Instituto Nacional de Pesquisas da Amazônia
Programa de Pós-Graduação em Ecologia

Conectando biogeografia histórica e assembleias locais de aves de sub-bosque na Amazônia: áreas de endemismo, diversidade de espécies e proporcionalidade de guildas

Pilar Louisy Maia Braga

Orientador: Fabricio Beggiato Baccaro
Coorientador: Sérgio Henrique Borges

Manaus - AM
Março, 2019

Instituto Nacional de Pesquisas da Amazônia

Programa de Pós-Graduação em Ecologia

Conectando biogeografia histórica e assembleias locais de aves de sub-bosque na Amazônia: áreas de endemismo, diversidade de espécies e proporcionalidade de guildas

Pilar Louisy Maia Braga

Dissertação de mestrado apresentada à Coordenação do Programa de Pós-Graduação em Ecologia, como requisito para obtenção do título de Mestre em Biologia (Ecologia).

Manaus - AM

Março, 2019

B813c Braga, Pilar Louisy Maia
Conectando biogeografia histórica e assembleias locais de aves de sub-bosque na Amazônia: áreas de endemismo, diversidade de espécies e proporcionalidade de guildas / Pilar Louisy Maia Braga; orientador Fabricio Beggiato Baccaro; coorientador Sérgio Henrique Borges. -- Manaus:[s.l], 2019.
55 f.

Dissertação (Mestrado - Programa de Pós Graduação em Ecologia) -- Coordenação do Programa de Pós-Graduação, INPA, 2019.

1. Padrões de diversidade e estruturação. 2. Áreas de endemismo da Amazônia. 3. Aves de sub-bosque. 4. Competição interespecifica. I. Baccaro, Fabricio Beggiato, orient. II. Borges, Sérgio Henrique, coorient. III. Título.

CDD: 598

Sinopse:

Estudou-se os padrões de diversidade, composição e estruturação das assembleias de aves de sub-bosque em florestas de terra firme em sete áreas de endemismo da Amazônia.

Palavras-chave: Diversidade, composição, estruturação, Áreas de endemismo, aves de sub-bosque, proporcionalidade de guildas, competição interespecífica.

AGRADECIMENTOS

Primeiramente agradeço aos meus pais, Núncio e Petrô, aos meus irmãos, Rodolpho, Bernard e Carol, e aos meus amigos, Isabella, Pablo, Raphael e Priscilla, que sempre me incentivaram a correr atrás dos meus sonhos e se fizeram presentes em minha vida, mesmo à distância.

Alguns anos após me formar tive a oportunidade de vir trabalhar pela primeira vez na Amazônia. O encantamento com a floresta foi enorme e com ele veio o sentimento de que eu deveria permanecer ali. Meu maior crescimento profissional e pessoal com certeza aconteceu na Amazônia e tenho muito a agradecer a todos os amigos e profissionais que passaram pela minha vida neste tempo, em especial a Tamires, Robertinha e Regina. Vocês foram parte fundamental neste processo.

Decidida a permanecer na Amazônia e retornar à vida acadêmica, em 2016 fiz a prova do mestrado em Ecologia no INPA. Depois de aprovada, com malas prontas e de mudança para Manaus, comecei um novo ciclo de bastante aprendizado. Só tenho a agradecer aos meus orientadores, Fabricio Baccaro e Sérgio Borges que aceitaram me orientar e se dedicaram bastante ao meu desenvolvimento profissional. Agradeço por todo o aprendizado e, principalmente, pela paciência nesses dois anos.

Este trabalho só foi possível devido a vários pesquisadores que cederam seus dados de captura e foram essenciais para o desenvolvimento da dissertação. Agradeço a todos os envolvidos, que se preocuparam em organizar seus bancos de dados e sempre estiveram disponíveis quando precisei. Em especial a Luiza Magalli Pinto Henriques, pela maior parte dos dados cedidos.

Agradeço ao CNPq pela bolsa me mestrado e ao INPA pela oportunidade de crescimento pessoal e profissional. Aos bons amigos que fiz aqui, Nataniel, Thays, Daniel, Bojo, Gabiwesley, Podrera, Yarine, Bezinha, Isa, Raffaello, Ramiro, Kelly, Bicudo, Pantoja e Uélito. Todos se tornaram minha família em Manaus, e sem vocês este mestrado não teria a menor graça. Obrigada pelos ensinamentos, convivência, sorrisos, lágrimas e claro, pelas festas!

Ao final deste mestrado, só tenho a agradecer a todos que passaram pelo meu caminho desde o início da minha vida profissional. Amigos, colegas de trabalho, orientadores, de alguma forma todos vocês me ensinaram muito sobre a vida e me ajudaram a me tornar quem eu sou hoje. Todos são parte desta evolução e esta dissertação eu dedico a vocês!

RESUMO

Os padrões de diversidade das comunidades biológicas são um reflexo de eventos históricos e contemporâneos que ocorrem em diferentes escalas espaciais. Na Amazônia, há um consenso de que processos históricos relacionados ao estabelecimento da drenagem e das florestas de terra firme desencadearam eventos de vicariância, especiação e dispersão, determinando o *pool* regional de espécies. Adicionalmente, fatores ecológicos locais como a disponibilidade de recursos e as interações entre as espécies são importantes na manutenção dos padrões estabelecidos historicamente. As áreas de endemismo (AE) são unidades de interpretação da biogeografia histórica e investigar as assembleias nestas áreas pode aperfeiçoar nosso conhecimento sobre a interação dos eventos históricos com a diversidade local. Nós investigamos os padrões de diversidade, composição e estruturação das assembleias de aves de sub-bosque de florestas de terra firme em sete áreas de endemismo da Amazônia, usando dados de capturas de aves com redes de neblina, cedidos por diversos pesquisadores. Nosso trabalho buscou compreender se o efeito histórico que resultou na delimitação das áreas de endemismo pode ser extrapolado para toda assembleia de aves, além das espécies endêmicas, atuando nos padrões atuais de diversidade e composição de espécies. Averiguamos quais as guildas predominantes em cada AE e se há uma substituição das guildas entre as AE. Também testamos se existe proporcionalidade de guildas em cada área de endemismo. Os padrões de diversidade e composição de espécies foi distinto entre as sete AE estudadas, tanto na riqueza e composição intrínseca das assembleias considerando todas as espécies estudadas, como nas abundâncias relativas das espécies amplamente distribuídas na Amazônia. A guilda dos insetívoros foi predominante em todas as áreas e a proporção de espécies e indivíduos nas guildas permanece constante entre as áreas de endemismo. Há uma prevalência de alpha guildas (proporcionalidade de guildas) em quase todas as áreas investigadas. A substituição de espécies entre as áreas de endemismo não ocorre de forma aleatória e mantém as mesmas funções ecológicas das espécies, indicando uma certa homogeneidade na disponibilidade de recursos das florestas de terra firme. A prevalência de alpha guildas indica que a competição interespecífica é um forte fator estruturante das assembleias locais, provavelmente em um processo de limitação de similaridade no tamanho corporal das espécies. A congruência entre a estruturação das assembleias de aves de sub-bosque e as áreas de endemismo demonstram o quanto processos históricos e evolutivos que atuam em larga escala, em conjunto com processos ecológicos locais, conduzem aos padrões atuais de diversidade e composição de espécies na Amazônia.

Palavras chave: Diversidade, composição, estruturação, áreas de endemismo, aves de sub-bosque, proporcionalidade de guildas, competição interespecífica.

ABSTRACT

The patterns of diversity in biological communities reflects historical and contemporaneous events that occurs at different spatial scales. In the Amazon, there is a consensus that historical processes related to the establishment of the drainage and the terra firme forests had triggered events of vicariance, speciation and dispersal, determining the regional pool of species. In addition, local ecological factors such as resource availability and species interactions are important in maintaining historically established patterns. The areas of endemism are units of interpretation of historical biogeography and investigating the assemblages in these areas can enhance our knowledge about the interaction between historical events and local diversity. We investigated patterns of diversity, composition, and structuring of understory bird assemblages from upland forests in seven Amazonian areas of endemism, using data from birds captured by mist nets, provided by several researchers. Our research sought to understand if the historical effect that resulted in the delimitation of the endemic areas could be extrapolated to the whole bird assemblage, besides the endemic species, acting in the current patterns of diversity and species composition. We find out which guilds predominate in each AE and if there is guilds substitution between the AE. We also tested if exists guild proportionality in each endemic area. The patterns of diversity and species composition were distinct among the seven areas of endemism studied, both in richness and in the assemblages intrinsic composition considering all the species studied, as in the relative abundances of species widely distributed in the Amazon. The insectivorous guild was predominant in all areas and the proportion of species and individuals in the guilds was constant between the areas of endemism. There is a prevalence of alpha guilds (guild proportionality) in almost all investigated areas. The species substitution between the endemic areas does not occur in a random way and it maintains the same ecological functions of the species, indicating a relative homogeneity in the resources availability of the upland forests. The prevalence of alpha guilds indicates that interspecific competition is a strong structuring factor of local assemblages, probably in a process of limiting similarity in the body size of the species. The congruence between the structuring of the understory bird assemblages and the areas of endemism evidence how much historical and evolutionary processes that acts on a large scale, along with local ecological processes, lead to the current patterns of diversity and species composition in the Amazon.

Key words: Diversity, composition, structuring, areas of endemism, understory birds, guild proportionality, interspecific competition.

SUMÁRIO

1- INTRODUÇÃO GERAL

A ecologia de comunidades busca compreender os padrões de distribuição, diversidade, abundância e interação entre as espécies, que ocorrem em diferentes escalas temporais e espaciais. Enquanto Hubbell (1997) sugere que a dinâmica de uma comunidade ocorre de forma estocástica e somente a dispersão das espécies é suficiente para gerar os padrões de distribuição em escala local, há um consenso de que a distribuição das espécies e estruturação das comunidades é o resultado de processos históricos que atuam em larga escala, como da interação entre espécies e filtros ambientais que operam em escalas locais (Wiens, 1989; Leibold *et al.*, 2004). Consequentemente, as comunidades locais são um reflexo de processos históricos como movimentação de placas tectônicas, soerguimento de montanhas, alterações climáticas e consolidação da drenagem, que conduzem aos eventos de especiação, extinção e dispersão das espécies (Levin, 1992; Holt, 1993; Huston, 1994). Esses processos estão continuamente associados com as características intrínsecas das espécies, como requerimento de nicho, competição interespecífica e com características ambientais, e contribuem para a estruturação, dinâmica e organização das comunidades (Huston, 1979; Ernest *et al.*, 2008).

A Amazônia passou por diversos eventos geológicos que podem ter influenciado a dinâmica e organização das comunidades biológicas (Albert *et al.*, 2018), sendo ideal para compreender como as assembleias de espécies são influenciadas por eventos históricos e contemporâneos. A evolução da drenagem alterou a conformação geológica da Amazônia, isolando populações nas margens opostas dos grandes rios. Aliado a outros eventos como o estabelecimento das florestas de terra firme e o rearranjo mais recente dos cursos fluviais, eventos de vicariância, especiação e dispersão levaram aos padrões atuais de distribuição das espécies (Ribas *et al.*, 2011; Schultz *et al.*, 2017).

A distribuição restrita de várias espécies de aves culminou na delimitação das áreas de endemismo na Amazônia (Wallace, 1854; Haffer, 1969; Cracraft, 1985; Silva *et al.*, 2002; Naka, 2011; Borges & Silva, 2012). Estas áreas são caracterizadas pela distribuição congruente de duas ou mais espécies endêmicas, com seus congêneres habitando áreas de endemismo adjacentes (Platnick, 1991; Harold & Mooi, 1994), além de serem delimitadas por barreiras geográficas que limitaram a distribuição de várias espécies e impediram o fluxo gênico entre populações (Hausdorf, 2002).

A regionalização da Amazônia evoluiu a partir do trabalho pioneiro de Wallace (1854), que dividiu a Amazônia em quatro distritos biogeográficos delimitados pelos rios Amazonas, Negro e Madeira, a partir da distribuição restrita de algumas espécies de primatas. A partir de uma síntese da distribuição de algumas espécies de aves na Amazônia, Haffer (1969) propôs o reconhecimento de seis centros de distribuição, que foram posteriormente refinados e ampliados por Cracraft (1985) para sete áreas de endemismo. Em estudos mais recentes duas novas áreas foram descritas (Silva *et al.*, 2002; Borges & Silva, 2012), sugerindo, então, nove áreas de endemismo para aves amazônicas: Belém, Guiana, Imeri, Inambari, Jaú, Napo, Rondônia, Tapajós e Xingu (Haffer, 1969; Cracraft, 1985; Silva *et al.*, 2002; Naka, 2011; Borges & Silva, 2012).

As áreas de endemismo foram definidas unicamente em função das espécies endêmicas e coincidem com os grandes interflúvios amazônicos, delimitadas pelos grandes rios. Estudos sobre a história biogeográfica da Amazônia fornecem indícios da importância dos grandes rios na diversificação da biota local, limitação de dispersão e manutenção da diversidade de espécies (Silva *et al.*, 2002; Aleixo, 2004; Naka & Brumfield, 2018). Outros estudos evidenciaram o papel dos grandes rios amazônicos na restrição da distribuição de espécies, sendo considerados uma importante barreira ambiental para dispersão e fluxo gênico de vários táxons (Hayes & Sewlal, 2004; Moraes *et al.*, 2016; Pomara *et al.*, 2013).

Em escala regional, os grandes rios amazônicos atuaram como barreiras ambientais que culminaram em eventos de vicariância, especiação e dispersão e, ainda hoje, limitam a distribuição de várias espécies. Adicionalmente, a estruturação das assembleias também pode estar relacionada às variações ambientais locais, características do habitat, amplitude do nicho ecológico, disponibilidade de recursos e competição interespecífica (MacArthur & Levins, 1967; Steege & Zagt, 2002). A homogeneidade do habitat bem como a similaridade do nicho podem aumentar a força da competição interespecífica e conduzir a um processo de limitação de similaridade, em que espécies que utilizam recursos semelhantes (pertencem a mesma guilda) diferem em algum aspecto morfológico visando reduzir a sobreposição no uso dos recursos (Hutchinson, 1959; MacArthur & Levins, 1967; Gómez *et al.*, 2010).

O conceito de limitação de similaridade levou alguns autores a proporem modelos de regras de montagem de assembleias que permitem a coexistência de espécies (Diamond, 1975; Wilson, 1989; Wilson & Whittaker, 1995; Feeley, 2003). O modelo de proporcionalidade de guildas apresentado por Wilson (1989) estabelece que se a competição é um fator importante na estruturação das assembleias, a proporção relativa de espécies em cada guilda deveria permanecer estável entre assembleias com diversidade e composição distintas (Feeley, 2003). A proporcionalidade similar entre assembleias seria o resultado das interações entre as espécies que coocorrem, onde uma espécie tem menor chance de se estabelecer em um local se ela pertencer a mesma guilda de outra espécie que já ocupa o local. Por outro lado, se o indivíduo consegue se estabelecer, é provável que um indivíduo da outra espécie residente seja excluído competitivamente. Nos dois casos, a proporcionalidade de espécies entre guildas é mantida.

A importância de entender os processos que levaram aos padrões atuais de distribuição das espécies é indiscutível, dado que a Amazônia é um bioma relativamente bem preservado e de grande diversidade. Os fatores históricos envolvidos na delimitação das áreas de endemismo podem exercer um papel relevante na diversidade e composição das assembleias de espécies endêmicas e não endêmicas, determinando o pool regional de espécies dentro de cada área de endemismo. Complementarmente, a estruturação das assembleias locais dentro de cada área de endemismo também está relacionada às características do habitat, proporção de espécies nas guildas e disponibilidade de recursos, que irão determinar as relações ecológicas entre as espécies e a coexistência, conectando, então, os fatores históricos, ambientais e ecológicos aos padrões atuais de diversidade e estruturação das assembleias.

As aves, sendo primordiais na delimitação das áreas de endemismo e precursoras de muitos estudos biogeográficos na Amazônia (Borges *et al*., 2001; Aleixo, 2004; Ribas *et al*., 2005; Cohn-haft *et al*., 2008; Naka & Brumfield, 2018), são ideais para compreender como os fatores históricos e ambientais resultaram nos padrões atuais de diversidade. Além de ser um grupo relativamente bem estudado, com revisões recentes sobre taxonomia e distribuição (Remsen *et al*., 2018), também dispõe de muitas informações sobre a ecologia das espécies, morfologia, dieta e habitat (Wilman *et al*., 2014), iluminando os fatores ecológicos que podem atuar na estruturação das assembleias locais.

Nós investigamos os padrões de diversidade das assembleias de aves de sub-bosque de florestas de terra firme em sete áreas de endemismo da Amazônia. Buscamos compreender se os processos históricos que culminaram na delimitação das áreas de endemismo influenciaram toda a assembleia de aves de sub-bosque, incluindo as espécies amplamente distribuídas. Agrupando as espécies em guildas de acordo com sua dieta e tamanho corporal, analisamos como as espécies exploram os recursos localmente e testamos a existência de proporcionalidade de guildas (alpha guildas) em cada AE. Nosso trabalho reforça a importância de estudos com dados já coletados, que conseguem alcançar diversas escalas temporais e espaciais e englobar tanto a biogeografia histórica quanto os fatores intrínsecos da ecologia de comunidades.

2- OBJETIVOS

2.1- Objetivo geral

Investigar os padrões de diversidade, composição de espécies e estruturação das assembleias de aves de sub-bosque de florestas de terra firme em sete áreas de endemismo da Amazônia.

2.2- Objetivos específicos

1) Testar a hipótese de que há uma diferença nos padrões de diversidade entre as sete áreas de endemismo investigadas e se estas áreas podem ser diferenciadas em sua diversidade considerando somente as espécies de ampla distribuição.

2) Testar se existe proporcionalidade nas guildas em cada área de endemismo e se a proporção de espécies e indivíduos em cada guilda varia entre as sete áreas.

Capítulo 1

Braga, P. L. M; Borges, S. H.; Anciães, M.; Blake, J. G.; Bueno, A. S.; de Abreu, F. H. T.; d'Horta, F. M.; Henriques, L. M. P.; Loiselle, B. A.; Maximiano, M. F. A.; Menger, J.; Souza, A. H. N.; Stouffer, P. C. & Baccaro, F. B. Connecting historical biogeography and local assemblies of understory birds in Amazonia: areas of endemism, species diversity and guild proportionality.

Manuscrito submetido para: Journal of Animal Ecology

Connecting historical biogeography and local assemblies of understory birds in Amazonia: areas of endemism, species diversity and guild proportionality

Braga, P. L. M [1]; Borges, S. H [2].; Anciães, M. [1]; Blake, J. G.[3]; Bueno, A. S.[4]; de Abreu, F. H. T.[1], L. M. P [1].; Loiselle, B. A.[3]; Maximiano, M. F. A [1].; Menger, J.[1,6]; Souza, A. H. N.[1] & Baccaro, F. B [2].

1- Instituto Nacional de Pesquisas da Amazônia (Programa de Pós-Graduação em Ecologia, Avenida André Araújo, 2.936 - Petrópolis - CEP 69.067-375 - Manaus – Amazonas, Brasil).
2- Universidade Federal do Amazonas (Departamento de Biologia, Avenida General Rodrigo Octávio, 6200 – Coroado I – CEP: 69080-900, Manaus, Amazonas, Brasil).
3- University of Florida (Department of Wildlife Ecology & Conservation, University of Florida, Gainesville, FL 32611, USA).
4- Instituto Federal de Educação, Ciência e Tecnologia Farroupilha (Rodovia RS-527, s/n -. CEP: 98130-000- Distrito de São João do Barro Preto, Júlio de Castilhos – Rio Grande do Sul, Brasil).
5- Center for Latin American Studies (Tropical Conservation & Development Program, Gainesville, FL 32611, USA).
6- German Centre for Integrative Research (iDiv) Halle-Jena-Leipzig (Deutscher Pl. 5E, 04103 Leipzig, Alemanha).

Abstract

1. Diversity patterns of biological communities are a reflection of historical and contemporary events that occur in different spatial scales. In Amazonia, historical processes related to the establishment of the drainage system and of terra-firme forests triggered events of vicariance, speciation and dispersal. Additionally, local ecological factors are important on the maintenance of historically established patterns. The areas of endemism are interpretation units of historical biogeography, and investigating assemblies in these areas may improve our understanding on the interaction between historical events and local diversity.
2. We investigated diversity and composition patterns of understory birds assemblies in terra-firme forests, compiling studies that employed mist nets as sampling method, in 13 localities inserted in seven areas of endemism in Amazonia. We sought to understand if the historical events that resulted in the delimitation of areas of endemism extended to the whole assembly of birds. We assessed which are the predominant guilds and if there is guild proportionality (alpha guilds) in each area of endemism.
3. Patterns of diversity and composition of species are distinct between the seven areas of endemism, both in composition and relative abundance of species. The proportion of species and individuals in guilds remain constant amongst the areas of endemism and there is a prevalence of alpha guilds (guild proportionality) in almost all the areas.
4. The replacement of species between the areas of endemism does not occur in a random way and maintains the same ecological functions of species, indicating certain homogeneity in the availability of resources in terra-firme forests. The prevalence of alpha guilds indicates that interspecific competition is a strong structuring factor of local assemblies, possibly in a process of limiting similarity in species body size.
5. The congruence between the structure of assemblies of understory birds and the areas of endemism demonstrates how much historical and evolutionary processes that act in large scale, together with local ecological processes, lead to current patterns of diversity and composition of species in Amazonia.

Introduction

Diversity patterns of biological communities result from historical and contemporary events that act in several spatial and temporal scales and that define, ultimately, the composition of local communities (Hubbel, 1997). Historical processes as the movement of tectonic plates, uplift of mountains, climatic changes and development of drainage systems acted in large scale throughout millions of years and contributed with the diversity patterns currently found (Levin, 1992; Holt, 1993; Huston, 1994; Hoorn, 2010). Complementarily, habitat characteristics, species particularities, availability of resources, biotic interactions and niche requirements that occur locally also have fundamental importance on the structure, dynamic and organization of communities in space and time (Huston, 1979; Wiens, 1989; Leibold *et al.*, 2004; Ernest *et al.*, 2008).

Amazonia is an ideal biome to test hypothesis on how communities are influenced by historical and contemporary events. This biome has gone through many geological events (Albert *et al.*, 2018) that may have influenced the dynamics and organization of local assemblies, besides its great geographical extension that accommodates a large environmental variation. It is believed, for example, that the evolution of the drainage system altered Amazonia's geological conformation, isolating populations in opposite margins of the major rivers and resulting in speciation (Ribas *et al.*, 2011). Other events as the establishment of terra-firme forests, and the more recent rearrange of the fluvial courses, also act in the diversification of many bird species, contributing to the current distribution patterns (Aleixo, 2004; Ferreira *et al.*, 2016; Schultz *et al.*, 2017).

The recognition of restrict and specific biogeographical patterns in the distribution of several bird species culminated in the delimitation of the areas of endemism in Amazonia (Cracraft, 1985). These areas are characterized by the congruent geographical distribution of two or more endemic species, with its congeners inhabiting adjacent areas of endemism (Platnick, 1991; Harold & Mooi, 1994), besides being demarcated by geographical barriers that limited the distribution of several species and impeded gene flow between populations (Hausdorf, 2002). The proposition of biogeographical units for Amazonia evolved from Wallace´s (1954) pioneer work, which divided the biome in four districts delimitated by the Amazonas, Negro and Madeira rivers, based on the restrict distribution of a few primate species. From a synthesis of the distribution of some bird species in Amazonia, Haffer (1969) proposed the acknowledgment of six centers of distribution, which were later refined and expanded by Cracraft (1985) to seven areas of endemism. After new studies, two other areas were recognized, totalizing nine areas of endemism acknowledged for Amazonian birds (Silva *et al.*, 2002; Borges & Silva, 2012). These areas were defined solely in function of endemic species and coincide with the major Amazonian interfluves, delimited by the great rivers.

Although there is a consensus that the origin of current distribution patterns of biodiversity in Amazonia is related to the evolution of the drainage system and the resulting limitation of dispersal and speciation, there are several decisive factors in the maintenance and reorganization of diversity patterns. In local scale, the structure of assemblies is also related to environmental variations, habitat characteristics, ecological niche range, availability of resources and interspecific competition (MacArthur & Levins, 1967; Steege & Zagt, 2002). Habitat homogeneity, as well as niche similarity, may increase the force of interspecific competition and lead to processes of limiting similarity, in which species that exploit similar resources must differ in some morphological aspect aiming to reduce the overlap in use of resources and allow coexistence (MacArthur & Levins, 1967; Gómez *et al*., 2010).

The concept of limiting similarity led some authors to propose assembly rule models that allow the coexistence of species (Diamond, 1975; Wilson, 1989; Wilson & Whittaker, 1995; Feeley, 2003). The model of guild proportionality presented by Wilson (1989) establishes that if competition is an important factor in the structure of assemblies, the relative proportion of species in each guild should remain stable between assemblies with distinct diversity and composition (Feeley, 2003). Similar proportionality between assemblies would be the result of interactions between species that co-occur, in which a species has smaller chance of establishing itself in a place if it belongs to the same guild as other species that already occupies the place. On the other hand, if the individual is able to establish itself, it is probable that one individual from the other resident species is competitively excluded. In both cases, species proportionality between guilds is maintained.

Amazonia is a relatively well preserved biome with great diversity that went through important geological and evolutionary events in the determination of the regional pool of species. Historical factors involved in the delimitation of areas of endemism may have an important role in patterns of diversity and composition of local assemblies, influencing endemic, non endemic and widely distributed species and defining distinct diversity patterns between the areas. The structure of local assemblies within each area of endemism is also related to habitat characteristics and availability of resources, which will determine ecological relations between species and coexistence, thus connecting historical and ecological factors to current patterns of diversity, composition and structure of species assemblies. Birds, being essential in delimiting areas of endemism and precursors of many biogeographical studies in Amazonia (Borges *et al*., 2001; Aleixo, 2004; Ribas *et al*., 2005; Cohn-Haft *et al*., 2008; Naka & Brumfield, 2018), are ideal to test how historical factors resulted in current patterns of diversity, besides highlighting ecological factors that act in the structure of local assemblies.

If areas of endemism represent useful biogeographical units to comprehend the diversity patterns of local assemblies, we expect that its historical influence also reaches non endemic and widely distributed species, and not only the endemic species that fostered the delimitation of those areas. We presume that the structure patterns of bird assemblies between areas are distinct and that the replacement of species occur maintaining the same ecological functions, with similar proportion of species in guilds in each area of endemism. Thus, we investigated patterns of diversity and composition of assemblies of terra-firme forest understory birds in seven areas of endemism in Amazonia. Our research sought to (i) Test if understory birds assemblies (endemic, non endemic and widely distributed) have distinct diversity patterns, consistent with the historical effect provided by the areas of endemism; (ii) comprehend which are the predominant guilds in each area; and (iii) test if there is guild proportionality in each area of endemism.

Material and Methods

Study area

Nine areas of endemism (AE) based on the geographical distribution of birds were described so far for Amazonia: Belém, Guiana, Imeri, Inambari, Jaú, Napo, Rondônia, Tapajós and Xingu (Wallace, 1854; Haffer, 1969; Cracraft, 1985; Silva *et al.*, 2002; Naka, 2011; Borges & Silva, 2012). The delimitation of these areas followed the methodology proposed by Müller (1972) of connecting the outermost distribution points and superposition of many species, taking into account only the points where the species were registered.

In this work we used data from mist nets (only understory birds) derived from 13 localities inserted in terra-firme forests in Amazonia (table 1). These locations encompass seven of the nine areas of endemism known for Amazonian birds: Napo, Jaú, Guiana, Inambari, Rondônia, Tapajós and Xingu (fig. 1).

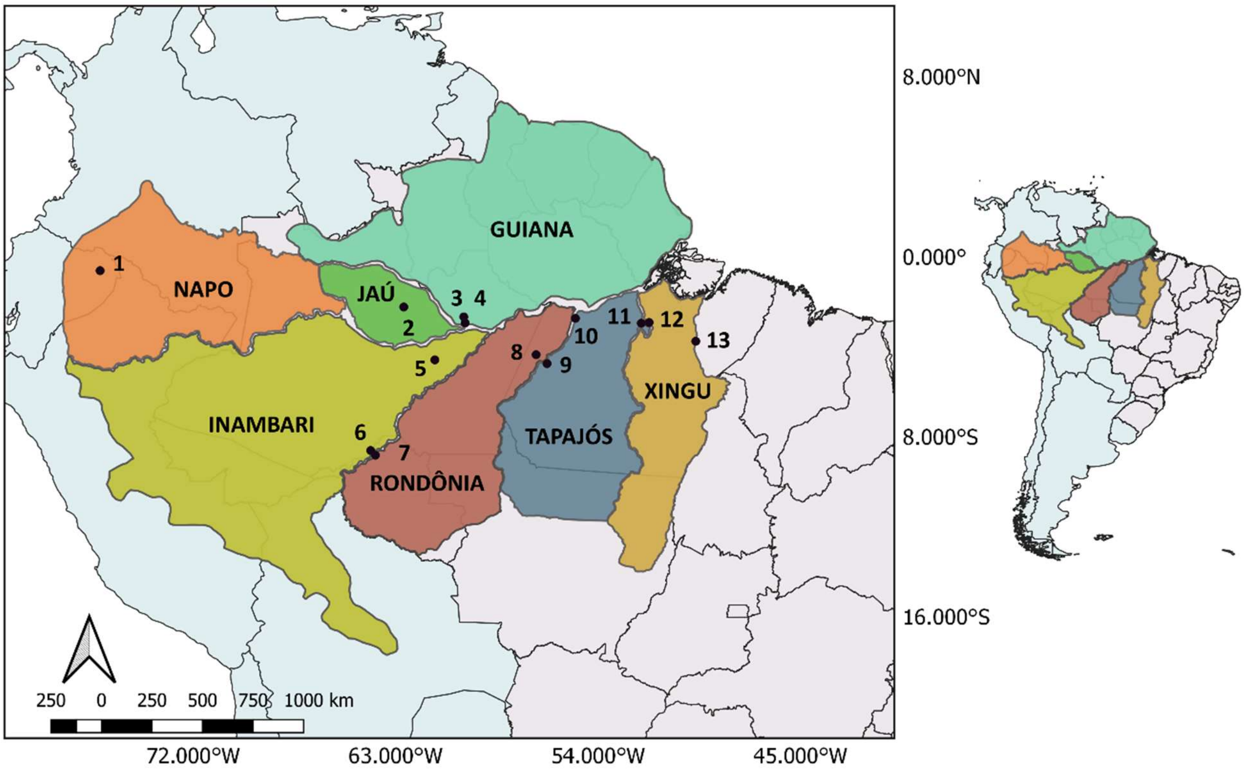

Figure 1: Sampling localities in seven areas of endemism in Amazonia. The delimitation of AE follows the boundaries proposed by Haffer (1969); Cracraft (1985); Silva *et al*. (2002); Borges & Silva (2012).

These localities were chosen for being i) localities where the avifauna was well sampled and ii) samples conducted only in terra-firme forests. Regarding this last criteria, we assume that there are no representative variation in the vegetation structure between study areas, characterizing similar habitats.

Sampling

The studies compiled here used mist nets as sampling method for birds. Mist nets are widely used for capturing birds, mainly those that inhabit the understory of forests. Amongst the disadvantages of the method, nets used at ground level limit captures among birds that move only from two to three meters from the ground, not being representative of the total species diversity locally (Remsen & Good, 1996; Blake & Loiselle, 2009). On the other hand, mist nets may be efficient in studies on the diversity and abundance of species, because it allows higher reliability in species identification and greater ease in the standardization of the sampling effort, besides allowing quantitative comparisions of species that are difficult to sample through visual or auditive censuses (Karr, 1981; Remsen & Good, 1996).

Mist net studies used in this work were implemented with distinct goals and contexts (see appendix 5.1), presenting variations in the number of captured individuals per site, with a minimum of 408 and a maximum of 3,674 captures. Despite this variation, we sought to make the data the most comparable possible. For example, in cases of experimental studies (PDBFF and Tapajós National Forest), only captures conducted in control areas were used. Samplings were limited to a small geographic portion within each area of endemism. However, with the exception of Xingu, all the other areas have very representative samples of the local assemblies, higher than 700 and totalizing 20,707 captures in the seven areas of endemism investigated.

Table 1: Samplings of understory birds in terra-firme forests in Amazonia.

Areas of endemism	Sampling sites*	Sampling periods	Number of captures
Napo	Tiputini Biodiversity Station [1]	2001 to 2005	3055
Jaú	Jaú National Park [2]	1994 to 2007	2942
Guiana	PDBFF [3]	1985 to 1989	1403
Inambari	Adolfo Ducke Forest Reserve [4]	2009, 2012 to 2014	3674
	BR 319 [5]	2012 to 2013	935
	Santo Antônio HPP [6]	2010 to 2011	1800
Rondônia	Santo Antônio HPP [7]	2010 to 2011	1440
Tapajós	Tapajós River [8]	2012 to 2013	855
	Tapajós River [9]	2012 to 2013	1172
	Tapajós National Forest [10]	1997 to 2001	1422
Xingu	Belo Monte HPP [11]	2007 to 2008	727
	Belo Monte HPP [12]	2007 to 2008	408
	Tucuruí HPP [13]	2005	874
TOTAL	**-**	**-**	**20,707**

* 1) Blake & Loiselle, 2009; 2015; 2) Borges *et al*., 2001; 3) Bierregaard & Lovejoy, 1989; Stouffer & Bierregaard, 1995; 4) Bueno *et al*., 2012; Menger *et al*., 2017; 5) Souza, 2014; de Abreu, 2018; 6 and 7) Santo Antônio HPP Pre-filling Report, 2013; 8 and 9) Maximiano, 2017; 10) Henriques *et al*., 2008; 11 and 12) EIA/ RIMA from Belo Monte HPP, 2008; 13) Assessment and Monitoring of the Avifauna in the Tucuruí Reservoir, 2008.

Taxonomic and ecological standardization of data

The taxonomy of Neotropical birds has been going through intense modification due to recent reviews, mainly through molecular techniques (Piacentini *et al.*, 2015; Remsen *et al.*, 2018). Many of these alterations involved separating species that were once considered as one, which resulted in the necessity of a complete review of the taxonomy adopted in each study.

First we integrated the obtained data in a single base and upgraded the scientific names of species, standardizing it according to the Brazilian Committee of Ornithological Records (Piacentini et al., 2015) for species that occur in Brazil, and according to the South American Classification Committee (Remsen *et al.*, 2018) for the ones that do not occur in Brazil. The taxonomy of all species was assessed and those that were recently separated were duly altered according to its current geographical distribution. This approach implicated in renaming some species that were previously known by the same name in different interfluves. For example, the species *Hypocnemis cantator*, which was formerly known as one, was divided into five others, *H. peruviana, H. flavescens, H.ochrogyna, H. subflava* and *H. striata* (Isler *et al.*, 2007).

We checked the geographical distribution of all species through the digital platforms Xeno-Canto and Handbook of the Birds of the World. We also assessed the database searching for species that are not characteristic from understory, or that inhabit mainly open areas or floodplains, but were sampled in the mist nets, and these were excluded from the database (appendix 5.2). As part of the data was obtained in long lasting projects, there was a high number of recaptures and, once we were interested in relative abundance of species, those were also excluded.

Guilds may be defined as an ecologically similar group of species that explore similar resources (Wilson, 1999). In this work we defined species feeding guilds according to the most consumed item by the species (over 50%), using a global database that has information on birds diet and weight (Wilman *et al.*, 2014). We designated the following guilds: insectivorous (feed on invertebrates, mainly insects), frugivores, nectarivores, carnivorous (feed on vertebrates) and omnivores (consume more than three food items, though each item represents less than 50% of its diet).

Within each feeding guild we divided species in size categories according to its weight: small insectivorous (≤ 15g), medium insectivorous (16 to 60g), large insectivorous (> 60g), small frugivores (≤ 20 g), medium frugivores (between 21 and 80g), large frugivores (> 80g), small nectarivores (≤ 5g), large nectarivores (> 5g), small carnivorous (≤ 60g), large carnivorous (> 100g), small omnivores (≤ 40g), medium omnivores (70 to 170g) and large omnivores (> 200g). The weight was used aiming to refine species categorization into guilds, avoiding grouping species that, even consuming the same type of food, probably do not compete directly for resources. For species in our database that were recently split and renamed, we used diet and weight data from the original species.

Statistical analyses

<u>Diversity and composition of species</u>

Due to the heterogeneity in capture data used in this work, we delimited distinct sampling units for each analysis, either based on the number of captured individuals or according to capture sites (each capture site represents a sampling unit, as described below).

Aiming to compare species richness of bird assemblies and to assess the representativeness of samplings, we created rarefaction curves based on the total number of captures in each area of endemism (Gotelli & Colwell, 2001).We did this comparison considering the number of species observed and extrapolated to 5,100 individuals, which was the number of captures in Guiana (the area with most records). We used the package iNEXT in the software R to create the rarefactions and extrapolations, as well as to calculate the 95% confidence interval (Colwell *et al.*, 2004).

We checked the dissimilarity in species composition between areas of endemism through an ordination by non metric multidimensional scaling (NMDS) using four approaches considering: i) relative abundance data from all species, ii) presence or absence data from all species, iii) relative abundance data from species that occur in all the areas of endemism (only species of wide distribution) and iv) presence or absence data from species of wide distribution.

For the ordination analyses we delimitated sampling units by the number of captured individuals. In the analyses that included all species, samples were composed by 250 individuals, while for species of wide distribution the standardized number was reduced to 100 individuals due to the smaller number of species and captures. Sampling units were generated by Bootstrap (draw amongst captured individuals within each area of endemism, without reposition), until all captures from each area ended. This procedure was adopted due to the impossibility of using real samples (e.g. captures by hours/net). The random samplings standardized by number of individuals preserve the intrinsic structure of the assemblies, as relative frequency, besides allowing more reliable comparisons between areas of endemism. By the end of the randomization process we obtained 79 sampling units of 250 individuals and 61 sampling units of 100 individuals. Dissimilarity between samples was based in Bray-Curtis index for the abundance matrix and in Jaccard index for the presence or absence matrix (Melo & Hepp, 2008). We tested the hypothesis that species composition is distinct between areas of endemism through pair to pair comparisons in a multivariate analysis of variance – MANOVA (Anderson, 2001).

We used a heat map (package heatmap.2 in the software R) to order species of wide distribution in a dendrogram. First we created a matrix with the relative abundance of species in each area of endemism. We generated a dendrogram using a Euclidean distance measure to calculate the distances between lines and columns of the data matrix, and the results were calculated according to the values of relative abundance of species in each AE. We generated a heat map, in which the color scales represent differences in abundance, and the histogram (Z-scores) represents the distribution of relative abundance values in the seven areas of endemism.

Guild proportionality

We calculated the proportion of species and individuals that belong to each guild, for each area of endemism, seeking to comprehend how species are distributed amongst distinct ecological groups. We assessed if there are differences in these proportions between the seven areas of endemism studied through a variance analysis – ANOVA.

We also checked the incidence of proportionality in species distribution amongst different guilds. For this analysis we used real sampling units according to the capture sites, with the exception of Guiana and Napo (long term monitoring), in which, besides the sites, sampling years were also used. The goal was to use only sets of sampling units where the species actually co-occurred. As there is great variation in sample sizes, and that may bias the results, only sites with more than 50 individuals were included in the analysis.

The relative variance of species proportions in guilds (RVgp) was used as an index to test the existence of guild proportionality (alpha guilds), within each area of endemism, in relation to the expected by the null model (Wilson, 1989). Null models are used to eliminate the effects of deterministic processes, and in this case it was create by the randomization of the observed data set (Gotelli, 2000), keeping the richness and the species number of occurrences in each site constant.

Guild proportionality (gp) for each sample was calculated as:

$$gp = \frac{\text{n° of species that belong to each guild (g)}}{\text{total n° of species in the sample}}$$

Thus:

$$RVgp = 2\,\frac{\text{observed variance in pg in all samples}}{\text{obs. variance + expected variance under the null model}} - 1$$

The RVgp index varies from -1 to +1, and is: < 0, when the observed variance in guilds proportions between samples is smaller than expected by the null model (alpha guilds), indicating guild proportionality; equal to 0, when the observed variance in guilds proportions is exactly as expected, on average, under the null model; > 0, when the observed variance in guilds proportions between samples is higher than expected by the null model (beta guilds), indicating guild disproportionality (Wilson, 1989; Watkins & Wilson, 2003; Holdaway & Sparrow, 2006). A different value of RVgp was generated for each guild, in each area of endemism. The use of RVgp only makes sense if the individuals from a particular sample have the chance to co-occur with other individuals from the same sample. Thus, in these analyses we delimitated the local assemblies to meet the following criteria: i) local assemblies were composed by individuals captured in the same site and within one year at most and ii) the number of individuals by assembly was greater than 50. We compared RVgp values generated for each guild, in each area of endemism, through a variance analysis – ANOVA.

Results

Diversity and composition of species

We recorded a total of 231 species of understory birds in Amazonian terra-firme forests, distributed in nine orders, 32 families and 116 genera. From this total, only 24 (10%) species are of wide distribution and occur in the seven areas of endemism studied.

The rarefaction curves tended to stabilize at around 1,500 individuals, with the exception of Rondônia and Xingu. Considering the extrapolation to 5,100 individuals, almost every curve stabilized, with the exception of Rondônia (fig. 2A). The area of endemism with the highest species richness (observed) was Rondônia, followed by Tapajós (113), Napo (109), Inambari (108), Guiana (93), Jaú (92) and Xingu (89). Napo, Inambari and Tapajós areas of endemism did not present significant differences in the number of species extrapolated to 5,100 individuals, once the confidence intervals overlap. Guiana presents lower species richness than the other areas. At the other extreme, Rondônia appears with higher richness than all the other areas, followed by Xingu. However, the confidence interval from the Xingu AE is very large due to the lesser number of captures (fig. 2B).

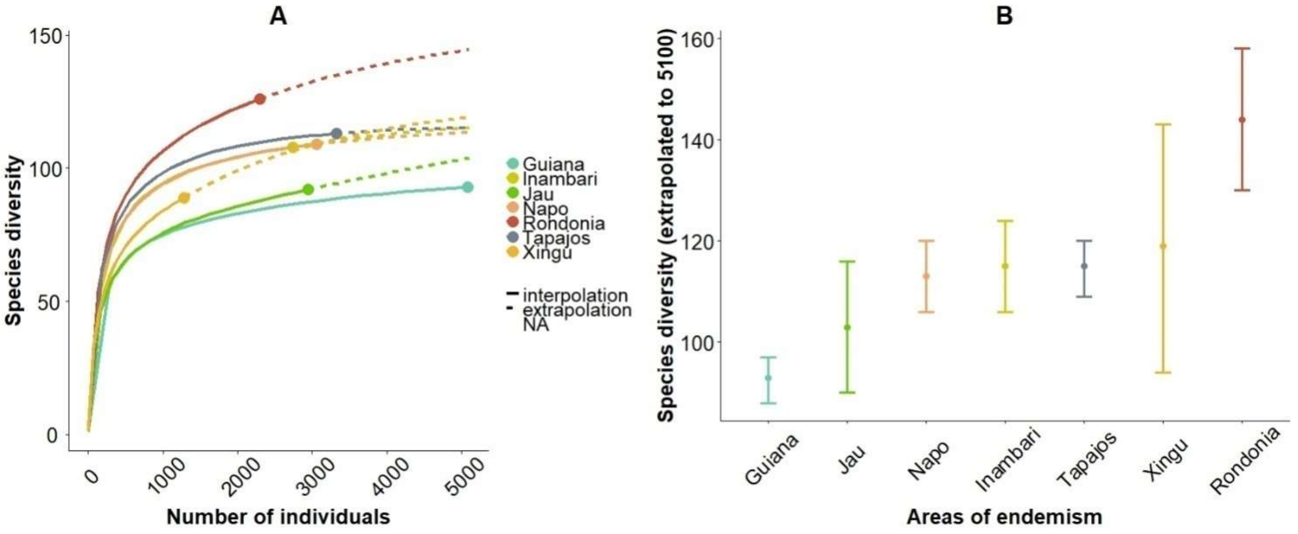

Figure 2: A) Rarefaction curves for the seven areas of endemism studied, extrapolated to 5,100 individuals. B) Number of species expected for each area of endemism, according to the extrapolation of the number of individuals.

Species composition was distinct between the seven areas of endemism studied, considering data on relative abundance and presence or absence (fig. 3 A and 3B, MANOVA; $p < 0.05$). Analyzing only the species of wide distribution, dissimilarity between assemblies is significant between the seven areas of endemism, when data on relative abundance are considered (fig. 3C, MANOVA; $p < 0.05$). However, there is no distinction between Inambari, Rondônia, Tapajós and Xingu AE, considering data on presence or absence (fig. 3D, MANOVA; $p > 0.05$).

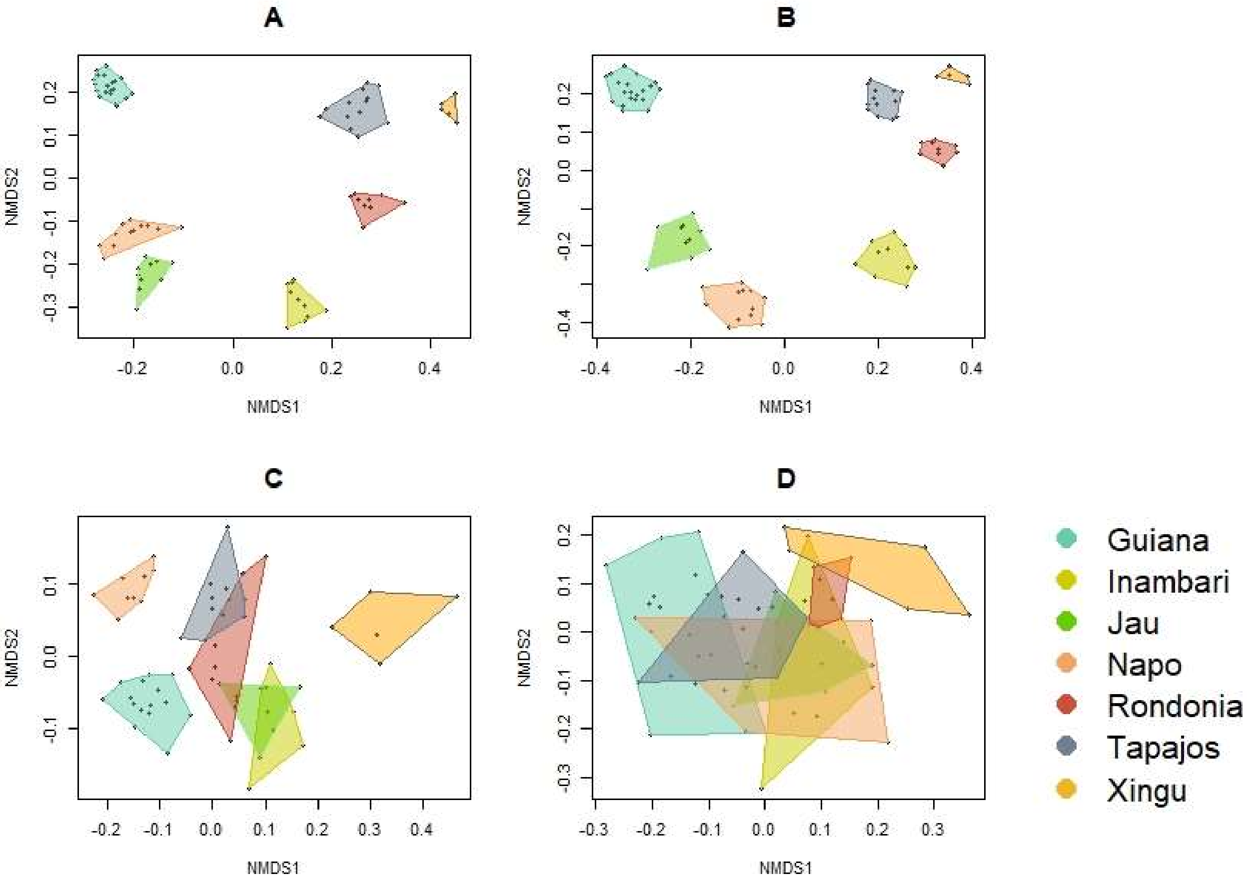

Figure 3: A) NMDS with all species, using data of the abundance matrix. B) NMDS with all species, using data on presence or absence. C) NMDS with species of wide distribution, using data from the abundance matrix. D) NMDS with species of wide distribution, using data on presence or absence. Dots represent the sampling units created, of 250 (A and B) and 100 individuals (C and D).

The dendrogram generated with widely distributed species kept the species *Glyphorynchus spirurus* in a separate group. The Xingu area of endemism also remained as an isolated group, in which the most abundant species was *Myrmotherula axillaris*. The histogram shows the distribution of relative abundance values in the seven areas of endemism, in which few species occurred with high relative abundance (fig. 4).

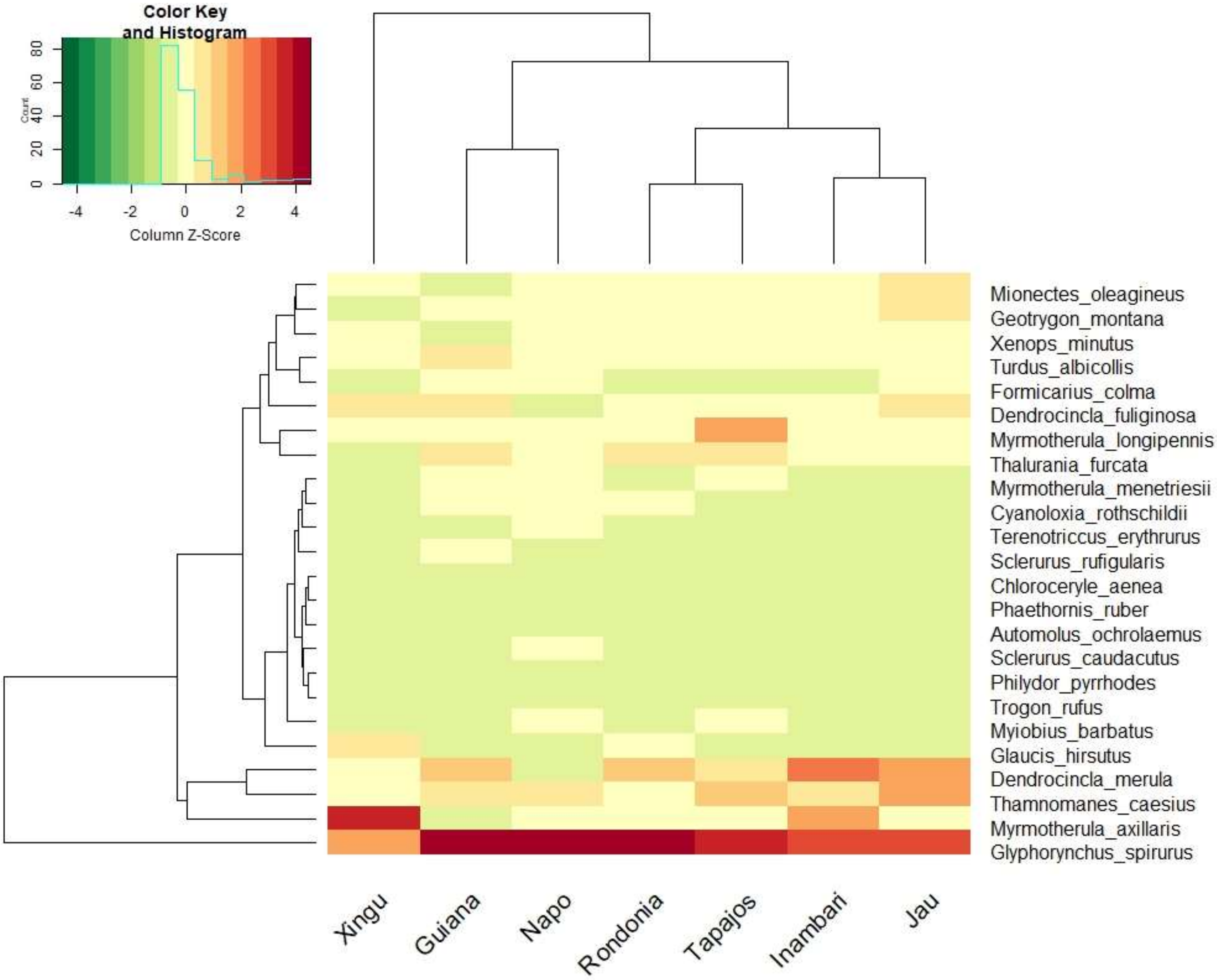

Figure 4: Dendrogram of species of wide distribution in the seven areas of endemism studied. The left dendrogram groups species according to its relative abundance, and the upper one groups the areas of endemism. Z-scores present, in a histogram, the distribution of relative abundance values in the areas of endemism, in which darker colors indicate the most abundant species.

Some species, despite not being endemic, were registered in only one area of endemism (table 2).

Table 2: Number of species registered in only one area of endemism.

Areas of endemism (AE)	Total n° of species	N° of species registered in only one AE
Guiana	93	13 (13.97%)
Inambari	108	7 (6.48%)
Jaú	92	7 (7.60%)

Napo	109	17 (15.59%)
Rondônia	126	15 (11.90%)
Tapajós	113	11 (9.73%)
Xingu	89	7 (7.86%)
TOTAL	**-**	**77 (33.33%)**

Guild proportionality

Out of the total bird species registered, the greatest majority (170 – 73.59%) is insectivorous, followed by frugivores (19 – 8.22%), omnivores (16 – 6.92%), nectarivores (15 – 6.49%) and carnivorous (11 – 4.76%). Detailed values of species and of total and widely distributed individuals in each guild, defined using data on diet and body size, are presented in table 3.

Table 3: Number of species and individuals by guild. Not every guild has widely distributed species.

Guilds	Total n° of species	Total n° of individuals	N° of species of wide distribution	N° of individuals of wide distribution
Large insectivorous	20 (8.65%)	258 (1.24%)	-	-
Medium insectivorous	99 (42.85%)	8915 (43.05%)	9 (37.50%)	1675 (26.34%)
Small insectivorous	51 (22.07%)	6201 (29.94%)	8 (33.33%)	3489 (54.87%)
Large frugivores	2 (0.86%)	35 (0.16%)	-	-
Medium frugivores	2 (0.86%)	119 (0.57%)	1 (4.16%)	117 (1.84%)
Small frugivores	15 (6.49%)	2433 (11.74%)	1 (4.16%)	266 (4.18%)
Large omnivores	2 (0.86%)	3 (0.01%)	-	-
Medium omnivores	4 (1.73%)	381 (1.83%)	1 (4.16%)	281 (4.41%)
Small omnivores	10 (4.32%)	690 (3.33%)	-	-
Large nectarivores	7 (3.03%)	486 (2.34%)	1 (4.16%)	98 (1.54%)
Small nectarivores	8 (3.46%)	1005 (4.85%)	2 (8.33%)	365 (5.74%)
Large carnivorous	7 (3.03%)	66 (0.31%)	-	-
Small carnivorous	4 (1.73%)	115 (0.55%)	1 (4.16%)	67 (1.05%)

TOTAL	**231**	**20707**	**24**	**6358**

Despite some variation, the proportions of species (fig. 5A) and individuals (fig. 5B) by guild remained similar between the areas of endemism (ANOVA; p > 0.05).

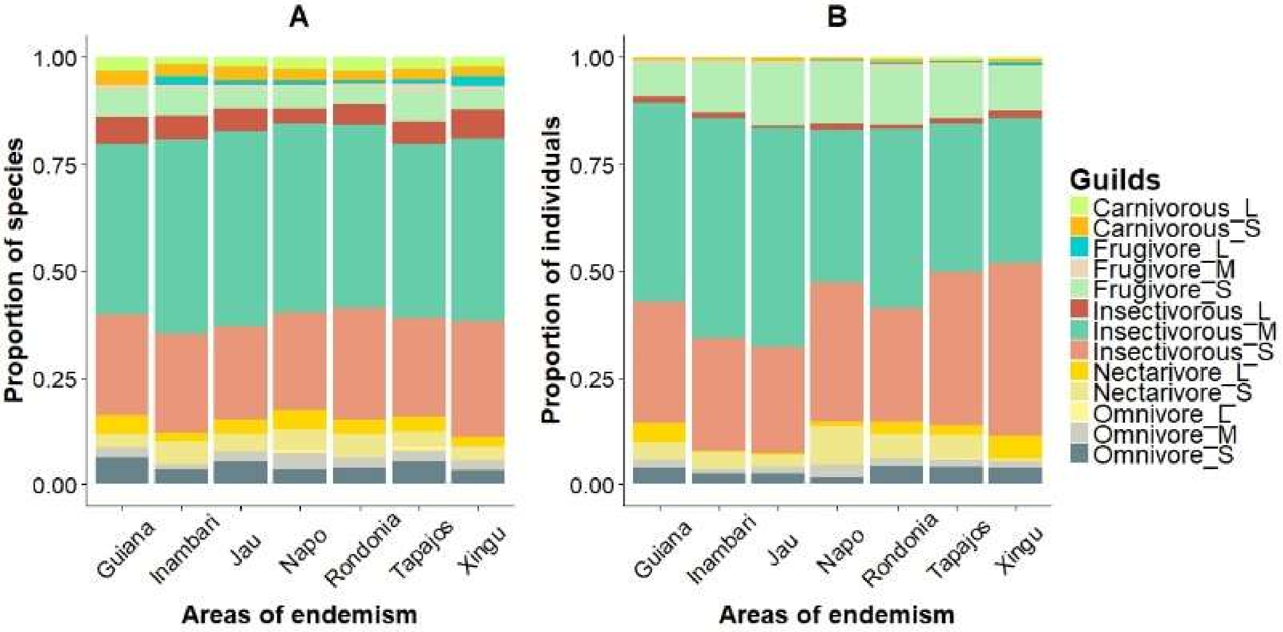

Figure 5: (A) Proportion of species and (B) of individuals by guild created based on diet and size, for the seven areas of endemism. The letters next to the diet refer to the size classes: L (large), M (medium) and S (small).

Values of RVgp did not vary significantly between guilds (p = 0.32), neither between the seven areas of endemism (p = 0.74). Data pointed out a prevalence of alpha guilds (RVgp < 0) in almost all the areas (fig. 6), with the exception of Jaú and Inambari. Alpha guilds indicate that the observed variance in guilds proportions between samples is smaller than expected by the null model (guild proportionality).

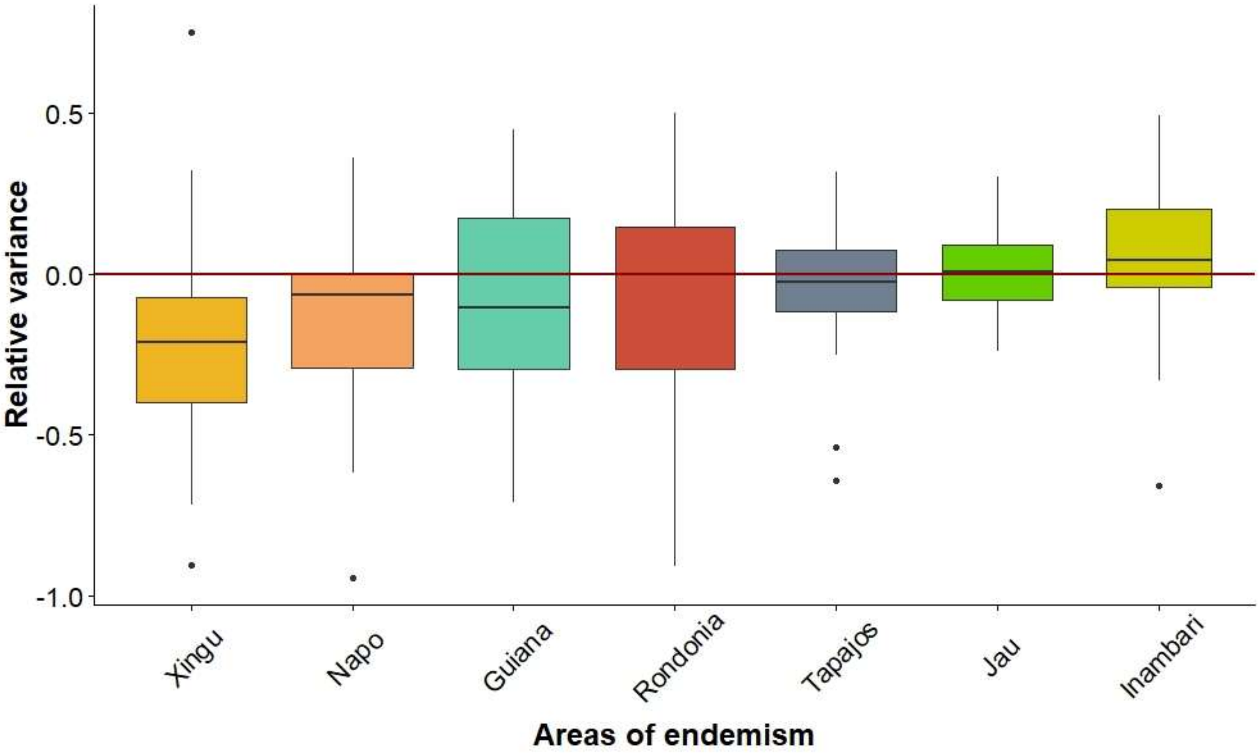

Figure 6: Relative variance (RVgp) calculated in the seven areas of endemism studied, using species feeding guilds and size classes. Values below zero indicate Alpha guilds (proportionality) and values above zero represent Beta guilds (disproportionality). The red line indicates the expected value under the null model.

Discussion

The areas of endemism delimited for Amazonian birds (Wallace, 1854; Haffer, 1969; Cracraft, 1985; Silva *et al*., 2002; Naka, 2011; Ribas *et al*., 2011; Borges & Silva, 2012; Schultz *et al.*, 2017) are relevant biogeographical units to understanding the current distribution and diversity of local assemblies of understory birds. The distinct diversity patterns found amongst these areas, even considering widely distributed species, indicate that the historical influence of the areas of endemism extends to the whole assembly of understory birds, and not only to endemic species. Our results reaffirm the consensus that the diversity patterns currently found in Amazonia are related to historical processes of the drainage system evolution and the resulting limitation of dispersal and speciation, which culminated on the delimitation of the areas of endemism. Additionally, species proportionality in guilds between sites, in almost every AE (prevalence of alpha guilds), indicates that interspecific competition is an important factor in the maintenance of historically established patterns, suggesting that the structure of local assemblies of birds are a reflection from both the historical processes that act in large scale and the local ecological factors.

Species richness of understory birds amongst the seven areas of endemism investigated is pretty heterogeneous. Our results point to a higher richness of species in Meridional Amazonia, in the Rondônia area of endemism, followed by Tapajós. With the exception of the Xingu AE, sites studied here accurately represent the local assemblies and, therefore, the highest diversity in the Rondônia AE is not a reflection of a sub-sample in the other areas. Even considering the extrapolated data for all areas of endemism, in which almost every rarefaction curve stabilizes and matches the sampling effort between them, Rondônia still remains with the highest richness, although followed by the Xingu AE, located eastward in Amazonia. Xingu was the area of endemism with the least sampling effort in this work, which explains the difference between observed and extrapolated data and the larger confidence interval.

Species diversity in the state of Rondônia was also discussed by Stotz *et al*. (1997) and by Emmel & Austin (1990), where they found the highest richness of birds and butterflies in Brazil, respectively. Historically, the highest richness in the Rondônia AE may be related to its central geographical position in relation to the other areas of endemism, favoring immigration of species before and after the establishment of the Amazonian drainage. The vicariance process of Madeira and Tapajós rivers that delimitated the Rondônia AE occurred primarily (Ribas *et al*., 2011), unleashing diversification and speciation events in long periods of time. Additionally, the high richness of species may be related to local environmental conditions and biotic interactions that allowed a high number of species to coexist.

Our data encompassed a small geographical portion of each area of endemism and were restricted to understory birds of terra-firme forests. However, the results presented here reaffirm the AE as historical units that defined distinct patterns of diversity and composition of species, considering data on presence or absence and of relative abundance of species. Bird species turnover was also found in a recently published work on the Amazonian areas of endemism (Oliveira *et al*.; 2017). Although the authors do not recognize that the major rivers delimit the AE and use distinct boundaries than the ones we considered in our work, the composition of bird species amongst the main interfluves was also distinct.

The differences in species relative abundance maintained a high dissimilarity between samples in the NMDS ordinations, suggesting a biogeographical pattern even on the widely distributed species. This pattern may be related to the role of the major rivers as a selective filter of species, since the dispersal of many species and individuals occurred after the consolidation of the drainage system (Schultz *et al*., 2017). Major rivers may also act as physical barriers, limiting dispersal of non endemic species, which may explain the percentage of species registered in only one AE. Our results suggest that the historical influence of the areas of endemism may be extrapolated to the whole assembly of understory birds of terra-firme forests, including non endemic and widely distributed species, and determine distinct diversity patterns between the seven areas investigated.

The dendrogram presented in our results on the widely distributed species kept the Xingu AE as a separate group for presenting a smaller number of captures when compared to the other areas. The species *Glyphorynchus spirurus* also appeared in a separate group for being the species with highest relative abundance in the Guiana, Napo, Rondônia and Tapajós AE. *Glyphorynchus spirurus* is one of the most common understory birds from tropical forests of South America (Blake & Loiselle, 2012). Although it is recognized as a single species, Fernandes *et al*. (2012) pointed to lineages with high genetic differentiation on the opposite sides of the main Amazonian rivers, reaffirming the importance of major rivers in the diversification processes, even of species of wide distribution.

Despite the substitution of species between the seven studied areas, all of them presented similar proportion of species in each guild, with prevalence of insectivorous and frugivores. The predominance of these guilds was also registered in other works conducted using mist nets in Amazonia (Bierregard, 1990; Robinson & Terborgh, 1990), since nets tend to capture understory individuals that fly at a maximum height of four meters, or that forage close to ground level, favoring the capture of insectivorous, frugivore and nectarivore species (Remsen & Good, 1996). The similar proportion of species in guilds suggests that the turnover between areas does not happen in a random way, maybe indicating also a certain similarity of the available resources in terra-firme forests.

The prevalence of alpha guilds in most AE indicates that there is a similar distribution in species proportions in guilds (guild proportionality) between local assemblies in each area of endemism, suggesting that the selective force that acts in the structure of assemblies is more associated to relations of interspecific competition and availability of resources (Wilson, 1989; Wilson, 1999; Fox & Brown, 1993; Wilson & Whittaker, 1995). According to Wilson (1989), when interspecific competition is the main actor in the structure of local assemblies, the proportion of species within guilds remains constant in distinct assemblies (alpha guilds), since the species inhibit the invasion of others or exclude members that belong to the same guild, in a process of competitive exclusion. Competition may also be related to the different values of relative abundance found amongst assemblies, once it may determine which species may co-occur and in which quantities (Watkins & Wilson, 2003). The definition of guilds based on diet and body size data favors the definition of ecological niche, grouping species that likely compete directly for resources, highlighting MacArthur & Levins (1967) theory that species that co-occur possibly differ in some morphological aspect to reduce overlap in the use of resources and allow coexistence.

The congruence between the structure of understory birds assemblies and the areas of endemism shows how much historical and evolutionary processes that act in large scale conduct to current patterns of biodiversity and composition of species in Amazonia. We highlight the importance of joining concepts of historical biogeography with assembly rules in analyses that reach several temporal and spatial scales, aiming to improve our understanding of the factors that generate and maintain species diversity in the largest forest ecosystem of the world.

Acknowledgements

We thank CAPES for the funding of the postgraduate program, the CNPq for the master's scholarship that financed the beginning of this research and the INPA for the professional partnerships. To Fernando d'Horta, Phillip Stouffer and Luiza Magalli P. Henriques for the data provided and to Mario Conh-Haft for information on the species.

References

Albert, J. S., Val, P., & Hoorn, C. (2018). The changing course of the Amazon River in the Neogene : center stage for Neotropical diversification. *Neotropical Ichthyology*, *16(3)*(October), 1–23.

Aleixo, A. (2004). Historical diversification of a terra-firme forest bird superspecies: a phylogeographic perspective on the role of different hypotheses of Amazonian diversification. *The Society for the Study of Evolution*, *58*(6).

Anderson, M. J. (2001). A new method for non parametric multivariate analysis of variance. *Austral Ecology*, *26*(2001), 32–46.

Avaliação e Monitoramento da Avifauna na Área do Reservatório de Tucuruí (2008). Relatório Final apresentado pelo Museu Paraense Emílio Goeldi ao Programa de Pesquisa e Desenvolvimento da Eletronorte na Usina Hidrelétrica Tucuruí. Eletronorte.

Bierregaard, J. (1988). Morphological data from understory birds in terra firme forest in the central amazonian basin. *Rev. Brasil. Biol.*, *48*(2), 169–178.

Bierregaard, R., & Lovejoy, T. E. (1989). Effects of Forest Fragmentation on Amazonian Dnderstory Bird Communities. *Acta Amazonica*, *9*, 219–241.

Bierregaard, R. O. JR. (1990). Species composition and trophic organization of the understory bird Community in a Central Amazonian terra firme forest. *Four Neotropical Rainforests*, 217-236.

Blake, J. G., & Loiselle, B. A. (2009). Species Composition of Neotropical Understory Bird Communities : Local versus Regional Perspectives Based on Capture Data. *Biotropica*, *41*(1), 85–94.

Blake, J. G., & Loiselle, B. A. (2012). Temporal and Spatial Patterns in Abundance of the Wedge- Billed Woodcreeper (*Glyphorynchus spirurus*) in Lowland Ecuador. *The Wilson Journal of Ornithology*, *124*(3), 436–445.

Blake, J. G., & Loiselle, B. A. (2015). Enigmatic declines in bird numbers in lowland forest of eastern Ecuador may be a consequence of climate change. *PeerJ*, 1–20.

Borges, Sérgio H.; Silva, J. M. C. da. (2012). A new area of endemism for amazonian birds in the Rio Negro basin. *The Wilson Journal of Ornithology*, *124*(September), 15–23.

Borges, S. H., & Carvalhaes, A. M. P. (2000). Bird species richness of black water inundation forests in the Jaú National Park (Amazonas state, Brazil): their contribution to regional species richness. *Biodiversity and Conservation*, *9*(Peres 1997), 201–214.

Borges, S. H., Cohn-Haft, M., Carvalhaes, A. M. P., Henriques, L. M., Pacheco, J. F., & Whittaker, A. (2001). Birds of Jaú National Park, Brazilian Amazon: Species checklist, biogeography and conservation. *Ornitologia Neotropical*, *12*(January), 109–140.

Boubli, J. P., Ribas, C., Lynch Alfaro, J. W., Alfaro, M. E., da Silva, M. N. F., Pinho, G. M., & Farias, I. P. (2014). Spatial and temporal patterns of diversification on the Amazon: A test of the riverine hypothesis for all diurnal primates of Rio Negro and Rio Branco in Brazil. *Molecular Phylogenetics and Evolution*, *82*(PB), 400–412.

Bueno A. S.; Bruno, R. S; Pimentel, T. P.; Sanaiotti, T. M.; Magnusson, W. E. (2012). The width of riparian habitats for understory birds in an Amazonian forest. *Ecological Applications*, *22*(2), 722–734.

Cohn-haft, M., Naka, L. N., & Fernandes, A. M. (2008). Padrões de distribuição da avifauna da várzea dos rios Solimões e Amazonas. *Conservação Da Várzea: Identificação E*

Caracterização de Regiões Biogeográficas, (January 2016), 287–323.

Colwell, R. K., Mao, C. X., & Chang, J. (2004). Interpolating, extrapolating, and comparing incidence-based species accumulation curves. *Ecology*, *85*(10), 2717–2727.

Cracraft, J. (1985). Historical Biogeography and Patterns of Differentiation within the South American Avifauna : Areas of Endemism. *Neotropical Ornithology*, *36*(36), 49–84.

de Abreu, F. H. T. ., Schietti, J. &, & Anciães, M. (2018). Spatial and environmental correlates of intraspecific morphological variation in three species of passerine birds from the Purus – Madeira interfluvium , Central Amazonia. *Evol Ecol*.

Diamond, J. M. (1975). Assembly of species Community. In: Feeley, K. (2003). Analysis of avian communities in Lake Guri , Venezuela , using multiple assembly rule models. *Oecologia*, 137, 104-113.

Emmel, T. C., & Austin, G. T. (1990). Tha tropical rain forest butterfly fauna of Rondonia, Brazil: species diversity and conservation. *Tropical Lepidoptera*, *1*(1), 1–12.

Ernest, S. K. M., Brown, J. H., Thibault, K. M., White, E. P., & Goheen, J. R. (2008). Zero Sum, the Niche, and Metacommunities: Long-Term Dynamics of Community Assembly. *The American Naturalist*, *172*(6), 257–269.

Estudo e Relatório de Impacto Ambiental da Usina Hidrelétrica Belo Monte (2008). Diagnóstico avifaunístico da área de influência do UHE Belo Monte como subsídio ao estudo de impacto ambiental (EIA/ RIMA). Norte Energia S.A.

Feeley, K. (2003). Analysis of avian communities in Lake Guri , Venezuela , using multiple assembly rule models. *Oecologia*, *137*, 104–113.

Fernandes, A. M., Gonzalez, J., Wink, M., & Aleixo, A. (2012). Molecular Phylogenetics and Evolution Multilocus phylogeography of the Wedge-billed Woodcreeper Glyphorynchus spirurus (Aves , Furnariidae) in lowland Amazonia : Widespread cryptic diversity and paraphyly reveal a complex diversification pattern. *Molecular Phylogenetics and Evolution*, *66*(1), 270–282.

Ferreira, M., Aleixo, A., Ribas, C. C., & Santos, M. P. D. (2016). Biogeography of the Neotropical genus Malacoptila (Aves: Bucconidae): the influence of the Andean orogeny, Amazonian drainage evolution and palaeoclimate. *Journal of Biogeography*, *44*(4), 748–759.

Fox, B. J., & Brown, J. H. (1993). Assembly Rules for Functional Groups in North American Desert Rodent Communities in North American rules for functional desert Assembly groups communities rodent. *Oikos*, *67*, 358–370.

Gómez, Juan P; Bravo, G. A., Brumfield, Robb T.; Tello, J. G. ., & Cadena, C. D. (2010). A phylogenetic approach to disentangling the role of competition and habitat filtering in community assembly of Neotropical forest birds. *Journal of Animal Ecology*, *79*, 1181–1192.

Gotelli, N. J. (2000). Null model analysis of species co-ocurrence patterns. *Ecology*, *81*(9), 2606–2621.

Gotelli & Colwell. (2001). Quantifying biodiversity : procedures and pitfalls in the measurement and comparison of species richness. *Ecology Letters*, *4*(May 1988), 379–391.

Haffer, J. (1969). Speciation in Amazonian Forest Birds. *Science*, *165*(3889), 131–137.

Handbook of the birds of the world. Disponível em: <https://www.hbw.com>. Acesso em: 05/2018.

Harold, A. S. & M. R. D. (1994). Areas of endemism: definition and recognition criteria. *Systematic Biology*, *43*, 261–266.

Hausdorf, B. (2002). Units in Biogeography. *Systematic Biology*, *51*(4), 648–652.

Holdaway, R. J., & Sparrow, A. D. (2006). Assembly rules operating along a primary riverbed – grassland successional sequence. *Journal of Ecology*, *94*, 1092–1102.

Hoorn, C. (2010). Amazonia Through Time : Andean upflit, climate change, landscape evolution, and biodiversity. *Science*, *330*(November), 927–931.

Hubbell, S. P. (1997). A unified theory of biogeography and relative species abundance and its application to tropical rain forests and coral reefs. *Coral Reefs*, *16*(5), S9–S21.

Huston, M. A. (1979). A general hypothesis of species diversity. *The American Naturalist*, *113*(1), 81–101.

Huston, M. A. (1994). Non-equilibrium processes and the maintenance of local species diversity. *Biological Diversity: The Coexistence of Species on Changing Landscapes*. Cambridge University Press.

Hutchinson, G. E. (1959). Homage to Santa Rosalia.pdf. *The American Naturalist*. Retrieved from http://bio.classes.ucsc.edu/bio160/bioe_108_summer_10/Bio160readings/Homage to Santa Rosalia.pdf

Isler, M. L., Isler, P. R., & Whitney, B. M. (2007). Species limits in antbirds (Thamnophilidae): the warbling antbird (Hypocnemis cantator) complex. *The Auk*, *124*(1), 11–28.

Karr, J. R. (1981). Surveying birds with mist nets. *Studies in Avian Biology*, *6*(January 1981), 62–67.

Leibold, M. A., Holyoak, M., Mouquet, N., Amarasekare, P., Chase, J. M., Hoopes, M. F., … Gonzalez, A. (2004). The metacommunity concept: A framework for multi-scale community ecology. *Ecology Letters*, *7*(7), 601–613.

Levin, S. A. (1992). The problem of pattern and scale in ecology. *Ecology*, *73*(August 1989), 1943–1967.

Macarthu.R, & Levins, R. (1967). Limiting Similarity Convergence and Divergence of Coexisting Species. *American Naturalist*, *101*(921), 377-.

Maximiano, M. F. de A. (2017). Determinantes físicos e ecológicos que afetam as assembleias de aves no sudeste da Amazônia : o papel da história na distribuição das espécies. *Dissertação Apresentada Ao Instituto Nacional de Pesquisas Da Amazônia.*

Melo, A. S., & Hepp, L. U. (2008). Ferramentas Estatísticas Para Análises De Dados Provenientes De Biomonitoramento. *Oecologia Australis*, *12*(3), 463–486.

Menger, J., Magnusson, W. E., Anderson, M. J., Schlegel, M., Pe'er, G., & Henle, K. (2017). Environmental characteristics drive variation in Amazonian understorey bird assemblages. *PLoS ONE*, *12*(2), 1–20.

Moraes, L. J. C. L., Pavan, D., Barros, M. C., & Ribas, C. C. (2016). The combined influence of riverine barriers and flooding gradients on biogeographical patterns for amphibians and squamates in south-eastern Amazonia. *Journal of Biogeography*, *43*(11), 2113–2124.

Müller, P. (1972). Studies on Neotropical Fauna and Environment Centres of dispersal and evolution in the neotropical region. *Studies on Neotropical Fauna*, *7*, 173–185.

Naka, L. N. (2011). Avian distribution patterns in the Guiana Shield: Implications for the delimitation of Amazonian areas of endemism. *Journal of Biogeography*, *38*(4), 681–696.

Naka, L. N., & Brumfield, R. T. (2018). The dual role of Amazonian rivers in the generation and maintenance of avian diversity, (August).

Oliveira, U., Vasconcelos, M. F., & Santos, A. J. (2017). Biogeography of Amazon birds: rivers limit species composition, but not areas of endemism. *Scientific Reports*, *7*(1), 2992.

Piacentini, V. de Q., Aleixo, A., Agne, C. E., Maurício, G. N., Pacheco, J. F., Bravo, G. A., … Cesari, E. (2015). Annotated checklist of the birds of Brazil by the Brazilian Ornithological Records Committee. *Revista Brasileira de Ornitologia*, *23*(2), 91–298.

Pinto Henriques, L. M., Wunderle Jr., J. M., Oren, D. C., & Willig, M. R. (2008). Efeitos da exploracao madeireira de baixo impacto sobre uma comunidade de Aves de sub-bosque na Floresta Nacional do Tapajos, Pará, Brasil. *Acta Amazonica*, *38*(2), 267–289.

Platnick, N. (1991). On areas of endemism. *Australian Systematic Botany*, *4*(April), 11–12.

Relatório de pré-enchimento da Usina Hidrelétrica Santo Antônio (2013). Subprograma de monitoramento da Avifauna. Santo Antônio Energia.

Remsen, Jr, J. V, & Good, D. A. (1996). Misuse of data from mist-net captures to assess relative abundance in bird populations. *The Auk*, *113*(2), 381–398.

Remsen, J. V., Jr., J. I. Areta, C. D. Cadena, S. Claramunt, A. Jaramillo, J. F. Pacheco, M. B. Robbins, F. G. Stiles, D. F. Stotz, and K. J. Zimmer (2018). A classification of the bird species of South America. American Ornithologists' Union.

http://www.museum.lsu.edu/~Remsen/SACCBaseline.htm

Ribas, C. C., Aleixo, A., Nogueira, A. C. R., Miyaki, C. Y., & Cracraft, J. (2011). A palaeobiogeographic model for biotic diversification within Amazonia over the past three million years. *Proceedings of the Royal Society B: Biological Sciences*, *279*(1729), 681–689.

Ribas, C. C., Gaban-Lima, R., Miyaki, C. Y., & Cracraft, J. (2005). Historical biogeography and diversification within the Neotropical parrot genus Pionopsitta (Aves: Psittacidae). *Journal of Biogeography*, *32*(8), 1409–1427.

Robinson, S. & Terborgh, J. (1990). Bird communities of the Cocha Cashu Biological Station in Amazonian Peru. *Four Neotropical Rainforests*, 199-216.

Schultz, E. D., Burney, C. W., Brumfield, R. T., Polo, E. M., Cracraft, J., & Ribas, C. C. (2017). Systematics and biogeography of the Automolus infuscatus complex (Aves; Furnariidae): Cryptic diversity reveals western Amazonia as the origin of a transcontinental radiation. *Molecular Phylogenetics and Evolution*, *107*, 503–515.

Silva, J. M. C. da, Novaes, F. C., & Oren, D. C. (2002). Differentiation of Xiphocolaptes (Dendrocolaptidae) across the river Xingu, Brazilian Amazonia : Recognition of a new phylogenetic species and implications. *Bull. B. O. C.*, *122*(3), 185–194.

Steege, H. t. ; Zagt, R. (2002). Density and diversity. *Nature*, *417*(June), 698–699.

Stotz, D. F., Lanyon, S. M., Schulenberg, T. S., Willard, D. E., Peterson, T., & Fitzpatrick, J. W. (1997). An avifaunal survey of two tropical forest localities on the middle Rio Jiparaná, Rondônia, Brazil. *Ornithological Monographs*, (48), 763–781.

Stouffer, P. C., & Bierregaard, R. O. (1995). Use of Amazonian Forest Fragments by Understory Insectivorous Birds. *Ecology*, *76*(8), 2429–2445.

Wallace, A. R. (1854). On the Monkeys of the Amazon. *Journal of Natural History Series 2*, *14*(84), 451–454.

Watkins, A. J., & Wilson, J. B. (2003). Local Texture Convergence : A New Approach to Seeking Assembly Rules. *Oikos*, *102*(3), 525–532.

Wiens. (1989). Spatial Scaling in Ecology Published by : British Ecological Society Stable URL : https://www.jstor.org/stable/2389612 Spatial scaling in ecology1. *Functional Ecology*, *3*(4), 385–397.

Wiens, J. J. (2011). The causes of species richness patterns across space, time and clades and the role of “Ecological limits.” *The Quarterly Review of Biology*, *86*(2), 75–96.

Wilman, H., Belmaker, J., Jennifer, S., de la Rosa, C., Rivadeneira, M. M., & Jetz, W. (2014). EltonTraits 1 . 0 : Species-level foraging attributes of the world ’ s birds and mammals. *Ecology*, *95*(October 2013), 2027.

Wilson, J. & Whittaker, J. (1995). Assembly rules demonstrated in a saltmarsh community. *Journal of Ecology*, *83*(5), 801–807.

Wilson, J. B. (1989). A null model of guild proportionality , applied to stratification of a New Zealand temperate rain forest. *Oecologia*, *80*, 263–267.

Wilson, J. B. (1999). Guilds , Functional Types and Ecological Groups Guilds , functional types and ecological groups. *Oikos*, *86*(3), 507–522.

Xeno-canto. Disponível em: < https://www.xeno-canto.org>. Acesso em: 05/2018.

3- CONCLUSÃO

Os padrões de diversidade das assembleias de aves encontrados atualmente na Amazônia provavelmente estão relacionados a diversos processos históricos que ocorreram em larga escala ao longo de milhões de anos e conduziram eventos de vicariância e especiação, definindo o pool regional de espécies. As áreas de endemismo, delimitadas em função das espécies de distribuição restrita e limitadas pelos grandes rios, podem ser consideradas unidades de interpretação da história biogeográfica amazônica, uma vez que as assembleias locais de aves entre estas áreas apresentam padrões de diversidade distintos em termos de composição, riqueza e abundância relativa das espécies. Nossos resultados indicam que a influência histórica das áreas de endemismo pode ser extrapolada para toda a assembleia de aves de sub-bosque das florestas de terra firme, incluindo as espécies endêmicas, não endêmicas e de ampla distribuição.

Entretanto, fatores históricos não operam sozinhos e as interações entre as espécies e disponibilidade de recursos também têm grande relevância na estruturação das assembleias locais. A proporcionalidade de guildas na maioria das áreas de endemismo sugere que a força seletiva que atua na estruturação das assembleias está associada às relações de competição interespecífica que ocorrem localmente. Portanto, nosso trabalho reitera a conexão entre fatores históricos e ecológicos que determinam os padrões atuais de diversidade, composição e estruturação das assembleias de aves de sub-bosque em florestas de terra firme na Amazônia.

Este trabalho reforça a relevância das áreas de endemismo como unidades biogeográficas únicas para compreender os padrões atuais de diversidade das assembleias de aves na Amazônia. A influência histórica destas áreas, juntamente aos processos ecológicos locais, permanecem determinando os padrões de diversidade e distribuição das espécies em escalas regional e local. Reiteramos a importância de unir conceitos da biogeografia histórica com os processos ecológicos intrínsecos das comunidades biológicas, buscando compreender todos os fatores que geram e mantêm a diversidade no maior ecossistema florestal do mundo.

4- REFERÊNCIAS BIBLIOGRÁFICAS

Albert, J. S., Val, P., & Hoorn, C. (2018). The changing course of the Amazon River in the Neogene : center stage for Neotropical diversification. *Neotropical Ichthyology*, *16(3)*(October), 1–23.

Aleixo, A. (2004). Historical diversification of a terra-firme forest bird superspecies: a phylogeographic perspective on the role of different hypotheses of Amazonian diversification. *The Society for the Study of Evolution*, *58*(6).

Anderson, M. J. (2001). A new method for non parametric multivariate analysis of variance. *Austral Ecology*, *26*(2001), 32–46.

Avaliação e Monitoramento da Avifauna na Área do Reservatório de Tucuruí (2008). Relatório Final apresentado pelo Museu Paraense Emílio Goeldi ao Programa de Pesquisa e Desenvolvimento da Eletronorte na Usina Hidrelétrica Tucuruí. Eletronorte.

Bierregaard, J. (1988). Morphological data from understory birds in terra firme forest in the central amazonian basin. *Rev. Brasil. Biol.*, *48*(2), 169–178.

Bierregaard, R., & Lovejoy, T. E. (1989). Effects of Forest Fragmentation on Amazonian Dnderstory Bird Communities. *Acta Amazonica*, *9*, 219–241.

Bierregaard, R. O. JR. (1990). Species composition and trophic organization of the understory bird Community in a Central Amazonian terra firme forest. *Four Neotropical Rainforests*, 217-236.

Blake, J. G., & Loiselle, B. A. (2009). Species Composition of Neotropical Understory Bird Communities : Local versus Regional Perspectives Based on Capture Data. *Biotropica*, *41*(1), 85–94.

Blake, J. G., & Loiselle, B. A. (2012). Temporal and Spatial Patterns in Abundance of the Wedge- Billed Woodcreeper (Glyphorynchus spirurus) in Lowland Ecuador. *The Wilson Journal of Ornithology*, *124*(3), 436–445.

Blake, J. G., & Loiselle, B. A. (2015). Enigmatic declines in bird numbers in lowland forest of eastern Ecuador may be a consequence of climate change. *PeerJ*, 1–20.

Borges, Sérgio H.; Silva, J. M. C. da. (2012). A new area of endemism for amazonian birds in the Rio Negro basin. *The Wilson Journal of Ornithology*, *124*(September), 15–23.

Borges, S. H., & Carvalhaes, A. M. P. (2000). Bird species richness of black water inundation forests in the Jaú National Park (Amazonas state, Brazil): their contribution to regional species richness. *Biodiversity and Conservation*, *9*(Peres 1997), 201–214.

Borges, S. H., Cohn-Haft, M., Carvalhaes, A. M. P., Henriques, L. M., Pacheco, J. F., & Whittaker, A. (2001). Birds of Jaú National Park, Brazilian Amazon: Species checklist, biogeography and conservation. *Ornitologia Neotropical*, *12*(January), 109–140.

Boubli, J. P., Ribas, C., Lynch Alfaro, J. W., Alfaro, M. E., da Silva, M. N. F., Pinho, G. M., & Farias, I. P. (2014). Spatial and temporal patterns of diversification on the Amazon: A test of the riverine hypothesis for all diurnal primates of Rio Negro and Rio Branco in Brazil. *Molecular Phylogenetics and Evolution*, *82*(PB), 400–412.

Bueno A. S.; Bruno, R. S; Pimentel, T. P.; Sanaiotti, T. M.; Magnusson, W. E. (2012). The width of riparian habitats for understory birds in an Amazonian forest. *Ecological Applications*, *22*(2), 722–734.

Cohn-haft, M., Naka, L. N., & Fernandes, A. M. (2008). Padrões de distribuição da avifauna da várzea dos rios Solimões e Amazonas. *Conservação Da Várzea: Identificação E Caracterização de Regiões Biogeográficas*, (January 2016), 287–323.

Colwell, R. K., Mao, C. X., & Chang, J. (2004). Interpolating, extrapolating, and comparing incidence-based species accumulation curves. *Ecology*, *85*(10), 2717–2727.

Cracraft, J. (1985). Historical Biogeography and Patterns of Differentiation within the South American Avifauna : Areas of Endemism. *Neotropical Ornithology*, *36*(36), 49–84.

de Abreu, F. H. T. ., Schietti, J. &, & Anciães, M. (2018). Spatial and environmental correlates of intraspecific morphological variation in three species of passerine birds from the Purus – Madeira interfluvium , Central Amazonia. *Evol Ecol*.

Diamond, J. M. (1975). Assembly of species Community. In: Feeley, K. (2003). Analysis of avian communities in Lake Guri , Venezuela , using multiple assembly rule models. *Oecologia*, 137, 104-113.

Emmel, T. C., & Austin, G. T. (1990). Tha tropical rain forest butterfly fauna of Rondonia, Brazil: species diversity and conservation. *Tropical Lepidoptera*, *1*(1), 1–12.

Ernest, S. K. M., Brown, J. H., Thibault, K. M., White, E. P., & Goheen, J. R. (2008). Zero Sum, the Niche, and Metacommunities: Long-Term Dynamics of Community Assembly. *The American Naturalist*, *172*(6), 257–269.

Estudo e Relatório de Impacto Ambiental da Usina Hidrelétrica Belo Monte (2008). Diagnóstico avifaunístico da área de influência do UHE Belo Monte como subsídio ao estudo de impacto ambiental (EIA/ RIMA). Norte Energia S.A.

Feeley, K. (2003). Analysis of avian communities in Lake Guri , Venezuela , using multiple assembly rule models. *Oecologia*, *137*, 104–113.

Fernandes, A. M., Gonzalez, J., Wink, M., & Aleixo, A. (2012). Molecular Phylogenetics and Evolution Multilocus phylogeography of the Wedge-billed Woodcreeper Glyphorynchus spirurus (Aves , Furnariidae) in lowland Amazonia : Widespread cryptic diversity and paraphyly reveal a complex diversification pattern. *Molecular Phylogenetics and Evolution*, *66*(1), 270–282.

Ferreira, M., Aleixo, A., Ribas, C. C., & Santos, M. P. D. (2016). Biogeography of the Neotropical genus Malacoptila (Aves: Bucconidae): the influence of the Andean orogeny, Amazonian drainage evolution and palaeoclimate. *Journal of Biogeography*, *44*(4), 748–759.

Fox, B. J., & Brown, J. H. (1993). Assembly Rules for Functional Groups in North American Desert Rodent Communities in North American rules for functional desert Assembly groups communities rodent. *Oikos*, *67*, 358–370.

Gómez, Juan P; Bravo, G. A., Brumfield, Robb T.; Tello, J. G. ., & Cadena, C. D. (2010). A phylogenetic approach to disentangling the role of competition and habitat filtering in community assembly of Neotropical forest birds. *Journal of Animal Ecology*, *79*, 1181–1192.

Gotelli, N. J. (2000). Null model analysis of species co-ocurrence patterns. *Ecology*, *81*(9), 2606–2621.

Gotelli & Colwell. (2001). Quantifying biodiversity : procedures and pitfalls in the measurement and comparison of species richness. *Ecology Letters*, *4*(May 1988), 379–391.

Haffer, J. (1969). Speciation in Amazonian Forest Birds. *Science*, *165*(3889), 131–137.

Handbook of the birds of the world. Disponível em: <https://www.hbw.com>. Acesso em: 05/2018.

Harold, A. S. & M. R. D. (1994). Areas of endemism: definition and recognition criteria. *Systematic Biology*, *43*, 261–266.

Hayes, F. E., & Sewlal, J. N. (2004). The Amazon River as a dispersal barrier to Passerine Birds : Effects of river width, Habitat and Taxonomy. *Journal of Biogeography*, *31*(11), 1809–1818.

Hausdorf, B. (2002). Units in Biogeography. *Systematic Biology*, *51*(4), 648–652.

Holdaway, R. J., & Sparrow, A. D. (2006). Assembly rules operating along a primary riverbed – grassland successional sequence. *Journal of Ecology*, *94*, 1092–1102.

Hoorn, C. (2010). Amazonia Through Time : Andean upflit, climate change, landscape evolution, and biodiversity. *Science*, *330*(November), 927–931.

Hubbell, S. P. (1997). A unified theory of biogeography and relative species abundance and its application to tropical rain forests and coral reefs. *Coral Reefs*, *16*(5), S9–S21.

Huston, M. A. (1979). A general hypothesis of species diversity. *The American Naturalist*, *113*(1), 81–101.

Huston, M. A. (1994). Non-equilibrium processes and the maintenance of local species diversity. *Biological Diversity: The Coexistence of Species on Changing Landscapes*. Cambridge University Press.

Hutchinson, G. E. (1959). Homage to Santa Rosalia.pdf. *The American Naturalist*. Retrieved from http://bio.classes.ucsc.edu/bio160/bioe_108_summer_10/Bio160readings/Homage to Santa Rosalia.pdf

Isler, M. L., Isler, P. R., & Whitney, B. M. (2007). Species limits in antbirds (Thamnophilidae): the warbling antbird (Hypocnemis cantator) complex. *The Auk*, *124*(1), 11–28.

Karr, J. R. (1981). Surveying birds with mist nets. *Studies in Avian Biology*, *6*(January 1981), 62–67.

Leibold, M. A., Holyoak, M., Mouquet, N., Amarasekare, P., Chase, J. M., Hoopes, M. F., … Gonzalez, A. (2004). The metacommunity concept: A framework for multi-scale community ecology. *Ecology Letters*, *7*(7), 601–613.

Levin, S. A. (1992). The problem of pattern and scale in ecology. *Ecology*, *73*(August 1989), 1943–1967.

Macarthu.R, & Levins, R. (1967). Limiting Similarity Convergence and Divergence of Coexisting Species. *American Naturalist*, *101*(921), 377-.

Maximiano, M. F. de A. (2017). Determinantes físicos e ecológicos que afetam as assembleias de aves no sudeste da Amazônia : o papel da história na distribuição das espécies. *Dissertação Apresentada Ao Instituto Nacional de Pesquisas Da Amazônia.*

Melo, A. S., & Hepp, L. U. (2008). Ferramentas Estatísticas Para Análises De Dados Provenientes De Biomonitoramento. *Oecologia Australis*, *12*(3), 463–486.

Menger, J., Magnusson, W. E., Anderson, M. J., Schlegel, M., Pe'er, G., & Henle, K. (2017). Environmental characteristics drive variation in Amazonian understorey bird assemblages. *PLoS ONE*, *12*(2), 1–20.

Moraes, L. J. C. L., Pavan, D., Barros, M. C., & Ribas, C. C. (2016). The combined influence of riverine barriers and flooding gradients on biogeographical patterns for amphibians and squamates in south-eastern Amazonia. *Journal of Biogeography*, *43*(11), 2113–2124.

Müller, P. (1972). Studies on Neotropical Fauna and Environment Centres of dispersal and evolution in the neotropical region. *Studies on Neotropical Fauna*, *7*, 173–185.

Naka, L. N. (2011). Avian distribution patterns in the Guiana Shield: Implications for the delimitation of Amazonian areas of endemism. *Journal of Biogeography*, *38*(4), 681–696.

Naka, L. N., & Brumfield, R. T. (2018). The dual role of Amazonian rivers in the generation and maintenance of avian diversity, (August).

Oliveira, U., Vasconcelos, M. F., & Santos, A. J. (2017). Biogeography of Amazon birds: rivers limit species composition, but not areas of endemism. *Scientific Reports*, *7*(1), 2992.

Piacentini, V. de Q., Aleixo, A., Agne, C. E., Maurício, G. N., Pacheco, J. F., Bravo, G. A., … Cesari, E. (2015). Annotated checklist of the birds of Brazil by the Brazilian Ornithological Records Committee. *Revista Brasileira de Ornitologia*, *23*(2), 91–298.

Pinto Henriques, L. M., Wunderle Jr., J. M., Oren, D. C., & Willig, M. R. (2008). Efeitos da exploracao madeireira de baixo impacto sobre uma comunidade de Aves de sub-bosque na Floresta Nacional do Tapajos, Pará, Brasil. *Acta Amazonica*, *38*(2), 267–289.

Platnick, N. (1991). On areas of endemism. *Australian Systematic Botany*, *4*(April), 11–12.

Pomara, Lars; Ruokolainen, Kalle & Young, K. R. (2013). Avian species composition across the Amazon river: the roles of dispersal limitation and environmental heterogeneity. *Journal of Biogeography*.

Relatório de pré-enchimento da Usina Hidrelétrica Santo Antônio (2013). Subprograma de monitoramento da Avifauna. Santo Antônio Energia.

Remsen, Jr, J. V, & Good, D. A. (1996). Misuse of data from mist-net captures to assess relative abundance in bird populations. *The Auk*, *113*(2), 381–398.

Remsen, J. V., Jr., J. I. Areta, C. D. Cadena, S. Claramunt, A. Jaramillo, J. F. Pacheco, M. B. Robbins, F. G. Stiles, D. F. Stotz, and K. J. Zimmer (2018). A classification of the bird species of South America. American Ornithologists' Union. **http://www.museum.lsu.edu/~Remsen/SACCBaseline.htm**

Ribas, C. C., Aleixo, A., Nogueira, A. C. R., Miyaki, C. Y., & Cracraft, J. (2011). A palaeobiogeographic model for biotic diversification within Amazonia over the past three million years. *Proceedings of the Royal Society B: Biological Sciences*, *279*(1729), 681–689.

Ribas, C. C., Gaban-Lima, R., Miyaki, C. Y., & Cracraft, J. (2005). Historical biogeography and diversification within the Neotropical parrot genus Pionopsitta (Aves: Psittacidae). *Journal of Biogeography*, *32*(8), 1409–1427.

Robinson, S. & Terborgh, J. (1990). Bird communities of the Cocha Cashu Biological Station in Amazonian Peru. *Four Neotropical Rainforests*, 199-216.

Schultz, E. D., Burney, C. W., Brumfield, R. T., Polo, E. M., Cracraft, J., & Ribas, C. C. (2017). Systematics and biogeography of the Automolus infuscatus complex (Aves; Furnariidae): Cryptic diversity reveals western Amazonia as the origin of a transcontinental radiation. *Molecular Phylogenetics and Evolution*, *107*, 503–515.

Silva, J. M. C. da, Novaes, F. C., & Oren, D. C. (2002). Differentiation of Xiphocolaptes (Dendrocolaptidae) across the river Xingu, Brazilian Amazonia : Recognition of a new phylogenetic species and implications. *Bull. B. O. C.*, *122*(3), 185–194.

Steege, H. t. ; Zagt, R. (2002). Density and diversity. *Nature*, *417*(June), 698–699.

Stotz, D. F., Lanyon, S. M., Schulenberg, T. S., Willard, D. E., Peterson, T., & Fitzpatrick, J. W. (1997). An avifaunal survey of two tropical forest localities on the middle Rio Jiparaná, Rondônia, Brazil. *Ornithological Monographs*, (48), 763–781.

Stouffer, P. C., & Bierregaard, R. O. (1995). Use of Amazonian Forest Fragments by Understory Insectivorous Birds. *Ecology*, *76*(8), 2429–2445.

Wallace, A. R. (1854). On the Monkeys of the Amazon. *Journal of Natural History Series 2*, *14*(84), 451–454.

Watkins, A. J., & Wilson, J. B. (2003). Local Texture Convergence : A New Approach to Seeking Assembly Rules. *Oikos*, *102*(3), 525–532.

Wiens. (1989). Spatial Scaling in Ecology Published by : British Ecological Society Stable URL : https://www.jstor.org/stable/2389612 Spatial scaling in ecology1. *Functional Ecology*, *3*(4), 385–397.

Wiens, J. J. (2011). The causes of species richness patterns across space, time and clades and the role of "Ecological limits." *The Quarterly Review of Biology*, *86*(2), 75–96.

Wilman, H., Belmaker, J., Jennifer, S., de la Rosa, C., Rivadeneira, M. M., & Jetz, W. (2014). EltonTraits 1 . 0 : Species-level foraging attributes of the world ' s birds and mammals. *Ecology*, *95*(October 2013), 2027.

Wilson, J. & Whittaker, J. (1995). Assembly rules demonstrated in a saltmarsh community. *Journal of Ecology*, *83*(5), 801–807.

Wilson, J. B. (1989). A null model of guild proportionality , applied to stratification of a New Zealand temperate rain forest. *Oecologia*, *80*, 263–267.

Wilson, J. B. (1999). Guilds , Functional Types and Ecological Groups Guilds , functional types and ecological groups. *Oikos*, *86*(3), 507–522.

Xeno-canto. Disponível em: < https://www.xeno-canto.org>. Acesso em: 05/2018.

5- APÊNDICE

Apêndice 5.1- Descrição das amostragens em cada localidade

Na área de endemismo Guiana (n = 5077 capturas), os dados coletados no Projeto Dinâmica Biológica de Fragmentos Florestais (PDBFF) são referentes a um monitoramento de longa duração que objetivava compreender os efeitos da fragmentação florestal sobre a avifauna (Bierregaard, 1988; Bierregaard & Lovejoy, 1989; Stouffer & Bierregaard, 1995). Usamos somente os dados da área controle, na floresta contínua. Já na Reserva Florestal Adolpho Ducke os dados foram obtidos de dois projetos desenvolvidos separadamente, com amostragens realizadas em 45 parcelas permanentes do PPBio (Bueno *et al*., 2012) e em 87 parcelas (sendo 15 ripárias) da reserva (Menger et al., 2017).

Na área de endemismo Inambari (n = 2735 capturas), parte dos dados foram obtidos do monitoramento realizado durante o processo de licenciamento ambiental da UHE Santo Antônio, nas duas margens do rio Madeira. Outros dados foram cedidos de um projeto de pesquisa desenvolvido ao longo dos 700 km da BR 319, situada no interflúvio Purus-Madeira (Relatório de Pré-enchimento da UHE Santo Antônio, 2013; Souza; 2014; de Abreu *et al*., 2018).

Na área de endemismo Napo (n = 3055 capturas), os dados também pertencem a um projeto de longa duração realizado em dois sítios distintos na Tiputini Biodiversity Station (Blake & Loiselle, 2008; 2015) e apenas uma parte dos dados foi cedida para este trabalho, referente a cinco anos de amostragem (2001 a 2005).

Na área de endemismo Jaú (n = 2942), a amostragem foi realizada no Parque Nacional do Jaú em 46 sítios distribuídos ao longo do parque, em projetos desenvolvidos ao longo de 13 anos (Borges & Carvalhaes, 2000; Borges *et al*., 2001; Borges & Silva, 2012).

Na área de endemismo Rondônia (n = 2295 capturas), parte dos dados são os mesmos obtidos na UHE Santo Antônio, porém na margem direita do rio Madeira. A outra parte se refere a uma pesquisa de dois anos realizada no médio Tapajós, em que as coletas foram realizadas nas duas margens no rio (a margem esquerda pertence à área de endemismo Rondônia), próximo à região do Parque Nacional da Amazônia (Maximiano, 2017).

Na área de endemismo Tapajós (n = 3321 capturas), obtivemos dados do médio Tapajós (margem direita, como referido acima), da Floresta Nacional do Tapajós (Henriques *et al*., 2008) e da UHE Belo Monte (EIA/ RIMA da UHE Belo Monte, 2008). Na FLONA Tapajós, o objetivo do estudo era compreender os efeitos da extração de madeira, de forma que usamos apenas as amostras da área controle, em cinco anos de pesquisa. Já na UHE, o trabalho foi realizado durante o processo de licenciamento ambiental do empreendimento e foram amostradas as duas margens do rio Xingu (a margem esquerda pertence a área de endemismo Tapajós).

Na área de endemismo Xingu (n = 1282) foram coletados na UHE Belo Monte (margem direita do rio Xingu) e na UHE Tucuruí (Avaliação e Monitoramento da Avifauna na Área do Reservatório de Tucuruí, 2008). Neste último, o trabalho também foi realizado durante o processo de licenciamento ambiental do empreendimento, e usamos somente as capturas da margem esquerda do rio Tucuruí.

Apêndice 5.2- Tabelas

Tabela 4: Espécies retiradas das análises.

Ordem	**Família**	**Espécie**
Accipitriformes	Accipitridae	*Accipiter_bicolor*
Passeriformes	Thamnophilidae	*Akletos_melanoceps*
Apodiformes	Trochilidae	*Amazilia_fimbriata*
Apodiformes	Trochilidae	*Amazilia_versicolor*
Passeriformes	Passerellidae	*Ammodramus_aurifrons*
Passeriformes	Furnariidae	*Anabacerthia_ruficaudata*
Passeriformes	Tyrannidae	*Attila_cinnamomeus*
Passeriformes	Furnariidae	*Automolus_melanopezus*
Galbuliformes	Bucconidae	*Bucco_macrodactylus*
Galbuliformes	Bucconidae	*Bucco_tamatia*
Accipitriformes	Accipitridae	*Buteogallus_schistaceus*
Passeriformes	Icteridae	*Cacicus_haemorrhous*
Piciformes	Picidae	*Campephilus_rubricollis*
Passeriformes	Tyrannidae	*Camptostoma_obsoletum*
Passeriformes	Dendrocolaptidae	*Campylorhamphus_probatus*
Passeriformes	Dendrocolaptidae	*Campylorhamphus_procurvoides*
Passeriformes	Dendrocolaptidae	*Campylorhamphus_trochilirostris*

Passeriformes	Troglodytidae	*Campylorhynchus_turdinus*
Passeriformes	Troglodytidae	*Cantorchilus_leucotis*
Piciformes	Capitonidae	*Capito_auratus*
Piciformes	Capitonidae	*Capito_brunneipectus*
Piciformes	Capitonidae	*Capito_niger*
Passeriformes	Tyrannidae	*Casiornis_fuscus*
Passeriformes	Turdidae	*Catharus_fuscescens*
Passeriformes	Turdidae	*Catharus_minimus*
Passeriformes	Turdidae	*Catharus_ustulatus*
Piciformes	Picidae	*Celeus_grammicus*
Piciformes	Picidae	*Celeus_undatus*
Passeriformes	Formicariidae	*Chamaeza_nobilis*
Apodiformes	Trochilidae	*Chrysuronia_oenone*
Cuculiformes	Cuculidae	*Coccycua_minuta*
Passeriformes	Thraupidae	*Coereba_flaveola*
Passeriformes	Thraupidae	*Coryphospingus_cucullatus*
Passeriformes	Furnariidae	*Cranioleuca_gutturata*
Galliformes	Cracidae	*Crax_fasciolata*
Cuculiformes	Cuculidae	*Crotophaga_major*
Tinamiformes	Tinamidae	*Crypturellus_bartletti*
Tinamiformes	Tinamidae	*Crypturellus_cinereus*
Tinamiformes	Tinamidae	*Crypturellus_soui*
Tinamiformes	Tinamidae	*Crypturellus_variegatus*
Passeriformes	Thamnophilidae	*Cymbilaimus_lineatus*
Passeriformes	Thraupidae	*Dacnis_lineata*
Passeriformes	Dendrocolaptidae	*Dendrexetastes_rufigula*
Passeriformes	Dendrocolaptidae	*Dendroplex_kienerii*
Passeriformes	Dendrocolaptidae	*Dendroplex_picus*
Piciformes	Picidae	*Dryocopus_lineatus*
Passeriformes	Tyrannidae	*Elaenia_strepera*
Passeriformes	Fringillidae	*Euphonia_violacea*
Passeriformes	Fringillidae	*Euphonia_xanthogaster*
Passeriformes	Thamnophilidae	*Formicivora_grisea*

Galbuliformes	Galbulidae	*Galbula_dea*
Strigiformes	Strigidae	*Glaucidium_hardyi*
Passeriformes	Cardinalidae	*Granatellus_pelzelni*
Accipitriformes	Accipitridae	*Harpagus_bidentatus*
Apodiformes	Trochilidae	*Heliothryx_auritus*
Passeriformes	Thraupidae	*Hemithraupis_flavicollis*
Passeriformes	Thamnophilidae	*Herpsilochmus_rufimarginatus*
Passeriformes	Pipridae	*Heterocercus_flavivertex*
Passeriformes	Pipridae	*Heterocercus_linteatus*
Apodiformes	Trochilidae	*Hylocharis_sapphirina*
Passeriformes	Vireonidae	*Hylophilus_semicinereus*
Passeriformes	Thamnophilidae	*Hylophylax_punctulatus*
Passeriformes	Thamnophilidae	*Hypocnemoides_maculicauda*
Passeriformes	Thamnophilidae	*Hypocnemoides_melanopogon*
Galbuliformes	Galbulidae	*Jacamerops_aureus*
Passeriformes	Tyrannidae	*Knipolegus_poecilocercus*
Passeriformes	Cotingidae	*Lipaugus_vociferans*
Passeriformes	Rhynchocyclidae	*Lophotriccus_galeatus*
Passeriformes	Pipridae	*Machaeropterus_striolatus*
Galbuliformes	Bucconidae	*Monasa_atra*
Galbuliformes	Bucconidae	*Monasa_morphoeus*
Galbuliformes	Bucconidae	*Monasa_nigrifrons*
Passeriformes	Tyrannidae	*Myiarchus_ferox*
Passeriformes	Tyrannidae	*Myiarchus_swainsoni*
Passeriformes	Tyrannidae	*Myiarchus_tuberculifer*
Passeriformes	Onychorhynchidae	*Myiobius_atricaudus*
Passeriformes	Tyrannidae	*Myiodynastes_maculatus*
Passeriformes	Tyrannidae	*Myiopagis_flavivertex*
Passeriformes	Tyrannidae	*Myiopagis_gaimardii*
Passeriformes	Tyrannidae	*Myiopagis_viridicata*
Passeriformes	Parulidae	*Myiothlypis_flaveola*
Passeriformes	Parulidae	*Myiothlypis_fulvicauda*
Passeriformes	Parulidae	*Myiothlypis_mesoleuca*

Passeriformes	Parulidae	*Myiothlypis_rivularis*
Passeriformes	Thamnophilidae	*Myrmoborus_leucophrys*
Passeriformes	Thamnophilidae	*Myrmophylax_atrothorax*
Passeriformes	Grallariidae	*Myrmothera_campanisona*
Passeriformes	Thamnophilidae	*Myrmotherula_brachyura*
Passeriformes	Thamnophilidae	*Myrmotherula_multostriata*
Passeriformes	Dendrocolaptidae	*Nasica_longirostris*
Passeriformes	Platyrinchidae	*Neopipo_cinnamomea*
Galbuliformes	Bucconidae	*Nonnula_amaurocephala*
Galbuliformes	Bucconidae	*Notharchus_tectus*
Caprimulgiformes	Caprimulgidae	*Nyctidromus_nigrescens*
Caprimulgiformes	Caprimulgidae	*Nyctiphrynus_ocellatus*
Galliformes	Odontophoridae	*Odontophorus_gujanensis*
Passeriformes	Tityridae	*Pachyramphus_marginatus*
Passeriformes	Tityridae	*Pachyramphus_minor*
Passeriformes	Vireonidae	*Pachysylvia_muscicapina*
Passeriformes	Thraupidae	*Paroaria_gularis*
Columbiformes	Columbidae	*Patagioenas_plumbea*
Galliformes	Cracidae	*Penelope_jacquacu*
Passeriformes	Cardinalidae	*Periporphyrus_erythromelas*
Apodiformes	Trochilidae	*Phaethornis_aethopygus*
Apodiformes	Trochilidae	*Phaethornis_rupurumii*
Passeriformes	Cotingidae	*Phoenicircus_carnifex*
Cuculiformes	Cuculidae	*Piaya_cayana*
Piciformes	Picidae	*Piculus_flavigula*
Piciformes	Picidae	*Picumnus_rufiventris*
Passeriformes	Pipritidae	*Piprites_chloris*
Passeriformes	Tyrannidae	*Poecilotriccus_capitalis*
Passeriformes	Icteridae	*Procacicus_solitarius*
Gruiformes	Psophiidae	*Psophia_dextralis*
Gruiformes	Psophiidae	*Psophia_viridis*
Piciformes	Ramphastidae	*Pteroglossus_azara*
Piciformes	Ramphastidae	*Pteroglossus_beauharnaisii*

Piciformes	Ramphastidae	*Pteroglossus_bitorquatus*
Piciformes	Ramphastidae	*Pteroglossus_inscriptus*
Piciformes	Ramphastidae	*Pteroglossus_mariae*
Piciformes	Ramphastidae	*Pteroglossus_pluricinctus*
Piciformes	Ramphastidae	*Pteroglossus_viridis*
Passeriformes	Thamnophilidae	*Pygiptila_stellaris*
Psittaciformes	Psittacidae	*Pyrrhura_perlata*
Piciformes	Ramphastidae	*Ramphastos_tucanus*
Piciformes	Ramphastidae	*Ramphastos_vitellinus*
Passeriformes	Thraupidae	*Ramphocelus_carbo*
Passeriformes	Rhynchocyclidae	*Rhynchocyclus_olivaceus*
Passeriformes	Tyrannidae	*Rhytipterna_simplex*
Passeriformes	Thraupidae	*Saltator_coerulescens*
Passeriformes	Thraupidae	*Saltator_maximus*
Passeriformes	Thamnophilidae	*Sclateria_naevia*
Piciformes	Ramphastidae	*Selenidera_gouldii*
Piciformes	Ramphastidae	*Selenidera_nattereri*
Piciformes	Ramphastidae	*Selenidera_piperivora*
Piciformes	Ramphastidae	*Selenidera_reinwardtii*
Passeriformes	Parulidae	*Setophaga_striata*
Passeriformes	Thraupidae	*Sporophila_angolensis*
Passeriformes	Thraupidae	*Sporophila_schistacea*
Strigiformes	Strigidae	*Strix_virgata*
Passeriformes	Thraupidae	*Tachyphonus_rufus*
Passeriformes	Thraupidae	*Tangara_palmarum*
Passeriformes	Thraupidae	*Tangara_schrankii*
Passeriformes	Thamnophilidae	*Taraba_major*
Passeriformes	Thraupidae	*Tersina_viridis*
Passeriformes	Thamnophilidae	*Thamnophilus_amazonicus*
Passeriformes	Thamnophilidae	*Thamnophilus_nigrocinereus*
Tinamiformes	Tinamidae	*Tinamus_major*
Passeriformes	Rhynchocyclidae	*Tolmomyias_assimilis*
Passeriformes	Rhynchocyclidae	*Tolmomyias_poliocephalus*

Passeriformes	Rhynchocyclidae	*Tolmomyias_sulphurescens*
Apodiformes	Trochilidae	*Topaza_pella*
Passeriformes	Troglodytidae	*Troglodytes_musculus*
Trogoniformes	Trogonidae	*Trogon_collaris*
Trogoniformes	Trogonidae	*Trogon_melanurus*
Trogoniformes	Trogonidae	*Trogon_violaceus*
Trogoniformes	Trogonidae	*Trogon_viridis*
Passeriformes	Turdidae	*Turdus_amaurochalinus*
Passeriformes	Turdidae	*Turdus_fumigatus*
Passeriformes	Turdidae	*Turdus_hauxwelli*
Piciformes	Picidae	*Veniliornis_affinis*
Piciformes	Picidae	*Veniliornis_cassini*
Passeriformes	Vireonidae	*Vireolanius_leucotis*
Passeriformes	Thraupidae	*Volatinia_jacarina*
Passeriformes	Dendrocolaptidae	*Xiphocolaptes_promeropirhynchus*
Passeriformes	Dendrocolaptidae	*Xiphorhynchus_guttatoides*
Passeriformes	Dendrocolaptidae	*Xiphorhynchus_obsoletus*
Pelecaniformes	Ardeidae	*Zebrilus_undulatus*

Tabela 5: Espécies usadas nas análises.

Ordem	**Família**	**Espécie**
Passeriformes	Furnariidae	*Ancistrops_strigilatus*
Passeriformes	Passerellidae	*Arremon_taciturnus*
Passeriformes	Tyrannidae	*Attila_spadiceus*
Passeriformes	Furnariidae	*Automolus_infuscatus*
Passeriformes	Furnariidae	*Automolus_ochrolaemus*
Passeriformes	Furnariidae	*Automolus_paraensis*
Passeriformes	Furnariidae	*Automolus_rufipileatus*
Passeriformes	Furnariidae	*Automolus_subulatus*
Coraciiformes	Momotidae	*Baryphthengus_martii*
Galbuliformes	Bucconidae	*Bucco_capensis*
Apodiformes	Trochilidae	*Campylopterus_largipennis*

Piciformes	Picidae	*Celeus_elegans*
Passeriformes	Pipridae	*Ceratopipra_erythrocephala*
Passeriformes	Pipridae	*Ceratopipra_rubrocapilla*
Passeriformes	Thamnophilidae	*Cercomacra_cinerascens*
Passeriformes	Thamnophilidae	*Cercomacroides_nigrescens*
Passeriformes	Thamnophilidae	*Cercomacroides_serva*
Passeriformes	Thamnophilidae	*Cercomacroides_tyrannina*
Passeriformes	Dendrocolaptidae	*Certhiasomus_stictolaemus*
Passeriformes	Pipridae	*Chiroxiphia_pareola*
Coraciiformes	Alcedinidae	*Chloroceryle_aenea*
Coraciiformes	Alcedinidae	*Chloroceryle_amazona*
Coraciiformes	Alcedinidae	*Chloroceryle_americana*
Coraciiformes	Alcedinidae	*Chloroceryle_inda*
Apodiformes	Trochilidae	*Chlorostilbon_mellisugus*
Passeriformes	Furnariidae	*Clibanornis_obscurus*
Passeriformes	Furnariidae	*Clibanornis_rubiginosus*
Passeriformes	Rhynchocyclidae	*Cnipodectes_subbrunneus*
Passeriformes	Conopophagidae	*Conopophaga_aurita*
Passeriformes	Conopophagidae	*Conopophaga_melanogaster*
Passeriformes	Conopophagidae	*Conopophaga_peruviana*
Passeriformes	Pipridae	*Corapipo_gutturalis*
Passeriformes	Rhynchocyclidae	*Corythopis_torquatus*
Passeriformes	Thraupidae	*Cyanerpes_caeruleus*
Passeriformes	Cardinalidae	*Cyanoloxia_rothschildii*
Passeriformes	Troglodytidae	*Cyphorhinus_arada*
Passeriformes	Dendrocolaptidae	*Deconychura_longicauda*
Passeriformes	Dendrocolaptidae	*Dendrocincla_fuliginosa*
Passeriformes	Dendrocolaptidae	*Dendrocincla_merula*
Passeriformes	Dendrocolaptidae	*Dendrocolaptes_certhia*
Passeriformes	Dendrocolaptidae	*Dendrocolaptes_concolor*
Passeriformes	Dendrocolaptidae	*Dendrocolaptes_hoffmannsi*
Passeriformes	Dendrocolaptidae	*Dendrocolaptes_juruanus*
Passeriformes	Dendrocolaptidae	*Dendrocolaptes_picumnus*
Passeriformes	Dendrocolaptidae	*Dendrocolaptes_radiolatus*

Passeriformes	Dendrocolaptidae	*Dendrocolaptes_retentus*
Passeriformes	Dendrocolaptidae	*Dendrocolaptes_ridgwayi*
Passeriformes	Thamnophilidae	*Dichrozona_cincta*
Passeriformes	Pipridae	*Dixiphia_pipra*
Coraciiformes	Momotidae	*Electron_platyrhynchum*
Passeriformes	Thamnophilidae	*Epinecrophylla_amazonica*
Passeriformes	Thamnophilidae	*Epinecrophylla_dentei*
Passeriformes	Thamnophilidae	*Epinecrophylla_erythrura*
Passeriformes	Thamnophilidae	*Epinecrophylla_fjeldsaai*
Passeriformes	Thamnophilidae	*Epinecrophylla_gutturalis*
Passeriformes	Thamnophilidae	*Epinecrophylla_leucophthalma*
Passeriformes	Thamnophilidae	*Epinecrophylla_ornata*
Passeriformes	Thamnophilidae	*Epinecrophylla_pyrrhonota*
Apodiformes	Trochilidae	*Eutoxeres_condamini*
Apodiformes	Trochilidae	*Florisuga_mellivora*
Passeriformes	Formicariidae	*Formicarius_analis*
Passeriformes	Formicariidae	*Formicarius_colma*
Passeriformes	Thamnophilidae	*Frederickena_fulva*
Passeriformes	Thamnophilidae	*Frederickena_unduliger*
Passeriformes	Thamnophilidae	*Frederickena_viridis*
Galbuliformes	Galbulidae	*Galbula_albirostris*
Galbuliformes	Galbulidae	*Galbula_chalcothorax*
Galbuliformes	Galbulidae	*Galbula_cyanicollis*
Galbuliformes	Galbulidae	*Galbula_ruficauda*
Columbiformes	Columbidae	*Geotrygon_montana*
Columbiformes	Columbidae	*Geotrygon_saphirina*
Apodiformes	Trochilidae	*Glaucis_hirsutus*
Passeriformes	Dendrocolaptidae	*Glyphorynchus_spirurus*
Passeriformes	Grallariidae	*Grallaria_varia*
Passeriformes	Thamnophilidae	*Gymnopithys_leucaspis*
Passeriformes	Thamnophilidae	*Gymnopithys_rufigula*
Passeriformes	Cardinalidae	*Habia_rubica*
Passeriformes	Thamnophilidae	*Hafferia_fortis*
Apodiformes	Trochilidae	*Heliodoxa_aurescens*

Apodiformes	Trochilidae	*Heliodoxa_schreibersii*
Passeriformes	Rhynchocyclidae	*Hemitriccus_minor*
Passeriformes	Rhynchocyclidae	*Hemitriccus_zosterops*
Passeriformes	Troglodytidae	*Henicorhina_leucosticta*
Passeriformes	Dendrocolaptidae	*Hylexetastes_brigidai*
Passeriformes	Dendrocolaptidae	*Hylexetastes_perrotii*
Passeriformes	Dendrocolaptidae	*Hylexetastes_stresemanni*
Passeriformes	Dendrocolaptidae	*Hylexetastes_uniformis*
Passeriformes	Grallariidae	*Hylopezus_berlepschi*
Passeriformes	Grallariidae	*Hylopezus_dilutus*
Passeriformes	Grallariidae	*Hylopezus_macularius*
Passeriformes	Grallariidae	*Hylopezus_paraensis*
Passeriformes	Grallariidae	*Hylopezus_whittakeri*
Passeriformes	Thamnophilidae	*Hylophylax_naevius*
Passeriformes	Thamnophilidae	*Hypocnemis_cantator*
Passeriformes	Thamnophilidae	*Hypocnemis_hypoxantha*
Passeriformes	Thamnophilidae	*Hypocnemis_ochrogyna*
Passeriformes	Thamnophilidae	*Hypocnemis_peruviana*
Passeriformes	Thamnophilidae	*Hypocnemis_striata*
Passeriformes	Thamnophilidae	*Isleria_guttata*
Passeriformes	Thamnophilidae	*Isleria_hauxwelli*
Passeriformes	Thraupidae	*Lanio_cristatus*
Passeriformes	Thraupidae	*Lanio_fulvus*
Passeriformes	Thraupidae	*Lanio_luctuosus*
Passeriformes	Thraupidae	*Lanio_surinamus*
Passeriformes	Thraupidae	*Lanio_versicolor*
Passeriformes	Tityridae	*Laniocera_hypopyrra*
Passeriformes	Tyrannidae	*Lathrotriccus_euleri*
Passeriformes	Pipridae	*Lepidothrix_coronata*
Passeriformes	Pipridae	*Lepidothrix_iris*
Passeriformes	Pipridae	*Lepidothrix_nattereri*
Passeriformes	Pipridae	*Lepidothrix_serena*
Passeriformes	Pipridae	*Lepidothrix_vilasboasi*
Passeriformes	Rhynchocyclidae	*Leptopogon_amaurocephalus*

Columbiformes	Columbidae	*Leptotila_rufaxilla*
Columbiformes	Columbidae	*Leptotila_verreauxi*
Accipitriformes	Accipitridae	*Leucopternis_melanops*
Passeriformes	Rhinocryptidae	*Liosceles_thoracicus*
Passeriformes	Rhynchocyclidae	*Lophotriccus_vitiosus*
Passeriformes	Pipridae	*Machaeropterus_pyrocephalus*
Galbuliformes	Bucconidae	*Malacoptila_fusca*
Galbuliformes	Bucconidae	*Malacoptila_rufa*
Passeriformes	Pipridae	*Manacus_manacus*
Passeriformes	Thamnophilidae	*Megastictus_margaritatus*
Falconiformes	Falconidae	*Micrastur_buckleyi*
Falconiformes	Falconidae	*Micrastur_gilvicollis*
Falconiformes	Falconidae	*Micrastur_mintoni*
Falconiformes	Falconidae	*Micrastur_mirandollei*
Falconiformes	Falconidae	*Micrastur_ruficollis*
Falconiformes	Falconidae	*Micrastur_semitorquatus*
Passeriformes	Polioptilidae	*Microbates_cinereiventris*
Passeriformes	Polioptilidae	*Microbates_collaris*
Passeriformes	Troglodytidae	*Microcerculus_bambla*
Passeriformes	Troglodytidae	*Microcerculus_marginatus*
Galbuliformes	Bucconidae	*Micromonacha_lanceolata*
Passeriformes	Thamnophilidae	*Microrhopias_quixensis*
Passeriformes	Furnariidae	*Microxenops_milleri*
Passeriformes	Rhynchocyclidae	*Mionectes_macconnelli*
Passeriformes	Rhynchocyclidae	*Mionectes_oleagineus*
Coraciiformes	Momotidae	*Momotus_momota*
Passeriformes	Onychorhynchidae	*Myiobius_barbatus*
Passeriformes	Thamnophilidae	*Myrmelastes_humaythae*
Passeriformes	Thamnophilidae	*Myrmelastes_leucostigma*
Passeriformes	Thamnophilidae	*Myrmelastes_rufifacies*
Passeriformes	Thamnophilidae	*Myrmoborus_myotherinus*
Passeriformes	Thamnophilidae	*Myrmoderus_ferrugineus*
Passeriformes	Thamnophilidae	*Myrmornis_torquata*
Passeriformes	Thamnophilidae	*Myrmotherula_axillaris*

Passeriformes	Thamnophilidae	*Myrmotherula_heteroptera*
Passeriformes	Thamnophilidae	*Myrmotherula_iheringi*
Passeriformes	Thamnophilidae	*Myrmotherula_longipennis*
Passeriformes	Thamnophilidae	*Myrmotherula_menetriesii*
Passeriformes	Thamnophilidae	*Neoctantes_niger*
Passeriformes	Pipridae	*Neopelma_chrysocephalum*
Galbuliformes	Bucconidae	*Nonnula_brunnea*
Galbuliformes	Bucconidae	*Nonnula_rubecula*
Galbuliformes	Bucconidae	*Nonnula_ruficapilla*
Passeriformes	Thamnophilidae	*Oneillornis_lunulatus*
Passeriformes	Thamnophilidae	*Oneillornis_salvini*
Passeriformes	Onychorhynchidae	*Onychorhynchus_coronatus*
Passeriformes	Thamnophilidae	*Percnostola_minor*
Passeriformes	Thamnophilidae	*Percnostola_rufifrons*
Apodiformes	Trochilidae	*Phaethornis_bourcieri*
Apodiformes	Trochilidae	*Phaethornis_hispidus*
Apodiformes	Trochilidae	*Phaethornis_malaris*
Apodiformes	Trochilidae	*Phaethornis_philippii*
Apodiformes	Trochilidae	*Phaethornis_ruber*
Apodiformes	Trochilidae	*Phaethornis_superciliosus*
Passeriformes	Troglodytidae	*Pheugopedius_coraya*
Passeriformes	Troglodytidae	*Pheugopedius_genibarbis*
Passeriformes	Furnariidae	*Philydor_erythrocercum*
Passeriformes	Furnariidae	*Philydor_erythropterum*
Passeriformes	Furnariidae	*Philydor_pyrrhodes*
Passeriformes	Thamnophilidae	*Phlegopsis_erythroptera*
Passeriformes	Thamnophilidae	*Phlegopsis_nigromaculata*
Piciformes	Picidae	*Picumnus_aurifrons*
Passeriformes	Pipridae	*Pipra_fasciicauda*
Passeriformes	Pipridae	*Pipra_filicauda*
Passeriformes	Thamnophilidae	*Pithys_albifrons*
Passeriformes	Platyrinchidae	*Platyrinchus_coronatus*
Passeriformes	Platyrinchidae	*Platyrinchus_platyrhynchos*
Passeriformes	Platyrinchidae	*Platyrinchus_saturatus*

Accipitriformes	Accipitridae	*Pseudastur_albicollis*
Passeriformes	Thamnophilidae	*Pyriglena_leuconota*
Passeriformes	Polioptilidae	*Ramphocaenus_melanurus*
Passeriformes	Tyrannidae	*Ramphotrigon_ruficauda*
Passeriformes	Thamnophilidae	*Rhegmatorhina_berlepschi*
Passeriformes	Thamnophilidae	*Rhegmatorhina_cristata*
Passeriformes	Thamnophilidae	*Rhegmatorhina_gymnops*
Passeriformes	Thamnophilidae	*Rhegmatorhina_hoffmannsi*
Passeriformes	Thamnophilidae	*Rhegmatorhina_melanosticta*
Passeriformes	Thraupidae	*Saltator_grossus*
Passeriformes	Tityridae	*Schiffornis_amazonum*
Passeriformes	Tityridae	*Schiffornis_olivacea*
Passeriformes	Tityridae	*Schiffornis_turdina*
Passeriformes	Thamnophilidae	*Sciaphylax_hemimelaena*
Passeriformes	Thamnophilidae	*Sciaphylax_pallens*
Passeriformes	Scleruridae	*Sclerurus_albigularis*
Passeriformes	Scleruridae	*Sclerurus_caudacutus*
Passeriformes	Scleruridae	*Sclerurus_macconnelli*
Passeriformes	Scleruridae	*Sclerurus_rufigularis*
Passeriformes	Dendrocolaptidae	*Sittasomus_griseicapillus*
Passeriformes	Furnariidae	*Synallaxis_rutilans*
Passeriformes	Rhynchocyclidae	*Taeniotriccus_andrei*
Passeriformes	Onychorhynchidae	*Terenotriccus_erythrurus*
Apodiformes	Trochilidae	*Thalurania_furcata*
Passeriformes	Thamnophilidae	*Thamnomanes_ardesiacus*
Passeriformes	Thamnophilidae	*Thamnomanes_caesius*
Passeriformes	Thamnophilidae	*Thamnomanes_saturninus*
Passeriformes	Thamnophilidae	*Thamnomanes_schistogynus*
Passeriformes	Thamnophilidae	*Thamnophilus_aethiops*
Passeriformes	Thamnophilidae	*Thamnophilus_murinus*
Passeriformes	Thamnophilidae	*Thamnophilus_schistaceus*
Passeriformes	Thamnophilidae	*Thamnophilus_stictocephalus*
Apodiformes	Trochilidae	*Threnetes_leucurus*
Passeriformes	Tityridae	*Tityra_semifasciata*

Trogoniformes	Trogonidae	*Trogon_rufus*
Passeriformes	Vireonidae	*Tunchiornis_ochraceiceps*
Passeriformes	Turdidae	*Turdus_albicollis*
Passeriformes	Turdidae	*Turdus_lawrencii*
Passeriformes	Pipridae	*Tyranneutes_stolzmanni*
Passeriformes	Pipridae	*Tyranneutes_virescens*
Passeriformes	Thamnophilidae	*Willisornis_poecilinotus*
Passeriformes	Thamnophilidae	*Willisornis_vidua*
Passeriformes	Xenopidae	*Xenops_minutus*
Passeriformes	Dendrocolaptidae	*Xiphorhynchus_beauperthuysii*
Passeriformes	Dendrocolaptidae	*Xiphorhynchus_chunchotambo*
Passeriformes	Dendrocolaptidae	*Xiphorhynchus_elegans*
Passeriformes	Dendrocolaptidae	*Xiphorhynchus_guttatoides*
Passeriformes	Dendrocolaptidae	*Xiphorhynchus_ocellatus*
Passeriformes	Dendrocolaptidae	*Xiphorhynchus_pardalotus*
Passeriformes	Dendrocolaptidae	*Xiphorhynchus_spixii*

Tabela 6: Número de indivíduos das espécies de ampla distribuição nas sete áreas de endemismo.

Espécies	**Guiana**	**Inambari**	**Jaú**	**Napo**	**Rondônia**	**Tapajós**	**Xingu**
Automolus_ochrolaemus	15	8	1	5	16	16	1
Chloroceryle_aenea	8	8	13	10	17	6	5
Cyanoloxia_rothschildii	33	5	10	17	26	22	4
Dendrocincla_fuliginosa	109	40	46	3	26	51	50
Dendrocincla_merula	161	154	92	4	73	89	21
Formicarius_colma	88	17	22	34	13	22	6
Geotrygon_montana	58	29	44	52	35	51	12
Glaucis_hirsutus	2	6	2	5	21	9	53
Glyphorynchus_spirurus	520	170	131	365	172	229	90
Mionectes_oleagineus	20	33	41	59	35	47	31
Myiobius_barbatus	27	10	4	34	7	53	1
Myrmotherula_axillaris	8	105	39	37	32	34	147
Myrmotherula_longipennis	59	26	31	42	35	141	30

Myrmotherula_menetriesii	34	10	9	17	14	35	4
Phaethornis_ruber	2	3	5	3	16	3	7
Philydor_pyrrhodes	5	3	6	12	10	8	2
Sclerurus_caudacutus	9	6	1	26	8	12	9
Sclerurus_rufigularis	43	3	13	8	2	13	1
Terenotriccus_erythrurus	2	15	15	20	14	15	2
Thalurania_furcata	98	20	22	40	55	87	4
Thamnomanes_caesius	99	65	89	74	38	100	32
Trogon_rufus	4	1	1	6	2	4	3
Turdus_albicollis	107	28	29	32	21	36	18
Xenops_minutus	26	35	38	24	24	39	21
TOTAL	**1537**	**800**	**704**	**929**	**712**	**1122**	**554**

Tabela 7: Número de espécies por guilda, em cada área de endemismo.

Guilda	**Guiana**	**Inambari**	**Jaú**	**Napo**	**Rondônia**	**Tapajós**	**Xingu**
Carnivoro_G	3	2	2	3	4	3	2
Carnivoro_P	3	3	3	3	3	3	2
Frugivoro_G	0	2	1	1	1	1	2
Frugivoro_M	1	1	1	1	1	2	1
Frugivoro_P	6	7	4	5	5	8	4
Insetivoros_G	6	6	5	4	6	6	6
Insetivoros_M	37	49	42	48	54	46	38
Insetivoros_P	22	25	20	25	33	26	24
Nectarivoro_G	4	2	3	5	4	4	2
Nectarivoro_P	3	6	4	5	7	4	3
Onivoro_G	0	0	0	1	0	1	0
Onivoro_M	2	1	2	4	3	3	2
Onivoro_P	6	4	5	4	5	6	3
TOTAL	**93**	**108**	**92**	**109**	**126**	**113**	**89**

Tabela 8: Número de indivíduos por guilda, em cada área de endemismo.

Guilda	Guiana	Inambari	Jaú	Napo	Rondônia	Tapajós	Xingu
Carnivoro_G	13	5	4	6	10	21	7
Carnivoro_P	22	13	22	18	21	11	8
Frugivoro_G	0	3	1	3	8	8	12
Frugivoro_M	33	5	10	17	26	24	4
Frugivoro_P	397	333	436	432	298	407	130
Insetivoro_G	85	30	11	42	20	49	21
Insetivoro_M	2354	1409	1513	1094	963	1146	436
Insetivoro_P	1443	720	724	994	612	1189	519
Nectarivoro_G	221	9	16	32	62	81	65
Nectarivoro_P	209	108	82	275	134	185	12
Onivoro_G	0	0	0	2	0	1	0
Onivoro_M	101	29	47	88	40	58	18
Onivoro_P	199	71	76	52	101	141	50
TOTAL	**5077**	**2735**	**2942**	**3055**	**2295**	**3321**	**1282**