the last remaining sites where such specific communities persist.

Trophic guilds

Columns of army ants, displacing arthropods and small vertebrates, are common in Amazon Forest [43]. These columns attract mixed bird flocks that exploit the insect prey disturbed by the ants' foraging behavior; those mixed flocks comprise species mostly of the families Thamnophilidae and Dendrocolaptidae. This pattern was frequently observed during the samplings. Many occurrences

of thamnophilid and dendrocolaptid species were observed in mixed understory flocks, most frequently including *Thamnomanes caesius*, *Pyriglena leuconota, Myrmotherula axillaris, Isleria hauxwelli* (Thamnophilidae), *Xiphorhynchus guttatoides, Dendroplex picus, Glyphorhynchus spirurus* (Dendrocolaptidae). Other regular but less frequent species in understory flocks (C. M., pers. obs.) comprised *Myrmotherula menetriesii*, *Myrmotherula longipennis* (Thamnophilidae), *Dendrocolaptes medius* (Dendrocolaptidae) and *Piculus flavigula* (Picidae). This pattern largely matches the findings of Lima et al. [12].

On the other hand, Martínez [21] found 19 thamnophilid species in GBR, and described a gradient of species richness within this family, with maximum values in GBR to much lower ones at the BCE periphery. This supports the perception of GBR as a center of maximum bird diversity in BCE, with the highest complexity for some bird guilds, such as the ant followers.

Canopy frugivores comprise another important guild in tropical rainforest bird communities. And actually, Lima et al. [12] found a high number of species of this guild. In this study, several species of canopy frugivores were recorded, although not as frequently as mixed understory flocks. In any case, we found both mixed canopy flocks, canopy cotingas such as *Cotinga cotinga, Xipholena lamellipennis, Iodopleura isabellae* and *Querula purpurata,* and other frugivores as *Aburria cujubi.* Canopy frugivores are good indicators of habitat quality in tropical forests [44][45][46]; in any case, the family that could best indicate the habitat quality of southern GBR from the point of view of this guild would be the psittacids. And actually, that was the family that had the highest number of species in the entire study. Five species were among the 30 most common bird species; however, none of them ranked among the top 10 species (while some of them were among the top 10 in Pinheiro et al. [15], for example). We think that more data would be needed to take any conclusion on this point, but it is possible that psittacid number in southern GBR is slightly lower than in northern sites due to the lack of a more regular canopy layer, a consequence of illegal logging in previous years.

In relation to carnivore birds, the only specialist we found in our samplings indicating good primary forest cover was *Pseudastur albicollis*. The presence of specialized raptors may depend on large areas of pristine habitat [47], indicating a good quality of the ecosystem in the region. We did not find other specialists in our samplings; however, Lima et al. [12] reported the presence of *Spizaetus tyrannus*, *Spizaetus melanoleucus* and *Harpia harpyja* in southern GBR.

Conclusions

The bird assembly of GBR is essentially that of a primary tropical forest, with many species highly sensitive to habitat alterations. Despite some degree of disturbance in the region, indicators of preserved conditions overweight those of degradation. A high number of taxa are endangered or relevant for conservation, indicating a great value of the region for conservation purposes. Several taxa are endemic, with some among the most frequently recorded forest bird species, emphasizing the importance of the BCE unique characteristics in shaping the bird community composition.

There is also a wide variety of trophic guilds, where understory insectivorous birds, many of them thamnophilids, are among the most frequent species, being *Cercomacra cinerascens*, by far, the most frequent species. Psittacids, mostly canopy frugivores, also rank among the most frequent species, though in a lesser extent.

A special mention is deserved by the critically endangered *Psophia obscura*, that may have suffered a notorious decline in the years following this study's samplings. This species, endemic to BCE, is currently restricted to Protected Areas and Indigenous Lands. Additionally, the recent confirmation of the occurrence of *Crax (fasciolata) pinima* within the reserve and adjacent Indigenous Lands, [15][48] reinforced the urgent need for protecting the entire region as strictly as possible.

In fact, a growing number of workers advocate for a completely halt to deforestation in Maranhão State [3][13]. We believe this measure is essential for any scenario aiming to preserve the BCE's bird diversity.

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