INSTITUTO NACIONAL DE PESQUISAS DA AMAZÔNIA
PROGRAMA DE PÓS-GRADUAÇÃO EM ECOLOGIA

Determinantes físicos e ecológicos que afetam as assembleias de aves no sudeste da Amazônia: o papel da história na distribuição das espécies

MARINA FRANCO DE ALMEIDA MAXIMIANO

Manaus, AM
Agosto, 2017

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Coorientador: Dr. Fernando Mendonça d'Horta

Dissertação apresentada ao Instituto Nacional de Pesquisas da Amazônia como parte dos requisitos para obtenção do título de Mestre em Biologia (Ecologia).

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Agosto, 2017

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Sinopse:

Avaliou-se a contribuição relativa dos rios como barreira e das diferentes características ecológicas das espécies, especialmente aquelas que afetam a sua capacidade de dispersão, na geração dos padrões biogeográficos de assembleias de aves da região do médio Rio Tapajós, no sudeste da Amazônia, através do uso de análises uni e multivariadas.

Palavras chave: Aves neotropicais, assembleias, rios como barreira, guildas, Rio Tapajós.

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"Eu posso não ter ido para onde eu pretendia ir, mas eu acho que acabei terminando onde eu pretendia estar."

(Douglas Adams)

RESUMO

A união de processos históricos e ecológicos, atuando em diversas escalas espaciais e temporais, determinam os atuais padrões de distribuição das espécies. Para a megadiversa região amazônica, diversas hipóteses foram propostas para explicar a origem e manutenção de seus complexos padrões biogeográficos. Uma destas hipóteses evidencia o relevante papel dos seus grandes rios na segregação de assembleias distintas entre suas margens, porém, sabe-se que diversas características podem afetar a permeabilidade destas barreiras. Visando entender o que gera e mantém os padrões de distribuição das assembleias de aves da região do Médio Rio Tapajós (sudeste da Amazônia), investigamos como a variação espacial da mesma é influenciada pelas barreiras físicas (rios Tapajós e Jamanxim) e por distintas características ecológicas (diferentes guildas). Para isso, nós amostramos as aves florestais em amabas as margens dos rios usando pontos fixos e redes de neblina e investigamos a variação da composição taxonômica quali- e quantitativa, abundância intraespecífica e biomassa. Avaliamos e testamos os padrões encontrados por análises multivariadas (Escalonamento Multidimensional Não Métrico) e univariadas (ANOVA + Tukey HSD), considerando diferentes resoluções taxonômicas e guildas de acordo com o hábito alimentar e estrato de forrageio. Nós registramos 381 espécies, com uma maior riqueza na margem esquerda do Rio Tapajós. A composição taxonômica variou apenas entre as margens do Rio Tapajós, que também se mostrou uma barreira para as assembleias de aves frugívoras, insetívoras, nectarívoras, habitantes do sub-bosque e estrato médio das florestas. Algumas espécies apresentaram abundâncias desiguais entre as margens deste rio. O Rio Jamanxim não foi evidenciado como uma barreira efetiva. Apesar da variação encontrada para a composição e abundância das assembleias, não encontramos evidências de variação da biomassa entre as margens dos rios. Estes resultados demonstram a contribuição relativa dos rios como barreira e das diferentes características ecológicas das espécies, especialmente as que afetam a sua capacidade de dispersão, na geração dos padrões biogeográficos, e indicam que as variações paleoclimáticas no Leste amazônico foram relevantes na estruturação das assembleias dessa região e na geração do gradiente Oeste-Leste de diversidade.

Palavras-chave: Biogeografia**,** rios como barreira, hábito alimentar, estrato de forrageio, biomassa, dispersão, gradiente Oeste-Leste, paleoclima, Rio Tapajós.

ABSTRACT

The integration of historical and ecological processes, acting in several spatial and temporal scales, shape the current patterns of species' distribution. For the megadiverse Amazon region, several hypotheses have been proposed to explain the origin and maintenance of the complex biogeographic patterns. One of these hypotheses relies on the relevant role of large rivers in segregating distinct assemblages. Although, some characteristics of the rivers can influence the permeability of these barriers. To understand what generates and maintains distribution patterns of bird assemblages in the middle Tapajós River region (southeastern Amazonia), we investigate how their spatial variation is influenced by physical barriers (Tapajós and Jamanxim rivers) and different ecological characteristics (distinct guilds). Therefore, we sampled the forest birds through point counts and mist nets in all river banks and investigated the variation on the qualitative and quantitative taxonomic composition, intraspecific abundance and biomass. We evaluated and tested the patterns through multivariate (Non-Metric Multidimensional Scaling) and univariate (ANOVA + Tukey HSD) analyses, considering different taxonomic resolutions and guilds according to their feeding habit and foraging stratum. We recorded 381 species, with greater richness on the left bank of the Tapajós River. The taxonomic composition varied only between the banks of the Tapajós River, which acts as a barrier to the assemblages of frugivores, insectivores, nectarivores, inhabitants of the understory and midstory of the forest. Some species presented unequal abundances between the banks of this river. The Jamanxim River does not seem to act as an effective barrier. Despite the variation found in the composition and abundance of the assemblages, we found no evidence of biomass variation between river banks. These results demonstrate the relative contribution of rivers as barriers and different ecological traits of species, especially those that affect their dispersal, in driving the biogeographic patterns, and indicate that palaeoclimatic variations in Eastern Amazonia were relevant for the local assemblages history and in the origin of the West–East gradient of species diversity.

Keywords: Biogeography, riverine barrier, feeding habits, foraging stratum, biomass, dispersal, West–East gradient, palaeoclimate, Tapajós River.

SUMÁRIO

PG·ECO·INPA — INPA — MCTI Ministério da Ciência, Tecnologia e Inovação — GOVERNO FEDERAL BRASIL PÁTRIA EDUCADORA

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Nível: MESTRADO
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Título:

"VARIAÇÃO ESPACIAL E TEMPORAL DA ASSEMBLEIA DE AVES NO MÉDIO RIO TAPAJÓS, AMAZÔNIA ORIENTAL"

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Manaus (AM), 18 de Abril de 2016.

OBS:______________________________

INTRODUÇÃO

A biogeografia é uma ciência multidisciplinar que estuda a distribuição dos organismos no espaço e no tempo, em busca da detecção de padrões e dos processos que os geraram (Carvalho e Almeida, 2016). Por muito tempo esta ciência esteve segregada em duas vertentes, a histórica e a ecológica. Enquanto a primeira procura compreender como processos de larga escala temporal que ocorreram durante milhões de anos (como o surgimento de uma barreira geográfica), influenciam a distribuição das espécies, a segunda foca na influência de processos em menores escalas temporais (como interações interespecíficas e requerimentos intrínsecos de cada espécie) na distribuição destas (Wiens e Donoghue, 2004). Porém, é cada vez mais evidente que estas vertentes não devem ser avaliadas de maneira dissociada, já que diversos processos, atuando em diferentes escalas temporais e espaciais, são os responsáveis pela origem e manutenção dos padrões de distribuição das espécies observáveis atualmente (Ricklefs e Jenkins, 2011; Weeks *et al*., 2016). Tais padrões biogeográficos podem ser reconhecidos em amplas escalas geográficas, como o gradiente latitudinal de biodiversidade global, segundo o qual há um decréscimo na diversidade biológica no sentido dos trópicos em direção aos pólos (Willig *et al.*, 2003; Mannion *et al.*, 2014). Também podem ser detectados em menores escalas geográficas, como as áreas de endemismos de espécies amazônicas, que possuem distribuições congruentes de táxons limitadas pelos grandes rios desta região (Cracraft, 1985; Silva *et al*., 2002; Borges e Silva, 2012).

Desde os primórdios da biogeografia, a região amazônica tem sido tratada com grande interesse, por possuir uma das biotas mais diversas do planeta (Jenkins *et al.*, 2013) associada a diversos eventos históricos relevantes. Diversas são as hipóteses que buscam entender essa elevada biodiversidade (Leite e Rogers, 2013), avaliando tanto influências históricas como a evolução da drenagem (Hoorn *et al.*, 2010) e as variações climáticas históricas (Haffer, 2008; Cheng *et al.*, 2013), quanto influências ecológicas como a elevada heterogeneidade ambiental nesta região, que abriga diversos habitats florestais e não-florestais com dinâmicas distintas (Junk *et al.*, 2011). Dentre os organismos vertebrados, o grupo das Aves representa grande parte desta alta biodiversidade, contando com cerca de 1.300 espécies reconhecidas para a porção brasileira deste bioma (Aleixo, 2016). Estes organismos representam ótimos modelos para estudos biogeográficos, uma vez que são conspícuos e abundantes, possuem uma boa resolução taxonômica e de distribuições geográficas, ocupam variados tipos de habitats ao longo de toda a região, e possuem ecologias distintas (Ferraz *et al.*, 2007; Smith *et al.*, 2014; Cornelius *et al.*, 2017).

A bacia do Rio Tapajós, um dos grandes afluentes do Rio Amazonas, possui um papel de destaque na bacia amazônica e em estudos biogeográficos, já que abriga uma grande diversidade de ambientes, limita duas áreas de endemismo de espécies (Cracraft, 1985; Silva *et al.*, 2002), percorre dois compartimentos geológicos com características distintas (o Escudo Cristalino Brasileiro e a bacia sedimentar do Rio Solimões-Amazonas) (IBGE, 2004), e possui uma rica avifauna associada à esta heterogeneidade. Esta avifauna vem sendo historicamente estudada desde que a naturalista alemã Emilie Snethlage notou padrões na distribuição das espécies desta região associados a distintos habitats (Snethlage, 1910). Mais recentemente, inventários localizados em distintas margens do Rio Tapajós ajudaram no reconhecimento da assembleia de aves que ocupa esta bacia (Oren e Parker, 1997; Henriques *et al*., 2003; Pacheco e Olmos, 2005; Wunderle *et al.*, 2006; Santos *et al.*, 2011a, 2011b; Lees *et al.*, 2013; Guilherme, 2014). Estes estudos avaliaram de maneira pontual os padrões de distribuições da avifauna da região, baseando-se na maioria dos casos em dados coletados em curto prazo, enquanto o conhecimento é escasso quando consideramos ambas as margens do Rio Tapajós de maneira integrada, com dados coletados em longo prazo e padronizados.

Além desta rica diversidade biológica, nos últimos anos a bacia do Rio Tapajós tornou-se ainda mais relevante por conta do planejamento de construções de grandes empreendimentos hidrelétricos (Fearnside, 2015), sendo atualmente considerada uma das bacias mais ameaçadas por estes empreendimentos (Latrubesse *et al.*, 2017). A construção destas barragens irá impactar a complexa dinâmica ecológica gerada pelo pulso de inundação sazonal e consequentemente afetar os padrões biogeográficos naturais da biota da região (Moraes *et al.*, 2016). Dessa forma, é essencial ampliarmos o conhecimento histórico sobre os padrões de distribuição espacial das assembleias de aves na ameaçada região do Médio Rio Tapajós, baseando-se em dados padronizados e coletados em longo prazo. Possibilitando com esta abordagem, compreendermos a história dessa biota e as características ecológicas determinantes da variação na composição das assembleias.

OBJETIVOS

Objetivo geral

Avaliar o efeito dos rios como barreiras para as diferentes assembleias de aves na região do médio Rio Tapajós, considerando diferentes resoluções taxonômicas e guildas.

Objetivos específicos

1. Avaliar se há diferença de composição e abundância de espécies entre as margens de rios com diferentes larguras (Tapajós e Jamanxim);

2. Avaliar se o efeito destes rios como barreira varia de forma significativa entre diferentes resoluções taxonômicas (espécies x subespécies/linhagens);

3. Avaliar se o efeito destes rios como barreira varia de forma significativa em guildas com diferentes características ecológicas (hábito alimentar e estrato de forrageio), e portanto com diferentes capacidades de dispersão;

4. Avaliar se, nas guildas com diferenças significativas de composição e riqueza de espécies entre margens opostas destes rios, também é verificada variação significativa de biomassa.

CAPÍTULO 1

Maximiano, M.F.A..; d'Horta, F.M..; Van Doninck, J.; Zuquim, G.; Tuomisto, H.; Ribas, C.C. **The relative role of rivers, environmental heterogeneity and species traits in driving compositional changes in Southeastern Amazonian bird assemblages.** Manuscrito submetido para *Biotropica*.

ORIGINAL RESEARCH

The relative role of rivers, environmental heterogeneity and species traits in driving compositional changes in Southeastern Amazonian bird assemblages

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ABSTRACT

Amazonian rivers have been proposed to act as geographic barriers to species dispersal, either driving allopatric speciation or defining current distribution limits. The strength of the barrier varies according to the species ecological characteristics and the river physical properties. Environmental heterogeneity may also drive compositional changes, but have hardly been assessed in Amazonia. Aiming to understand the contributions of riverine barriers and environmental heterogeneity in shaping compositional changes in Amazonian forest bird assemblages, we focus on the Tapajós River. We investigate how spatial variation in species composition is related to physical barriers (Tapajós and Jamanxim rivers), ecological characteristics of the species (distinct guilds) and environmental heterogeneity (canopy reflectance, soils and elevation). We sampled birds through point counts and mist nets on both sides of the Tapajós and Jamanxim rivers. To test for relationships between bird composition and environmental data, we used Mantel and partial Mantel tests, NMDS and ANOVA + Tukey HSD. The Mantel tests showed that the clearest compositional changes occurred across the Tapajós River, which seems to act unequally as a significant barrier to the bird guilds. The Jamanxim River was not associated with differences in bird communities. Our results reinforce that the Tapajós River is a biogeographical boundary for birds, but environmental heterogeneity determines compositional variation within interfluves. These results contrast with diversity patterns described for other vertebrates, suggesting that upland forest birds singularly respond to large rivers as barriers in Amazonia, leading to erroneous extrapolations for interpreting biogeographic results for other Amazonian organisms.

Keywords: dispersal; feeding habits; foraging stratum; body size; taxonomy; riverine barrier; Tapajós River.

INTRODUCTION

Geographical distribution patterns of Amazonian species and processes that generate and maintain such patterns have attracted the attention of scientists for centuries (Wallace, 1852; Snethlage, 1910; Sick, 1967; Cracraft, 1985; Haffer, 1990; Ayres & Clutton-Brock, 1992). Although hypotheses regarding these processes tend to be tested independently, taking into account the interaction between historical and ecological processes is a more comprehensive approach to understanding current species distribution patterns (Tuomisto & Ruokolainen, 1997; Ricklefs & Jenkins, 2011; Weeks, Claramunt & Cracraft, 2016). These processes are complex, as they act at several spatial and temporal scales and include both abiotic (e.g. climatic variation and emergence of geographical barriers; Ribas, Aleixo, Nogueira, Myiaki & Cracraft, 2012) and biotic (e.g. ecological competition and predation; Gutiérrez, Boria & Anderson, 2014) factors.

Large rivers are a conspicuous characteristic of Amazonian landscape, and their importance for delimiting distributions of taxa has been documented for some groups of forest organisms, such as primates (Wallace, 1852) and birds (Cracraft, 1985). These observations led to the formulation of the hypothesis that river establishment triggers allopatric isolation and diversification (Sick, 1967; Capparella, 1991). Since its original formulation, this hypothesis has been widely tested for a variety of taxonomic groups, with different approaches and contrasting results (e.g., Ribas et al., 2012; d'Horta, Cuervo, Ribas, Brumfield & Myiaki, 2013; Souza, Rodrigues & Cohn-Haft, 2013; Pomara, Ruokolainen & Young, 2014; Simões et al., 2014; Boubli et al., 2015; Thom & Aleixo, 2015; Moraes, Pavan, Barros & Ribas, 2016; Dambros, Morais, Azevedo & Gotelli, 2017; Nazareno, Dick & Lohmann, 2017; Naka & Brumfield, 2018).

The accumulation of knowledge on the evolutionary history of the Amazonian biota

(Rull, 2011; Naka & Brumfield, 2018; Silva et al., 2019) and on the geological evolution of Amazonian landscape (Räsänen, Salo & Kalliola, 1987; Rossetti, de Toledo & Góes, 2005; Hoorn et al., 2010; Latrubesse et al., 2010) indicates that the effect of rivers as dispersal barriers is complex (Colwell, 2000; Gascon et al., 2000; Tuomisto, 2007; Sandoval-H, Gómez & Cadena, 2017). The permeability of river barriers depends on their physical and hydrological characteristics (Weir, Faccio, Pulido-Santacruz, Barrera-Guzmán & Aleixo, 2015; Nazareno et al., 2017) and the historical changes to their configuration (Ruokolainen Moulatlet, Zuquim, Hoorn & Tuomisto, 2018; Pupim et al., 2019). The Amazon River has usually been considered a relevant barrier to biotic dispersal (Ayres & Clutton-Brock, 1992; Pomara et al., 2014). However, results concerning its tributaries have been more variable. Some studies have found evidence of intra- and interspecific barriers (Fernandes, Wink & Aleixo, 2012; Whitney et al., 2013; van Roosmalen & van Roosmalen, 2016; Maia, Lima & Kaefer, 2017) while others have not (Patton, da Silva & Malcolm, 2000; Smith et al. 2014).

The intrinsic characteristics of organisms that directly or indirectly affect their dispersal capacity also influence the permeability of barriers (Papadopoulou & Knowles, 2017). These include morphology, feeding habit, foraging strategies, and reproductive mode (Burney & Brumfield, 2009; Claramunt, Derryberry, Remsen & Brumfield, 2012; Fouquet et al., 2015; Moraes et al., 2016). Thus, the varying dispersal capacities of Amazonian species is a fundamental factor underpinning the origin of current patterns of assemblage composition and structure, and may even influence the rate of lineage diversification (Harvey, Aleixo, Ribas & Brumfield, 2017). Groups with greater dispersal capacity tend to be less species-rich because the lower relative effectiveness of geographical barriers results in greater connectivity between populations, and hence reduced differentiation (Claramunt et al., 2012). Most biogeographical studies of Amazonian birds consider, directly or indirectly, dispersal capacity as a parameter for the selection of the target taxa. Such studies are often focused on groups with morphological or vocal differentiation (complexes of species or polytypic species), and most of these inhabit the upland forest understory (e.g., d'Horta et al., 2013; Fernandes, Cohn-Haft, Hrbek & Farias, 2014). Comparative studies using multiple taxa have only recently incorporated dispersal capacity in the interpretation of biogeographical patterns (Smith et al., 2014; Harvey et al., 2017; Crouch, Capurucho, Hackett & Bates, 2018). Therefore, how the ecological characteristics of Amazonian species relate to the riverine barrier effect is poorly understood.

However, the perceived importance of rivers in delimiting species distributions in some groups of organisms may also be a consequence of environmental heterogeneity among interfluves. Environmental heterogeneity across the Amazon basin is known to drive changes in the composition and structure of bird assemblages (Pomara, Ruokolainen, Tuomisto & Young, 2012; Pomara et al., 2014; Menger et al., 2017). Several bird taxa present habitat specificity, and variation in environmental characteristics, such as soil characteristics, vegetation structure and climate can lead to species' absence or replacement (Terborgh Robinson, Parker III, Munn & Pierpont, 1990). For example, community composition between flooded and non-flooded forests is known to be highly different both for trees (Wittmann, Schöngart & Junk, 2010) and for some animal groups (e.g., birds, Remsen & Parker III, 1983; primates, Haugaasen & Peres, 2005). There is ample evidence that variation in plant species composition within the non-flooded forests closely reflects soil heterogeneity at all spatial scales (Tuomisto et al., 1995; Tuomisto, Ruokolainen & Yli-Halla, 2003, Tuomisto et al., 2016, 2019; Phillips et al., 2003; Baldeck, Tupayachi, Sinca, Jaramillo & Asner, 2016), and some evidence that such variation also affects bird assemblages (Bueno, Bruno, Pimentel, Sanaiotti & Magnusson, 2012; Cintra & Naka, 2012; Pomara et al., 2012; Pomara et al., 2014; Menger et al., 2017).

Our interest is in clarifying how the current patterns of species distribution in Amazonia relate to landscape characteristics, such as physical barriers and environmental heterogeneity.

The Tapajós River basin provides a natural laboratory for this purpose, as the basin has complex and contrasting landscape features and is known as an important area of species turnover (Cracraft, 1985; Haffer, 1997). The upper and middle courses of the Tapajós are deeply embedded in rocky beds of the crystalline Precambrian cratonic formations of the Brazilian Shield and have a fast water flow and erosive nature. The lower course traverses the flat sedimentary basin of the Amazon River, so the water flows slower and the Tapajós river expands into a ria lake before joining with the Amazon (Sioli, 1984), although the Brazilian Shield extends almost to the river on its eastern side. There is also a gradual climatic change, with general humidity increasing towards the west, such that. forests to the west of the Tapajós have been categorized as dense humid forest, while to the east there is a greater amount of open forest formations and a gradual transition towards the Cerrado (Brazilian Savannah) vegetation (IBGE, 2004). This environmental heterogeneity renders the Tapajós river basin a relevant area for biogeographical studies, and bird assemblages have the advantage that their taxonomy, geographical distributions and ecological characteristics are relatively well known (Ferraz et al., 2007; Smith et al., 2014; Cornelius, Awade, Cândia-Gallardo, Sieving & Metzger, 2017).

Here we aim to clarify the relative importance of physical barriers and environmental heterogeneity on the distributions of Amazonian upland birds by taking into account ecological traits of taxa in addition to landscape characteristics. We use the Tapajós river basin as a model area to address the following main questions: (1) To what degree are river barriers and environmental factors related to bird composition? (2) Do the compositional patterns differ among bird guilds with different feeding habits, foraging stratum or body size? (3) Is the interpretation of the compositional patterns different for taxa of different degrees of evolutionary separation (species vs. subspecies)? (4) Are compositional differences across a river related to its size (Tapajós itself vs. a tributary)?

METHODS

Study area

This study was conducted in an area where the Tapajós River is joined by one of its major tributaries, the Jamanxim. The channel of the Tapajós is more than 4 km wide, and that of the Jamanxim is about 1 km wide (Fig. 1). The Tapajós is a clear-water river with a small suspended sediment input, because it mostly runs through the ancient and not easily eroded cratonic shield (Junk et al., 2011). The climate of the region has two well defined seasons, a dry period from July to November, with monthly rainfall less than 60 mm and the number of consecutive months with less than 100 mm of rainfall can reach five, and a rainy period from December to June, where the monthly rainfall can exceed 300 mm (Ferreira & Prance, 1998; Sombroek, 2001). Regional mean annual temperature is 26°C, and the annual rainfall exceeds 2,400 mm (Wang et al., 2017).

Sampling design and data collection

Eleven sampling sites were established, four on the left bank of Tapajós River and seven on its right bank (of which four in the interfluve Tapajós-Jamanxim and three on the right bank of Jamanxim) (Fig. 1). Each sampling site consisted of a linear 4-km main trail perpendicular to the main river, and five 250-m secondary trails, spaced 1 km apart. The sampling design followed the RAPELD protocols, which allows a complete sampling of the biological community and comparison with other studies, due to the standardization of sampling (Magnusson et al., 2005). Birds were sampled during six survey campaigns from July 2012 to November 2013. We recorded birds using two complementary methods (Blake & Loiselle, 2001): (1) point counts, implemented every 500-m along the main trail at each sampling site, where we recorded all individuals seen or heard during a 10-min observation period. Each point was sampled four times during each survey campaign (generating a total sampling effort of ca. 255 h); (2) mist net lines (10 mist nets of 12 m x 2.5 m), positioned along the five secondary trails at each site and opened for three consecutive days during each survey campaign (a total sampling effort of 40,500 net-h). Due to differences in sampling effort between sites, we standardized the data (total of individuals registered) by dividing them by the number of sampling hours at each sampling site for the quantitative analyses.

Individuals captured with mist nets were identified and banded, and vouchers of each species and sex (when sexual dimorphism occurs) were collected (Authorizations for Capture, Collection and Transport of Biological Material #66/2012, issued by IBAMA, and #004/2012-CR3/Santarém, issued by ICMBio) and deposited in the Bird Collection of the Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus, AM, Brazil. Field identifications were confirmed with the help of the deposited specimens to assure data quality.

Earlier studies have found that canopy reflectance is indicative of floristic and edaphic patterns in Amazonia (Tuomisto et al., 2003a; Tuomisto, Ruokolainen, Aguilar & Sarmiento, 2003b, 2019; Salovaara, Thessler, Malik & Tuomisto, 2005; Higgins et al., 2011), so we used as one of the environmental data sources the canopy reflectance values from an Amazon-wide Landsat TM/ETM+ image composite (Van doninck & Tuomisto, 2018). In addition, we used interpolated estimates of the concentration of exchangeable base cations (Ca, Mg, K) in the soil (Zuquim, 2017) and elevation data from Shuttle Radar Topographic Mission (SRTM) as descriptors of environmental characteristics for each sampling unit. All data were extracted separately for each of the six sampling points at each site. The reflectance data were extracted using 15 by 15 pixel windows (450 m) centered on each of the sampling points (six points per site) and consist of the median and standard deviation of the reflectance values of Landsat bands 2–5 and 7. The point data were summarised to the site level by taking arithmetic means, except for standard deviation, which was summarised using the product of the SD of the medians and the mean of the SDs.

DATA ANALYSIS

Geographic barriers and environmental variables: We carried out Mantel tests to quantify the correlation between bird compositional turnover (as quantified with the Bray-Curtis dissimilarity index) and differences in which side of the rivers the sites were situated and in the available environmental proxies (canopy reflectance, soil estimates and elevation) (Rotenberry, 1985; Smouse, Long & Sokal, 1986; Tuomisto & Ruokolainen, 2006). We calculated both raw and log-transformed geographical distances to estimate the effect of isolation by distance, we conducted partial Mantel tests to compare the species composition with geographic data, controlling for environmental differences (Smouse et al., 1986). Environmental heterogeneity was also assessed through PCA ordinations of all the environmental axes using the Bray-Curtis index as a measure of dissimilarity among sampling sites.

Species traits: To understand the contribution of species traits to the variation of species composition, we investigated the variation of species composition among sampling sites on opposite riverbanks considering different guilds (sub-sets of species), based on species' classification according to their (1) feeding habit: frugivores, insectivores, omnivores, nectarivores, raptors and granivores (Terborgh et al., 1990); (2) foraging stratum: terrestrial, understory, midstory and canopy (Stotz, Fitzpatrick, Parker III. & Moskovits, 1996); and (3) body size based on species biomass: small (1-29 g), medium (30-100 g) and large (>100 g) (Wilman et al., 2014). Such traits were chosen because they may influence directly or indirectly the species' dispersal capacity (Terborgh et al., 1990). For these analyses, we used both quantitative (abundance) and qualitative data (presence–absence), where we combined the data from both methods. Similarity between the sampling sites was determined with Bray–Curtis and Jaccard indexes, respectively. The use of these two measurements of assemblage dissimilarities (based on presence–absence and abundance data) is relevant, since they emphases different aspects of community characteristics, giving more weight to valuing rare and common species, respectively (Hubbell & Foster, 1986). We visualized pairwise differences among communities in two dimensions using multivariate ordinations (Non-Metric Multidimensional Scaling, NMDS) (Clarke, 1993). We applied an Analysis of Variance (ANOVA) on the first axis of NMDS and *post-hoc* Tukey HSD to test statistical significance of the differences between assemblages on each bank. To reduce sampling and detectability bias and to avoid the detection of inaccurate patterns of river effect on assemblage composition, we excluded species with less than 10 records from the analyses. For species present in all riverbanks, we summed the number of records for each species in each sampling site, and applied ANOVA to investigate if the variation in abundance was significantly different in each of the three interfluves.

Taxonomic resolution: To account for the influence of taxonomic resolution in the results, we performed analyses twice, using either the currently recognized species (following Piacentini et al., 2015) or the subspecies/molecular lineages that have been described within each species, assuming in the latter case the lowest possible taxonomic level as the unit for analysis. We visualized the result with NMDS and used ANOVA applied on the first axis of NMDS, and *post-hoc* Tukey HSD.

Physical features of the rivers: To test if large rivers are stronger barriers than small rivers, i. e. the variation of species composition between opposite banks of Tapajós and Jamanxim rivers, we consider the three interfluves formed by these two rivers in all ordinations. We visualized the result with NMDS and used ANOVA applied on the first axis of NMDS, and *post-hoc*

Tukey HSD.

All analysis were done in R environment, (R Core Team, 2018) using the Community Ecology package VEGAN 2.5-3 (Oksanen et al., 2018).

RESULTS

We observed 385 species in almost 22,000 individual records. At higher taxonomic resolution (subspecies/molecular lineages), this corresponds to 417 taxa. Some of these taxa are endemic to the Tapajós River basin, as *L. vilasboasi* (Sick, 1959) (Snow & Sharpe, 2019), and some are threatened, as *Guarouba guaruba* (Gmelin, 1788) (Table S1). After excluding species with fewer than 10 records,which includes species occasionally recorded, and species that inhabits flooded forests or disturbed habitats like clearings and forest edges, our final database included 247 upland forest species (Supporting Information Table S1).

ENVIRONMENTAL HETEROGENEITY VS. RIVERINE BARRIER —Mantel tests showed a significant ($p>0.05$) and strong (r between 0.45 and 0.53) correlation of changes in bird species composition and interfluves (which can also be seen in Fig. 3) for both quantitative and qualitative approaches and regardless of the sampling method used (Tab. 1) We also found a significant correlation between species composition and different predictors of environmental heterogeneity (r between 0.27 and 0.49). Sampling sites dissimilarities in environmental characteristics (as capture by PCA axes) was not related to interfluves. Similar environmental conditions were found in plots in both sides of the rivers. Moreover, some sampling sites within the same riverbank were clearly distinct (Fig. 2).

Thirty two species were recorded on both banks of the Tapajós River, but their abundances varied significantly according to river side (Supporting Information Table S1). For example, 85% of the individuals of the thamnophilid *Willisornis poecilinotus* (Cabanis 1847) were recorded on the right bank of the Tapajós River, while *Ancistrops strigilatus* (Spix 1825) and *Automolus ochrolaemus* (Tschudi 1844) were more abundant on the opposite bank of the Tapajós River (85% and 72% of the records were done on the left side of Tapajós).

SPECIES COMPOSITION AND GUILDS —Species composition according to feeding habit varied unequally between the Tapajós River banks (Table 2). For insectivores, nectarivores and frugivores, the differences between Tapajós River banks were significant for all comparisons (Table 2, Fig. 4) but only for frugivores species composition dissimilarity was high between assemblages in two sides of Jamanxim River (Fig. 4). Omnivores composition showed significant differences only for quantitative data obtained from point counts (Fig. 4). Granivores and raptors sampled by point counts did not show significant compositional variation among riverbanks for any of the comparisons (Table 2, Fig. 4), and comparisons involving these guilds sampled by mist nets were not performed because there were not enough species in the dataset. These results indicate that Tapajós river is more permeable to avifaunal exchange for these three assemblages (omnivores, granivores and raptors).

Species composition also varied unequally according to foraging stratum (Table 2). For understory taxa, changes in species composition related to Tapajós River banks were significant in all comparisons (i. e. p<<0,05). For midstory taxa, distinction was also significant in all comparisons, but less evident than for understory taxa (Fig. 5). For the canopy and terrestrial taxa, composition varied significantly in relation to Tapajós River banks only for the bird assemblage sampled through point counts, but not for birds sampled through mist nets nor combined mist nets and point count dataset (Table 2, Fig. 5).

When classifying taxa by average body size, the variation in species composition between the Tapajós River banks is especially evident for small- or medium-sized species

(Table 2, Fig. 6). Differences in opposite banks of the Jamanxim River were not significant for any body size dataset (Table 3). Considering the guild of large-sized species, none of the large rivers were evidenced as affecting the variation of species composition (Fig. 6), also indicating a greater permeability of avifauna exchange for this assemblage.

SPECIES COMPOSITION AND TAXONOMIC RESOLUTION —At the species level, bird assemblage composition showed significant differences between the opposite banks of Tapajós River, but not when comparing opposite banks of the Jamanxim River (Tables 2, 3). This result is also evident through the two main clusters generated in the NMDS ordinations, which correspond to the opposite banks of the Tapajós River (Fig. 3). In fact, 108 taxa had their distributions delimited by the Tapajós River: 56 were restricted to the left bank and 52 to the right bank, while just one species pair, *Lepidothrix vilasboasi* and *Lepidothrix iris* (Schinz 1851), have their distribution boundaries in the Jamanxim River (Table S1). When we consider a more refined taxonomic resolution (subspecies/molecular lineages), only the influence of the Tapajós River is maintained (Table 2), with compositional dissimilarity between opposite banks being even more significant (Fig. 3).Our results indicate that the Tapajós River acts as a significant barrier to bird assemblages' dispersion in its middle course, but differentially influences the distinct ecological groups. In addition, with a refined taxonomic resolution, the riverine barrier effect becomes much more significant. The Jamanxim River does not appear as a significant barrier influencing variation in assemblage composition (Table 3). Although environmental heterogeneity is not the main factor structuring the bird assemblage variation in this region, it may explain differences in species composition within the same interfluve.

DISCUSSION

Bird diversity recorded in our study is comparable with previous regional inventories: Oren & Parker (1997), Santos, Aleixo, d'Horta & Portes (2011) and Guilherme (2014) recorded 448, 490 and 247 species, respectively, on the left bank of the Tapajós River, while Henriques, Wunderle & Willig (2003), Pacheco & Olmos (2005) and Wunderle, Henriques & Willig (2006) recorded 342, 451 and 134 species, respectively, on the right bank of this river.

RIVERINE BARRIERS AND ENVIRONMENTAL HETEROGENEITY —The effect of rivers in shaping species distributions have already been reported for bird and primate groups at several geographic scales (Alfaro, Cortés-Ortiz, Di Fiori & Boubli, 2015; Boubli et al., 2015; van Roosmalen & van Roosmalen, 2016; Hayes & Sewlal, 2004; Naka & Brumfield, 2018). However, none of the previous studies has taken into account environmental variation within and among interfluves combined to the presence of the river. Our approach represents the first attempt to combine the influence of environmental filtering and riverine barrier effect on the compositional variation of Amazonian biological assemblages. Our results indicate that variation in species assemblages' composition is strongly correlated to the presence of the Tapajós River and environmental variation and almost uncorrelated to the presence of the Jamanxim River.

Environmental heterogeneity has been evidenced as a strong driver of assemblage patterns within interfluvial regions for Amazonian birds (Bueno et al., 2012; Cintra & Naka 2011; Menger et al., 2017). Although the main differences found here in species composition are strongly correlated to the Tapajós River, more subtle compositional variation among sampling points with distinct forest structure, and the variations in species abundance, may be related to habitat heterogeneity within each interfluve, which can be evidenced by the significant correlation between some canopy reflectance bands and soil types (highlighted in Table 1) and the variation in species composition. In other words, once some species can cross the Tapajós River, the environmental heterogeneity between banks may act like a filter to its establishment, therefore, the effects of river and environment in shaping the distribution of a species acts synergistically. These species only establish viable populations or larger local abundances at environmentally similar localities on the opposite bank, and these localities may be unequally represented in our sampling of opposite banks. In some cases, the dispersal capacity and permeability of the barrier are not sufficient to explain the observed distribution patterns, which may be influenced by other factors like competition for resources (Moraes et al., 2016) or aggressive interactions between phylogenetically related species (Robinson & Terborgh, 1995). Even species currently considered restricted to one of the riverbanks may have undergone this process over time.

RIVERINE BARRIERS AND SPECIES TRAITS —The variation in taxonomic composition and relative abundance of bird assemblages showed influence of the Tapajós River as the main geographical barrier in the region, preventing or reducing the dispersal of species between its banks. This result corroborates previous studies focused on birds (e.g., Aleixo, 2004; Thom & Aleixo, 2015; Schultz et al., 2017), and other vertebrates (Moraes et al., 2016). However, this barrier effect varies along the course of the river, as previously shown by Haffer (1997), Bates, Haffer & Grismer (2004) and Weir et al., (2015), who analyzed geographical variation of birds in the headwaters of the Tapajós River and detected contact and hybridization zones between pairs of taxa that are otherwise separated by this river in its middle and upper courses.

The Jamanxim River, on the other hand, was evidenced as a weak barrier for birds, an effect also observed in other studies in this region (Moraes et al., 2016; Ferreira, Aleixo, Ribas & Santos, 2017). This greater permeability is possibly resulted due to the smaller width of this river compared to the Tapajós River (ca. 14% of its width), the greater number of fluvial islands covered by upland forests, which can act as stepping-stones, and headwaters located within forested habitats. The only pair of taxa with distributions delimited by the Jamanxim River in the study area belong to the genus *Lepidothrix*. Species from this genus form *leks*, are under strong sexual selection, and may have a faster evolutionary rate for the characters under selection, so phenotypic and behavioral changes may occur more rapidly after an emergence of a geographical barrier (Ellsworth, Honeycutt, Silvy, Rittenhouse & Smith, 1994; Snow, 1963; Prum 1990, Barrera-Guzmán., Aleixo, Shawkey & Weir, 2018; Dias et al., 2018). In fact, Amazonian microinterfluves are known to be relevant drivers of cryptic diversity (Fernandes et al., 2014; van Roosmalen & van Roosmalen, 2016), and future intraspecific studies to test the effect of the smaller rivers on population diversification may reveal unknown patterns.

Our results reinforce the relevance of taxonomic resolution in biogeographical studies. When we considered a refined taxonomic resolution, based on subspecies and described molecular lineages, we noticed a substantial increase in the riverine barrier effect. For example, the abundant and widely distributed woodcreeper *Glyphorynchus spirurus* (Vieillot 1819) is traditionally recognized as a single and widespread species due to the absence of clear morphological variation, but this species has deep molecular divergence among different Amazonian interfluves (Fernandes, Gonzales, Wink & Aleixo, 2013), including between banks of the Tapajós River. Considering those hidden lineages when comparing species assemblages is relevant to understand biogeographical processes (Fernandes, 2013).

Our results show unequal permeability of the riverine barrier for groups with distinct body sizes, feeding habits and that inhabit different forest stratum (Hayes & Sewlal, 2004; Burney & Brumfield, 2009; Fouquet et al., 2015; Moraes et al., 2016). Birds from distinct guilds tend to respond differently to habitat features (Cohn-Haft & Sherry, 1994; Winkler & Preleuthner, 2001; Moura et al., 2016; Bueno, Dantas, Henriques & Peres, 2018) exhibiting differences in behavior and morphology. Distributions of small and medium-sized taxa, frugivores, insectivores and nectarivores, that forage in the understory and midstory forest stratum, were especially affected by the Tapajós River as a barrier. This result may be due to many species in these assemblages being less dispersive, territorial and having high habitat specificity (Burney & Brumfield, 2009). Concerning insectivores, especially those inhabiting the understory, high levels of territoriality due to a more spatially and temporally constant food supply result in low dispersal (Greenberg, 1981; Loiselle, 1988; Herzog, Soria & Matthysen, 2003), favoring diversification associated with a geographical barrier. Examples of such species include several members of the families Dendrocolaptidae, as *Dendrocolaptes ridgwayi* Hellmayr 1905 and *Dendrocolaptes concolor* Pelzeln 1868, and Thamnophilidae, including the obligate army ant followers *Rhegmatorhina berlepschi* (Snethlage 1907) and *Rhegmatorhina gymnops* Ridgway 1888, each with distributions restricted to a single Tapajós River bank (Supporting Information Table S1). Most studies of understory birds show that this group is especially sensitive to habitat modifications, such as road construction or even natural clearings, and most of them tend to avoid open environments and forest edges (Lovejoy et al., 1986; Thiollay, 1992, Stouffer & Bierregaard, 1995; Sieving & Karr, 1997, Stouffer & Borges, 2001; Laurance, Stouffer & Laurance, 2004), and such ecological preference favors the diversification of these groups after emergence of geographic barriers.

The riverine barrier effect in nectarivores is generated mainly by members of the species-rich genus *Phaethornis* Swainson 1827. Of the six recorded *Phaethornis* species, three were restricted to a single Tapajós River bank, corroborating a distributional pattern already described (Piacentini, 2011). When using the refined taxonomic database, the number of taxa restricted to a single bank increased to four. In general, hummingbirds have ecological characteristics that favors the diversification after emergence of geographic barriers: they are known to be territorial and aggressive, chasing other hummingbirds and even larger birds (Sick, 2001), and have smaller body sizes, which are usually associated with shorter generation time, and therefore larger diversification rates (Owens, Bennett & Harvey, 1999). Wollenberg, Vieites, Glaw & Vences (2011) also found the same relationship with small body size and low dispersal capacity for frogs, where smaller species presented smaller and more fragmented distributions.

In contrast, none of the region's large rivers has been identified as a significant barrier to large-sized, granivore, raptor, omnivore or terrestrial birds. This is probably because species from these guilds depend on unpredictable resources across space and time, favoring a high dispersal rate (Greenberg, 1981; Loiselle, 1988). Such species often move over long distances, for example, searching for prey [e.g. raptors such as *Spizaetus ornatus* (Daudin 1800) and *Ibycter americanus* (Boddaert 1783)], or foraging for fruits and insects in the canopy [e.g. *Tyrannulus elatus* (Latham 1790) and species of the genera *Tangara* Brisson 1760, *Ara* Lacépède 1799 and *Amazona* Lesson 1830], or on the forest floor [e.g. *Odontophorus gujanensis* (Gmelin 1789) and *Tinamus guttatus* Pelzeln 1863]. Larger species are also less likely to be predated, and thus more successful in crossing non-suitable areas (Bélisle & Desrochers, 2002). However, even within such assemblages we find some exceptions, such as the large terrestrial species of the genus *Psophia* Linnaeus, 1758, which have a low dispersal capacity, are typical of primary forests, and have distributions delimited by the main Amazonian rivers, including the Tapajós River (Ribas et al., 2012).

These results indicate that, in addition to body size and foraging stratum (Burney & Brumfield, 2009; Wollenberg et al., 2011; Smith et al. 2014), feeding habits may also influence dispersal capacity and should be considered in further biogeographical studies. In addition, the assemblages detected here as especially affected by the riverine barriers (small to medium body-sized, frugivore, insectivore and nectarivore birds that forage in the understory and midstory forest stratum) may have lower dispersal capacities, and therefore may be subject to a higher rate of speciation (Claramunt et al., 2012).

The important contribution of riverine barriers in delimiting distribution patterns of Amazonian birds, even considering the large environmental heterogeneity in the region demonstrated here, may not hold for other biological groups, like plants, that are less dispersal limited and have their distribution patterns strongly determined by environmental conditions (Tuomisto et al., 2016; Nazareno et al., 2019). On the other hand, the taxonomy of birds tends to be better resolved than for other organisms and therefore better knowledge of species delimitation, including genetic data, may still reveal a stronger effect of rivers than previously thought.

Despite the relatively good knowledge of Amazonian bird biology, the combined effect of geographical barriers, environmental heterogeneity and species traits in compositional variation of assemblages is rarely investigated. Our data, obtained from a standardized long-term sampling, and carefully revised database, allowed us to infer that the Tapajós River is indeed the main barrier determining species distributions and assemblage composition in this region and environmental filtering also plays a role in the spatial variation of these assemblages. Moreover, the ecology of the species is a good predictor of the magnitude of the barrier effect of the river. Understanding these relationships is important not only to explain the currently observed biogeographical patterns, but also to predict and mitigate future changes in assemblages resulting from anthropogenic impacts.

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TABLES

Table 1. Results of Mantel and partial Mantel tests quantifying the matrix correlation between bird species compositional differences (Bray-Curtis index) and various landscape properties. Sampling was done either using point counts or mist nets and compositional dissimilarities were based on either presence-absence data (pa) or abundance data (ab). In the partial Mantel tests, the effect of logarithmically transformed geographical distances was partialled out.

		Point counts				Mist nets			
Factors	**Variable**	**Mantel**		**Mantel partial**		**Mantel**		**Mantel partial**	
		pa	**ab**	**pa**	**ab**	**pa**	**ab**	**pa**	**ab**
Geographic	**Interfluve**	0.52 **	0.45 **	0.5 **	0.5 **	0.53 **	0.52 **	0.53 **	0.53 **
Environmental	**Total**	0.05	0.3	-	-	0.29	0.23	-	-
Log (environmental)	**Total**	0.1	0.37 *	-	-	0.3 *	0.2	-	-
Canopy reflectance	**band 2 median**	0.06	0.03	-0.04	-0.04	0.24	0.12	0.08	0.08
	band 3 median	0.24	0.33	0.31	0.31	0.45 **	0.32 *	0.3 *	0.3 *
	band 4 median	-0.15	-0.13	-0.26	-0.26	-0.02	-0.01	-0.07	-0.07
	band 5 median	0.12	-0.01	0	0	0.01	0.06	0.06	0.06
	band 7 median	0.16	0.09	0.07	0.07	0.11	0.22	0.21	0.21
	band 2 SD	0.1	0.33	0.16	0.16	0.29	0.11	-0.01	-0.01
	band 3 SD	0.27 *	0.44	0.36	0.36	0.4	0.25	0.2	0.2
	band 4 SD	-0.13	-0.23	-0.35	-0.35	-0.12	-0.07	-0.12	-0.12
	band 5 SD	-0.12	-0.04	-0.26	-0.26	0.02	0.01	-0.1	-0.1
	band 7SD	0.24	0.49 **	0.39 *	0.39 *	0.38 *	0.23	0.16	0.16
Elevation	**SRTM**	0	0.01	-0.07	-0.07	0.02	0.11	0.07	0.07
Soil	**Modelled base cation conc.**	0.18	0.37 *	0.3	0.3	0.14	0.09	0.03	0.03

Significance codes (*P*): (*) < 0.05; (**) < 0.01; (***) < 0.001.

Table 2. Significance of differences in species composition of bird assemblages (ANOVA) across the Tapajós and Jamanxim rivers. Separate analyses were carried out for two different taxonomic resolutions and different bird guilds, for different dissimilarity indices and sampling methods, with presence-absence (pa) and abundance (ab) data.

Groups	Subgroups	Point counts + Mist nets		Point counts		Mist nets	
		Jaccard (pa)		Bray-Curtis (ab)		Bray-Curtis (ab)	
		$F_{2,8}$	P	$F_{2,8}$	P	$F_{2,8}$	P
Taxonomy	**Species**	27.66	< 0.001 ***	20.44	< 0.001 ***	157.7	< 0.001 ***
	Subspecies/ lineages	>99	< 0.001 ***	>99	< 0.001 ***	>99	< 0.001 ***
Feeding habit	**Frugivores**	12.93	0.003 **	30.85	< 0.001 ***	48.3	< 0.001 ***
	Insectivores	37.3	< 0.001 ***	11.86	0.004 **	14.37	0.002 **
	Nectarivores	20.71	< 0.001 ***	24.21	< 0.001 ***	29.25	< 0.001 ***
	Omnivores	37.3	< 0.001 ***	17.69	0.001 **	0.459	0.647
	Raptors	0.32	0.735	0.319	0.735	-	-
	Granivores	1.112	0.375	0.61	0.567	-	-
Foraging stratum	**Terrestrial**	1.236	0.341	7.51	0.014 *	1.074	0.386
	Understory	0.29	< 0.001 ***	187	< 0.001 ***	37.18	< 0.001 ***
	Midstory	4.655	0.046 *	39.04	< 0.001 ***	6.196	0.024 *
	Canopy	4.324	0.053	10.42	0.006 **	-	-
Body size	**Small**	51.82	< 0.001 ***	32.01	< 0.001 ***	35.05	< 0.001 ***
	Medium	108.7	< 0.001 ***	57.03	< 0.001 ***	23.37	< 0.001 ***
	Large	0.172	0.845	3.02	0.099	-	-

Significance codes (P): (*) < 0.05; (**) < 0.01; (***) < 0.001.

Table 3. Results of Tukey HSD (*P*) test between riverbanks, only for the significative variation in bird species composition (see Table 2). Riverbanks: (LT) left of Tapajós, (RT-LJ) right of Tapajós and left of Jamanxim and (RT-RJ) right of Tapajós and Jamanxim.

Groups	Subgroups	Point counts + Mist nets			Point counts			Mist nets		
		Jaccard			Bray-Curtis			Bray-Curtis		
		LT	RT-LJ	RT-RJ	LT	RT-LJ	RT-RJ	LT	RT-LJ	RT-RJ
Taxonomy	Species	< 0.001 ***	< 0.001 ***	0.782	0.001 **	0.002 **	0.951	< 0.001 ***	< 0.001 ***	0.788
	Subspecies/ lineages	< 0.001 ***	< 0.001 ***	0.585	< 0.001 ***	< 0.001 ***	0.622	< 0.001 ***	< 0.001 ***	0.973
Feeding habit	Frugivores	0.079	0.002 **	0.061	0.002 **	< 0.001 ***	0.044*	< 0.001 ***	< 0.001 ***	0.021*
	Insectivores	< 0.001 ***	< 0.001 ***	0.886	0.006**	0.01*	0.997	0.003**	0.007**	0.976
	Nectarivores	0.001 **	0.005**	0.456	0.003**	< 0.001 ***	0.131	< 0.001 ***	0.001 **	0.762
	Omnivores	0.035*	0.172	0.679	0.002**	0.003**	0.999	-	-	-
Foraging stratum	Terrestrial	-	-	-	0.034*	0.02*	0.819	-	-	-
	Understory	< 0.001 ***	< 0.001 ***	0.980	< 0.001 ***	< 0.001 ***	0.685	< 0.001 ***	< 0.001 ***	0.736
	Midstory	0.084	0.063	0.922	< 0.001 ***	<0.001 **	0.590	0.140	0.02*	0.352
	Canopy	0.088	0.078	0.963	0.027*	0.006 **	0.439	-	-	-
Body size	Small	< 0.001 ***	< 0.001 ***	0.562	< 0.001 ***	< 0.001 ***	0.576	< 0.001 ***	0.001 **	0.648
	Medium	< 0.001 ***	< 0.001 ***	0.833	< 0.001 ***	< 0.001 ***	0.991	0.001 **	0.001 **	0.714

Significance codes (*P*): (*) < 0.05; (**) < 0.01; (***) < 0.001.

FIGURE LEGENDS

FIGURE 1 Location of study area in relation to northern South America, highlighting the middle course of the Tapajós River, at the confluence with the Jamanxim River and location of the sampling sites, upon a background of composite Landsat images.

FIGURE 2 Multivariate ordination (PCA) of variation in sampling sites environmental variables, given by combined dataset of canopy reflectance, soil types and elevation. Note that interfluve clusters overlapped in the multivariate space, showing the existence of an environmental heterogeneity not related to riverbanks.

FIGURE 3 Multivariate ordinations (NMDS) of variation in bird assemblages composition according to different taxonomic resolutions, sampling methods (PC: point counts, MN: mist nets) and qualitative/quantitative data.

FIGURE 4 Multivariate ordinations (NMDS) of variation in bird assemblages composition according to different feeding habits, sampling methods (PC: point counts, MN: mist nets) and qualitative/quantitative data.

FIGURE 5 Multivariate ordinations (NMDS) of variation in bird assemblages composition according to different foraging stratum, sampling methods (PC: point counts, MN: mist nets) and qualitative/quantitative data.

FIGURE 6 Multivariate ordinations (NMDS) of variation in bird assemblages composition according to different body sizes, sampling methods (PC: point counts, MN: mist nets) and qualitative/quantitative data.

FIGURES

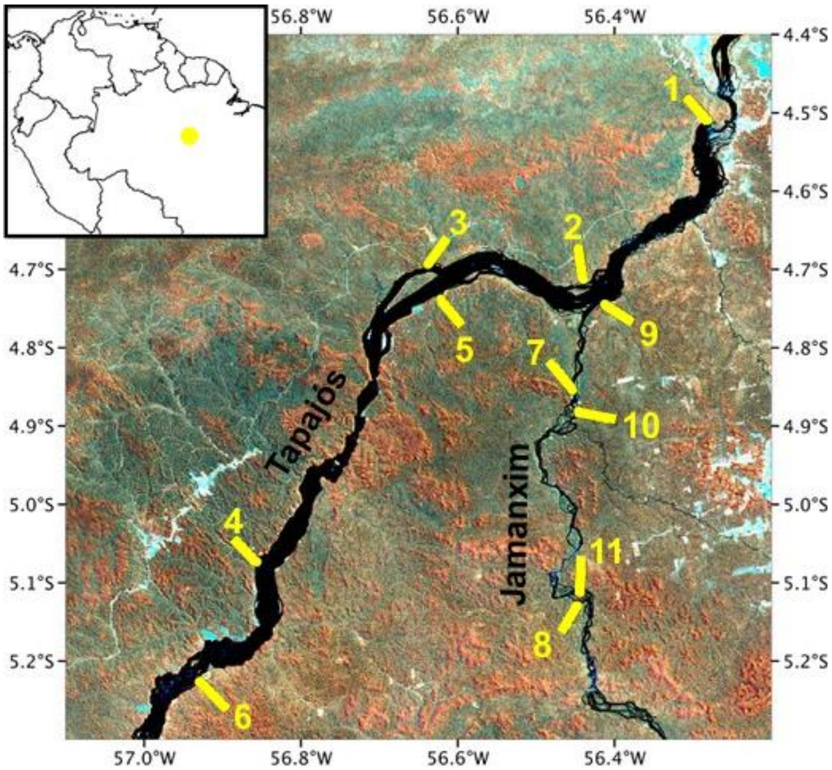


Figure 1

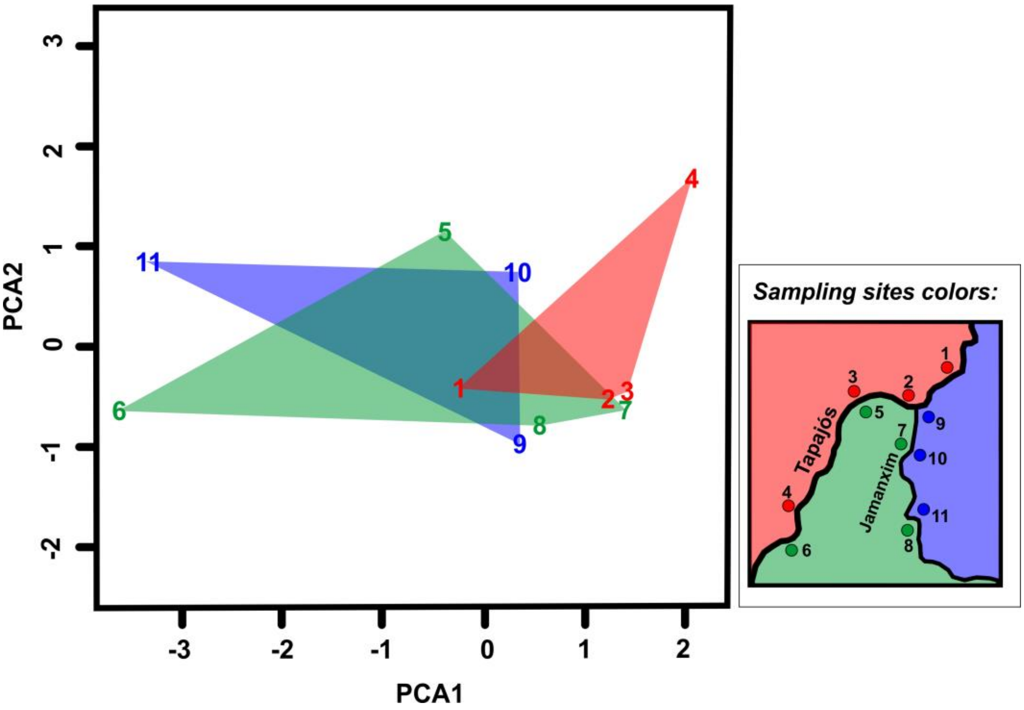
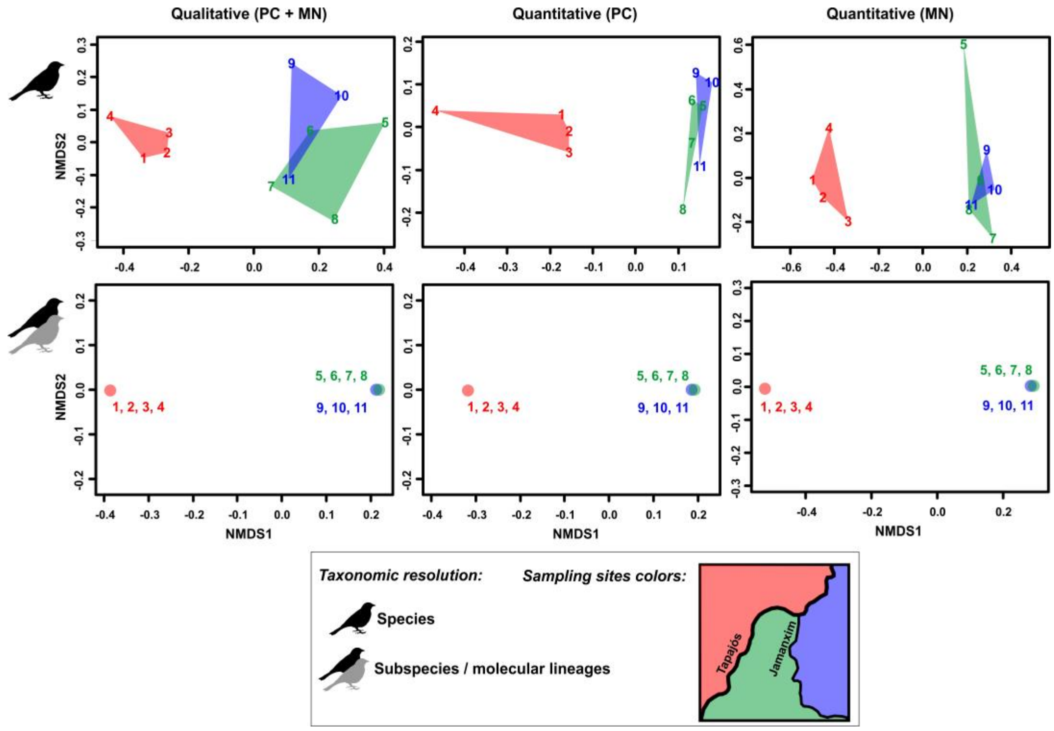
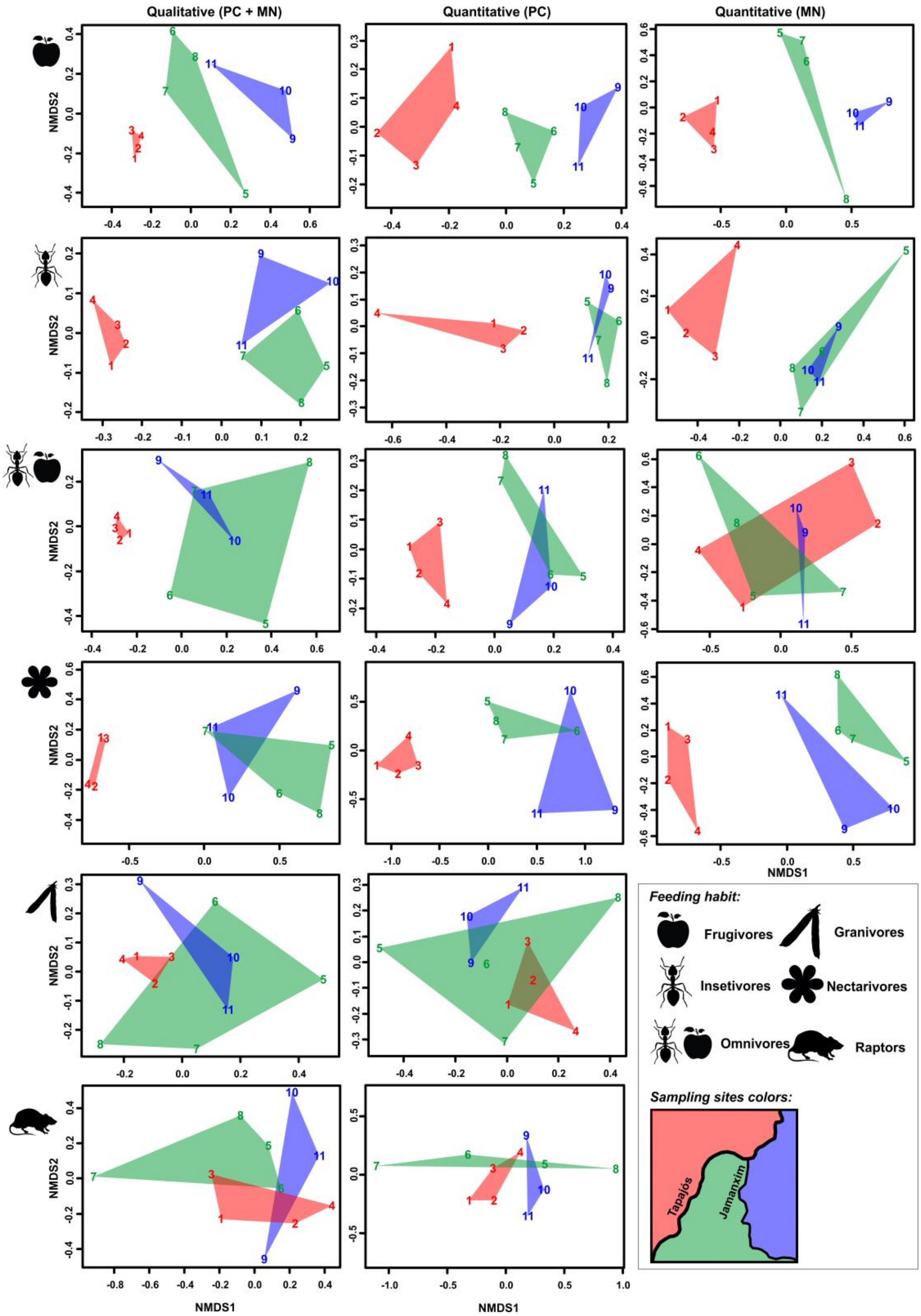

PCA2
PCA1
3
2
1
0
-1
-2
-3
-2
-1
0
1
2
11
10
5
4
1
2
3
6
8
7
9
Sampling sites colors:
Tapajós
Jamanxim
1
2
3
4
5
6
7
8
9
10
11

Figure 2



Qualitative (PC + MN)
Quantitative (PC)
Quantitative (MN)
NMDS2
NMDS1
1, 2, 3, 4
5, 6, 7, 8
9, 10, 11
Taxonomic resolution:
Species
Subspecies / molecular lineages
Sampling sites colors:
Tapajós
Jamanxim

Figure 3



Qualitative (PC + MN)
Quantitative (PC)
Quantitative (MN)
NMDS2
NMDS1
Feeding habit:
Frugivores
Granivores
Insetivores
Nectarivores
Omnivores
Raptors
Sampling sites colors:
Tapajós
Jamanxim

Figure 4

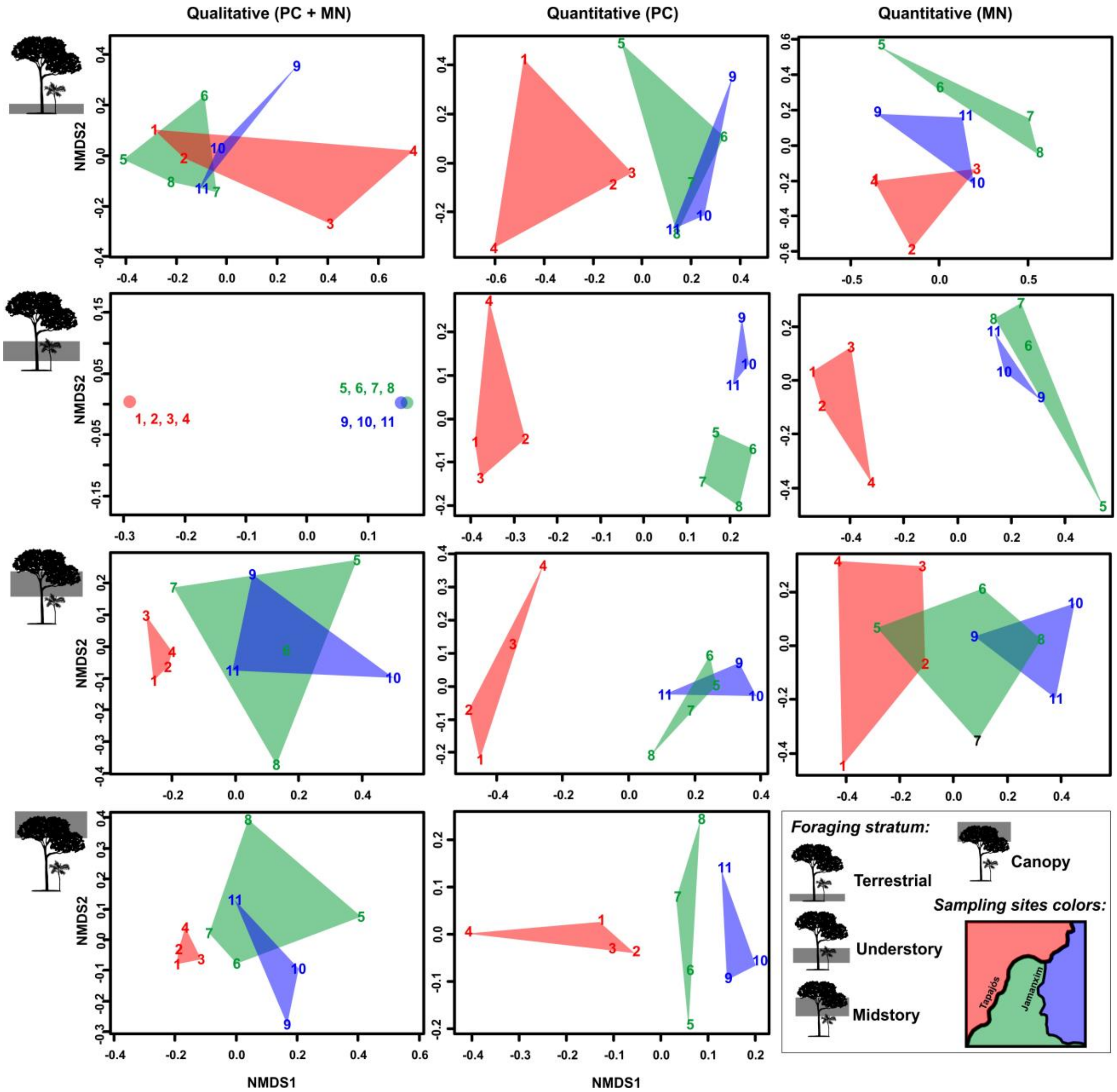
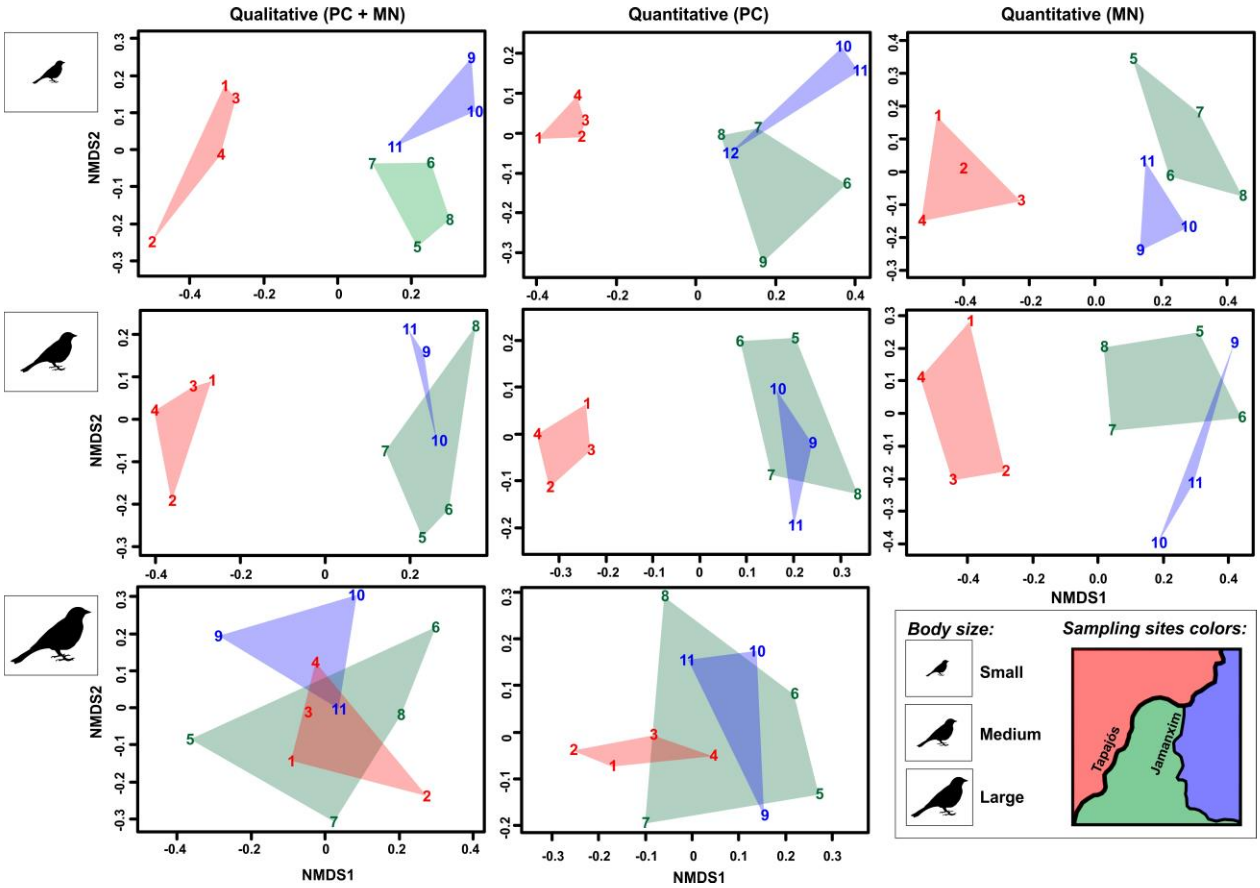

Qualitative (PC + MN)
Quantitative (PC)
Quantitative (MN)
NMDS2
NMDS1
1, 2, 3, 4
5, 6, 7, 8
9, 10, 11
Foraging stratum:
Terrestrial
Understory
Midstory
Canopy
Sampling sites colors:
Tapajós
Jamanxim

Figure 5



Qualitative (PC + MN)
Quantitative (PC)
Quantitative (MN)
NMDS2
NMDS1
Body size:
Small
Medium
Large
Sampling sites colors:
Tapajós
Jamanxim

Figure 6

SUPPORTING INFORMATION

Table S1. Recorded bird taxa in the study area, including their guilds based on feeding habit and foraging stratum, body size, sampling sites, river banks, and highlighting threatened species. Feeding habits: (F) frugivores, (G) granivores, (I) insectivores, (N) nectarivores, (R) raptors and (O) omnivores. Foraging stratum: (T) terrestrial, (U) understory, (M) midstory and (C) canopy. Body size: (S) small, (M) medium and (L) large. Riverbanks: (LT) left of Tapajós, (RT-LJ) right of Tapajós and left of Jamanxim and (RT-RJ) right of Tapajós and Jamanxim. Threat categories: (VU) vulnerable and (EN) endangered.

Taxa	**Feeding habit[1]**	**Foraging stratum[2]**	**Body size[3]**	**LT**				**RT-LJ**				**RT-RJ**			**Threatened species[4]**
				1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	
Tinamiformes Huxley, 1872															
Tinamidae Gray, 1840															
Tinamus tao Temminck, 1815	G	T	L		x	x	x		x		x		x	x	VU
Tinamus major (Gmelin, 1789)	G	T	L	x	x	x	x	x			x	x	x	x	-
Tinamus guttatus Pelzeln, 1863	G	T	L	x	x	x	x	x	x	x	x	x		x	NT
Crypturellus cinereus (Gmelin, 1789)	G	T	L	x	x	x	x		x	x	x		x	x	-
Crypturellus soui (Hermann, 1783)	G	T	L		x		x		x			x			-
Crypturellus undulatus (Temminck, 1815)	G	T	L		x	x									-
Crypturellus strigulosus (Temminck, 1815)	G	T	L	x	x	x	x	x	x	x	x	x	x	x	-
Crypturellus variegatus (Gmelin, 1789)	G	T	L	x	x	x	x	x	x	x	x	x	x	x	-
Galliformes Linnaeus, 1758															
Cracidae Rafinesque, 1815															
Aburria cujubi (Pelzeln, 1858)	F	C	L									x		x	-
Ortalis guttata (Spix, 1825)	F	U/C	L						x						-
Pauxi tuberosa (Spix, 1825)	G	T	L	x	x			x	x		x			x	-
Penelope jacquacu Spix, 1825	F	T/C	L		x			x						x	-

Taxa	Feeding habit[1]	Foraging stratum[2]	Body size[3]	LT				RT-LJ				RT-RJ			Threatened species[4]
				1	2	3	4	5	6	7	8	9	10	11	
Penelope pileata Wagler, 1830	F	C	L	x	x	x	x		x	x	x	x	x	x	VU
Odontophoridae Gould, 1844															
Odontophorus gujanensis (Gmelin, 1789)	G	T	L	x	x		x		x			x	x	x	NT
Accipitriformes Bonaparte, 1831															
Accipitridae Vigors, 1824															
Busarellus nigricollis (Latham, 1790)	R	T/C	L			x									-
Elanoides forficatus (Linnaeus, 1758)	I	C/A	L	x		x		x							-
Harpagus bidentatus (Latham, 1790)	R	C	L			x			x						-
Leucopternis kuhli Bonaparte, 1850	R	M/C	L	x		x	x		x						-
Leucopternis melanops (Latham, 1790)	R	M/C	L	x	x		x								-
Morphnus guianensis (Daudin, 1800)	R	C	L		x										NT
Pseudastur albicollis (Latham, 1790)	R	C	L	x											-
Rupornis magnirostris (Gmelin, 1788)	R	C	L	x											-
Spizaetus ornatus (Daudin, 1800)	R	C	L			x	x	x		x	x		x	x	-
Spizaetus tyrannus (Wied, 1820)	R	C	L	x										x	-
Urubitinga urubitinga (Gmelin, 1788)	R	T/C	L						x					x	-
Gruiformes Bonaparte, 1854															
Psophiidae Bonaparte, 1831															
Psophia dextralis Conover, 1934	F	T	L							x	x		x	x	EN
Psophia viridis Spix, 1825	F	T	L				x								VU
Columbiformes Latham, 1790															

Taxa	Feeding habit[1]	Foraging stratum[2]	Body size[3]	LT				RT-LJ				RT-RJ			Threatened species[4]
				1	2	3	4	5	6	7	8	9	10	11	
Columbidae Leach, 1820															
Claravis pretiosa (Ferrari-Perez, 1886)	F	T/M	M	x											-
Columbina passerina (Linnaeus, 1758)	G	T	M				x								-
Geotrygon montana (Linnaeus, 1758)	F	T	L	x	x	x	x	x	x	x	x	x	x	x	-
Leptotila rufaxilla (Richard & Bernard, 1792)	G	T	L	x	x	x	x	x	x	x	x	x	x	x	-
Patagioenas cayennensis (Bonnaterre, 1792)	F	C	L	x					x	x					-
Patagioenas plumbea (Vieillot, 1818)	F	C	L	x	x	x	x	x	x	x	x	x	x	x	-
Patagioenas speciosa (Gmelin, 1789)	F	C	L			x	x					x			-
Patagioenas subvinacea (Lawrence, 1868)	F	C	L	x	x	x	x	x	x	x	x	x	x	x	VU
Opisthocomiformes Sclater, 1880															
Opisthocomidae Swainson, 1837															
Opisthocomus hoazin (Statius Muller, 1776)	Fo	U/C	L	x											-
Cuculiformes Wagler, 1830															
Cuculidae Leach, 1820															
Crotophaga major Gmelin, 1788	I	T/C	L			x	x			x					-
Dromococcyx phasianellus (Spix, 1824)	I	T	M				x								-
Neomorphus geoffroyi (Temminck, 1820)	I	T	L		x										VU
Piaya cayana (Linnaeus, 1766)	I	C	L	x	x	x	x	x	x	x		x	x	x	-
Piaya melanogaster (Vieillot, 1817)	I	C	L	x	x	x	x		x			x	x	x	-
Strigiformes Wagler, 1830															
Strigidae Leach, 1820															

Taxa	Feeding habit[1]	Foraging stratum[2]	Body size[3]	LT				RT-LJ				RT-RJ			Threatened species[4]
				1	2	3	4	5	6	7	8	9	10	11	
Glaucidium brasilianum (Gmelin, 1788)	R	C	M					x							-
Glaucidium hardyi Vielliard, 1990	R	M/C	M	x	x	x	x	x		x		x		x	-
*Megascops usta (*Sclater, 1858)	R	U	L	x	x		x	x	x			x		x	
Pulsatrix perspicillata (Latham, 1790)	R	C	L				x			x					
Strix huhula Daudin, 1800	R	C	L											x	
Strix virgata (Cassin, 1849)	R	C	L										x	x	
Apodiformes Peters, 1940															
Trochilidae Vigors, 1825															
Amazilia fimbriata (Gmelin, 1788)	N	U/C	S	x									x		-
Campylopterus largipennis (Boddaert, 1783)	N	U/M	S	x	x	x	x		x				x	x	-
Florisuga mellivora (Linnaeus, 1758)	N	M/C	S		x		x					x	x	x	-
Glaucis hirsutus (Gmelin, 1788)	N	U	S	x		x		x	x			x		x	-
Heliodoxa aurescens (Gould, 1846)	N	#N/D	S			x					x				-
Heliothryx auritus (Gmelin, 1788)	N	M/C	S			x			x				x	x	-
Phaethornis aethopygus Zimmer, 1950	N	U	S					x	x	x	x	x	x	x	NT
Phaethornis bourcieri major Hinkelmann, 1989	N	U/M	S					x	x	x	x	x	x	x	-
Phaethornis philippii (Bourcier, 1847)	N	U	S	x	x	x	x								-
Phaethornis ruber (Linnaeus, 1758)	N	U	S	x	x	x	x	x	x	x	x		x	x	-
Phaethornis rupurumii Boucard, 1892	N	U	S											x	-
Phaethornis superciliosus insignis Todd, 1937	N	U	S	x	x	x	x								-
Phaethornis superciliosus muelleri Hellmayr, 1911	N	U	S						x	x		x	x	x	-

Taxa	Feeding habit[1]	Foraging stratum[2]	Body size[3]	LT				RT-LJ				RT-RJ			Threatened species[4]
				1	2	3	4	5	6	7	8	9	10	11	
Thalurania furcata balzani Simon, 1896	N	U/M	S	x	x	x	x								-
Thalurania furcata furcatoides Gould, 1861	N	U/M	S					x	x	x	x	x	x	x	-
Threnetes leucurus (Linnaeus, 1766)	N	U	S	x	x										-
Topaza pella (Linnaeus, 1758)	N	U/M	S				x							x	-
Trogoniformes A. O. U., 1886															
Trogonidae Lesson, 1828															
Trogon collaris Vieillot, 1817	O	M/C	M	x	x	x	x		x			x			-
Trogon curucui Linnaeus, 1766	O	C	M				x								-
Trogon melanurus Swainson, 1838	O	C	L	x	x	x	x	x	x	x	x	x	x	x	-
Trogon ramonianus Deville & DesMurs, 1849	O	C	M	x	x	x	x	x	x	x	x	x	x	x	-
Trogon rufus Gmelin, 1788	O	U/M	M	x	x	x	x	x	x	x	x	x	x	x	-
Trogon viridis Linnaeus, 1766	O	C	M	x	x	x	x	x	x	x	x	x	x	x	-
Coraciiformes Forbes, 1844															
Momotidae Gray, 1840															
Baryphthengus martii (Spix, 1824)	I	U/M	L		x	x		x	x	x	x	x	x	x	-
Electron platyrhynchum (Leadbeater, 1829)	I	M	M					x	x	x	x				-
Momotus momota (Linnaeus, 1766)	I	U/M	L	x				x	x	x	x			x	-
Galbuliformes Fürbringer, 1888															
Galbulidae Vigors, 1825															
Brachygalba lugubris (Swainson, 1838)	I	C	S				x								-
Galbula cyanicollis Cassin, 1851 West[5]	I	M	S	x	x	x	x								-

Taxa	Feeding habit[1]	Foraging stratum[2]	Body size[3]	LT				RT-LJ				RT-RJ			Threatened species[4]
				1	2	3	4	5	6	7	8	9	10	11	
Galbula cyanicollis Cassin, 1851 East[5]	I	M	S					x	x	x		x		x	-
Galbula dea brunneiceps (Todd, 1943)	I	C	S	x	x	x	x								-
Galbula dea amazonum (Sclater, 1855)	I	C	S					x	x	x	x	x	x	x	-
Galbula galbula (Linnaeus, 1766)	I	M	S	x											-
Galbula leucogastra Vieillot, 1817	I	C	S			x	x								-
Galbula ruficauda Cuvier, 1816	I	M	S	x										x	-
Jacamerops aureus (Statius Muller, 1776)	I	M/C	M	x	x	x	x	x	x	x	x	x	x	x	-
Bucconidae Horsfield, 1821															
Bucco capensis (Linnaeus, 1766)	I	C	M	x		x		x	x	x		x	x	x	-
Bucco tamatia (Gmelin, 1788)	I	C	M	x		x									-
Chelidoptera tenebrosa (Pallas, 1782)	I	C	M	x	x				x						-
Malacoptila rufa (Spix, 1824)	I	U	M	x	x	x	x	x	x	x	x	x	x	x	-
Monasa morphoeus peruana Sclater, 1856	I	M/C	M	x	x	x	x	x	x	x	x	x	x	x	-
Monasa morphoeus rikeri Ridgway, 1912	I	M/C	M					x	x	x	x	x	x	x	-
Monasa nigrifrons (Spix, 1824) West[6]	I	M/C	M	x	x	x	x	x	x	x	x	x	x		-
Monasa nigrifrons (Spix, 1824) East[6]	I	M/C	M					x	x	x	x	x	x		-
Nonnula rubecula (Spix, 1824)	I	U/M	S	x	x	x	x		x					x	-
Nonnula ruficapilla (Tschudi, 1844)	I	U/M	S	x								x			-
Notharchus hyperrhynchus hyperrhynchus (Sclater, 1856)	I	C	M	x	x	x	x	x		x	x	x	x	x	-
Notharchus hyperrhynchus paraensis Sassi, 1932	I	C	M					x		x	x	x	x	x	-
Notharchus ordii (Cassin, 1851)	I	C	M		x		x			x			x		-

Taxa	Feeding habit[1]	Foraging stratum[2]	Body size[3]	LT				RT-LJ				RT-RJ			Threatened species[4]
				1	2	3	4	5	6	7	8	9	10	11	
Notharchus tectus (Boddaert, 1783)	I	C	S	x	x		x		x	x		x		x	-
Nystalus torridus (Bond & Meyer de Schauensee, 1940)	I	C	M								x				-
Piciformes Meyer & Wolf, 1810															
Capitonidae Bonaparte, 1838															
Capito brunneipectus Chapman, 1921	O	C	M	x	x	x	x								-
Capito dayi Cherrie, 1916	O	C	M						x					x	VU
Ramphastidae Vigors, 1825															
Pteroglossus aracari (Linnaeus, 1758)	F	C	L	x	x	x	x	x	x		x	x	x	x	-
Pteroglossus beauharnaisii Wagler, 1831	F	C	L						x						-
Pteroglossus bitorquatus sturmii Natterer, 1843	F	C	L	x	x	x	x								NT
Pteroglossus bitorquatus reichenowi Snethlage, 1907	F	C	L						x	x	x			x	EN
Pteroglossus inscriptus Swainson, 1822	F	C	L	x	x	x							x		-
Ramphastos tucanus Linnaeus, 1758	F	C	L	x	x	x	x	x	x	x	x	x	x	x	-
Ramphastos vitellinus Lichtenstein, 1823	F	C	L	x	x	x	x	x	x	x	x	x	x	x	EN
Selenidera gouldii (Natterer, 1837)	F	C	L	x	x	x	x		x	x	x		x	x	-
Picidae Leach, 1820															
Campephilus melanoleucos (Gmelin, 1788)	I	C	L	x	x	x					x				-
Campephilus rubricollis (Boddaert, 1783)	I	M	L	x	x	x	x	x	x	x	x	x	x	x	-
Celeus elegans (Statius Muller, 1776)	I	M/C	L	x	x	x	x	x	x		x			x	-
Celeus flavus (Statius Muller, 1776)	I	C	L	x	x		x		x	x		x			-
Celeus grammicus (Natterer & Malherbe, 1845)	I	C	M	x	x	x	x		x	x	x	x	x	x	-

Taxa	Feeding habit[1]	Foraging stratum[2]	Body size[3]	LT				RT-LJ				RT-RJ			Threatened species[4]
				1	2	3	4	5	6	7	8	9	10	11	
Celeus torquatus (Boddaert, 1783)	I	C	L	x	x	x	x	x	x			x		x	NT
Dryocopus lineatus (Linnaeus, 1766)	I	C	L		x		x		x			x			-
Melanerpes cruentatus (Boddaert, 1783)	O	C	M	x	x	x	x		x	x	x	x		x	-
Piculus flavigula (Boddaert, 1783)	I	C	M	x	x	x	x	x	x	x	x	x	x	x	-
Piculus laemostictus Todd, 1937	I	C	M	x	x	x	x	x	x		x		x	x	-
Picumnus aurifrons borbae Pelzeln, 1870	I	M/C	S	x	x	x	x								-
Picumnus aurifrons transfasciatus Hellmayr & Gyldenstolpe, 1937	I	M/C	S								x				-
Veniliornis affinis (Swainson, 1821)	I	C	M	x	x	x	x	x	x	x	x	x	x		-
Veniliornis passerinus (Linnaeus, 1766)	I	C	M											x	-
Falconiformes Bonaparte, 1831															
Falconidae Leach, 1820															
Daptrius ater Vieillot, 1816	R	T/C	L		x	x		x			x	x	x	x	-
Falco rufigularis Daudin, 1800	R	C/A	L			x	x	x			x				-
Herpetotheres cachinnans (Linnaeus, 1758)	R	C	L								x	x			-
Ibycter americanus (Boddaert, 1783)	R	C	L	x	x	x	x	x	x	x	x	x	x	x	-
Micrastur mintoni Whittaker, 2003	R	M/C	L	x	x	x	x	x		x	x	x	x	x	-
Micrastur mirandollei (Schlegel, 1862)	R	M/C	L	x	x		x				x	x	x	x	-
Micrastur ruficollis (Vieillot, 1817)	R	U/M	L	x	x	x	x	x	x	x	x		x	x	-
Micrastur semitorquatus (Vieillot, 1817)	R	M/C	L	x	x		x			x	x			x	-
Psittaciformes Wagler, 1830															
Psittacidae Rafinesque, 1815															

Taxa	Feeding habit[1]	Foraging stratum[2]	Body size[3]	LT				RT-LJ				RT-RJ			Threatened species[4]
				1	2	3	4	5	6	7	8	9	10	11	
Amazona amazonica (Linnaeus, 1766)	G	C	L	x	x	x	x			x	x	x			-
Amazona farinosa (Boddaert, 1783)	G	C	L	x	x	x	x	x	x	x	x	x	x	x	NT
Amazona kawalli Grantsau & Camargo, 1989	G	C	L					x	x	x		x	x		NT
Amazona ochrocephala (Gmelin, 1788)	G	C	L	x	x	x		x	x	x		x	x	x	-
Ara ararauna (Linnaeus, 1758)	G	C	L	x	x	x	x		x	x	x			x	-
Ara chloropterus Gray, 1859	G	C	L	x	x	x	x	x	x	x	x	x	x	x	-
Ara macao (Linnaeus, 1758)	G	C	L	x	x	x	x	x	x	x	x	x	x	x	-
Ara severus (Linnaeus, 1758)	G	C	L							x				x	-
Brotogeris chrysoptera (Linnaeus, 1766)	G	C	M	x	x	x	x	x	x	x	x	x	x	x	-
Deroptyus accipitrinus (Linnaeus, 1758)	G	C	L		x	x	x			x	x	x	x	x	-
Diopsittaca nobilis (Linnaeus, 1758)	G	T/C	L									x			-
Guaruba guarouba (Gmelin, 1788)	G	C	L	x	x		x	x	x		x	x	x	x	VU
Orthopsittaca manilatus (Boddaert, 1783)	G	C	L	x	x	x	x		x			x	x		-
Pionites leucogaster (Kuhl, 1820)	G	C	L		x	x		x	x	x	x		x	x	EN
Pionus fuscus (Statius Muller, 1776)	G	C	L	x	x	x	x			x		x	x	x	-
Pionus menstruus (Linnaeus, 1766)	G	C	L	x	x	x	x	x	x	x	x	x	x	x	-
Psittacara leucophthalmus (Statius Muller, 1776)	G	C	L	x	x	x	x		x	x	x	x	x		-
Pyrilia aurantiocephala (Gaban-Lima, Raposo & Höfling, 2002)	G	C	L					x		x			x	x	NT
Pyrilia barrabandi (Kuhl, 1820)	G	C	L		x		x		x	x			x		NT
Pyrilia vulturina (Kuhl, 1820)	G	C	L	x	x	x	x	x		x	x	x	x	x	VU
Pyrrhura amazonum Hellmayr, 1906	G	C	M	x	x	x	x	x	x	x		x	x		EN

Taxa	Feeding habit[1]	Foraging stratum[2]	Body size[3]	LT				RT-LJ				RT-RJ			Threatened species[4]
				1	2	3	4	5	6	7	8	9	10	11	
Pyrrhura perlata (Spix, 1824)	G	C	M	x	x	x	x	x	x	x			x	x	VU
Touit huetii (Temminck, 1830)	G	C	M	x			x						x		VU
Touit purpuratus (Gmelin, 1788)	G	C	M			x		x	x	x		x	x		-
Passeriformes Linnaeus, 1758															
Thamnophilidae Swainson, 1824															
Cercomacra aff. *cinerascens*[7]	I	C	S	x	x	x	x								-
Cercomacra cinerascens iterata Zimmer, 1932	I	C	S					x	x	x	x	x	x	x	-
Cercomacroides nigrescens approximans (Pelzeln, 1868)	I	U	S	x	x	x	x								-
Cercomacroides nigrescens ochrogyna (Snethlage, 1928)	I	U	S					x	x		x	x	x	x	-
Cymbilaimus lineatus (Leach, 1814) West[8]	I	C	M	x	x	x	x								-
Cymbilaimus lineatus (Leach, 1814) East[8]	I	C	M					x	x	x	x	x	x	x	
Dichrozona cincta (Pelzeln, 1868)	I	T	S	x	x		x	x	x	x	x	x	x	x	-
Epinecrophylla leucophthalma phaeonota (Todd, 1927)	I	U	S	x	x	x	x								-
Epinecrophylla leucophthalma sordida (Todd, 1927)	I	U	S					x	x	x	x	x	x	x	-
Epinecrophylla ornata (Sclater, 1853)	I	U/M	S	x	x	x	x	x	x	x	x	x		x	-
Euchrepomis spodioptila (Sclater & Salvin, 1881)	I	C	S	x			x								-
Herpsilochmus rufimarginatus (Temminck, 1822)	I	C	S				x	x	x	x	x	x	x	x	-
Hylophylax naevius (Gmelin, 1789)	I	U	S	x		x	x	x	x	x	x	x	x	x	-
Hylophylax punctulatus (Des Murs, 1856)	I	U	S	x		x	x	x	x		x	x	x	x	-
Hypocnemis hypoxantha Sclater, 1869	I	U/M	S										x		-
Hypocnemis striata implicata Zimmer, 1932	I	U/M	S	x	x	x	x								-

Taxa	Feeding habit[1]	Foraging stratum[2]	Body size[3]	LT				RT-LJ				RT-RJ			Threatened species[4]
				1	2	3	4	5	6	7	8	9	10	11	
Hypocnemis striata striata (Spix, 1825)	I	U/M	S					x	x	x	x	x	x	x	-
Hypocnemoides maculicauda (Pelzeln, 1868)	I	U	S		x		x		x	x	x	x		x	-
Isleria hauxwelli (Sclater, 1857)	I	U	S	x	x	x	x	x	x	x	x	x	x	x	-
Microrhopias quixensis bicolor (Pelzeln, 1868)	I	M	S	x	x	x	x								-
Microrhopias quixensis emiliae Chapman, 1921	I	M	S					x	x		x	x		x	-
Myrmelastes rufifacies (Hellmayr, 1929)	I	T/U	S	x		x		x	x		x			x	-
Myrmoborus leucophrys (Tschudi, 1844)	I	U	S						x	x	x	x		x	-
Myrmoborus myotherinus (Spix, 1825)	I	U	S	x	x	x	x	x	x	x	x	x	x	x	-
Myrmoderus ferrugineus (Statius Muller, 1776)	I	T	S	x	x	x									-
Myrmornis torquata (Boddaert, 1783)	I	T	M		x			x	x	x	x		x	x	-
Myrmotherula axillaris (Vieillot, 1817)	I	U/M	S	x	x	x	x	x	x	x	x	x	x	x	-
Myrmotherula brachyura (Hermann, 1783)	I	C	S	x	x	x	x	x	x	x	x	x	x	x	-
Myrmotherula iheringi Snethlage, 1914	I	M	S	x	x	x									-
Myrmotherula longipennis ochrogyna Todd, 1927	I	U/M	S	x	x	x	x								-
Myrmotherula longipennis paraensis (Todd, 1920)	I	U/M	S					x	x	x	x	x	x	x	-
Myrmotherula menetriesii berlepschi Hellmayr, 1903	I	M/C	S		x	x	x								-
Myrmotherula menetriesii omissa Todd, 1927	I	M/C	S					x	x	x	x	x	x	x	-
Myrmotherula multostriata Sclater, 1858	I	U/M	S			x	x		x		x			x	-
Myrmotherula sclateri Snethlage, 1912	I	C	S	x	x	x	x	x	x	x	x	x	x		-
Neoctantes niger (Pelzeln, 1859)	I	U	M		x										-
Phlegopsis borbae Hellmayr, 1907	I	M	M				x							x	-

Taxa	Feeding habit[1]	Foraging stratum[2]	Body size[3]	LT				RT-LJ				RT-RJ			Threatened species[4]
				1	2	3	4	5	6	7	8	9	10	11	
Phlegopsis nigromaculata (d'Orbigny & Lafresnaye, 1837)	I	U	M	x	x	x	x	x	x	x	x	x	x	x	-
Pygiptila stellaris (Spix, 1825)	I	C	S	x	x	x	x	x	x	x	x		x	x	-
Pyriglena leuconota (Spix, 1824)	I	U	M						x						-
Rhegmatorhina berlepschi (Snethlage, 1907)	I	U	M	x	x	x	x							x	-
Rhegmatorhina gymnops Ridgway, 1888	I	U	S					x	x	x	x	x	x	x	VU
Sakesphorus luctuosus (Lichtenstein, 1823)	I	U/M	M	x	x	x			x	x	x			x	-
Sciaphylax pallens (Berlepsch & Hellmayr, 1905)	I	T/U	S						x		x	x		x	-
Sclateria naevia (Gmelin, 1788)	I	T	S			x	x		x			x			-
Taraba major (Vieillot, 1816)	I	U	M				x					x		x	-
Thamnomanes caesius persimilis Hellmayr, 1907	I	U/M	S	x	x	x	x								-
Thamnomanes caesius hoffmannsi Hellmayr, 1906	I	U/M	S					x	x	x	x	x	x		-
Thamnomanes saturninus (Pelzeln, 1868)	I	U	S	x	x	x	x							x	-
Thamnophilus aethiops punctuliger Pelzeln, 1868	I	U	S	x	x	x									-
Thamnophilus aethiops atriceps Todd, 1927	I	U	S						x			x			-
Thamnophilus amazonicus amazonicus Sclater, 1858	I	U/M	S			x									-
Thamnophilus amazonicus obscurus Zimmer, 1933	I	U/M	S				x			x		x			-
Thamnophilus doliatus (Linnaeus, 1764)	I	U/M	S	x											-
Thamnophilus palliatus (Lichtenstein, 1823)	I	U/M	S				x							x	-
Thamnophilus schistaceus d'Orbigny, 1835	I	M	S	x	x	x	x	x	x	x	x	x	x		-
Thamnophilus stictocephalus Pelzeln, 1868	I	U/M	S	x		x								x	-
Willisornis poecilinotus (Cabanis, 1847)	I	U	S	x	x	x	x	x	x	x	x	x	x		-

Taxa	Feeding habit[1]	Foraging stratum[2]	Body size[3]	LT				RT-LJ				RT-RJ			Threatened species[4]
				1	2	3	4	5	6	7	8	9	10	11	
Conopophagidae Sclater & Salvin, 1873															
Conopophaga aurita (Gmelin, 1789)	I	U	S						x	x	x	x	x	x	-
Conopophaga melanogaster Ménétriès, 1835	I	U	M			x			x						-
Grallariidae Sclater & Salvin, 1873															
Grallaria varia (Boddaert, 1783)	I	T	L			x			x		x		x	x	-
Hylopezus berlepschi (Hellmayr, 1903)	I	T	M		x					x				x	-
Hylopezus whittakeri Carneiro, Gonzaga, Rêgo, Sampaio, Schneider & Aleixo, 2012	I	T	M	x	x	x				x	x	x	x	x	-
Myrmothera campanisona (Hermann, 1783)	I	T	M	x	x	x		x	x	x	x	x	x	x	-
Rhinocryptidae Wetmore, 1926 (1837)															
Liosceles thoracicus (Sclater, 1865)	I	T	M		x	x									-
Formicariidae Gray, 1840															
Chamaeza nobilis Gould, 1855	I	T	L						x						-
Formicarius analis analis (d'Orbigny & Lafresnaye, 1837)	I	T	M	x	x										-
Formicarius analis paraensis Novaes, 1957	I	T	M					x	x	x	x	x	x	x	-
Formicarius colma Boddaert, 1783	I	T	M	x	x	x	x	x	x	x	x	x	x	x	-
Scleruridae Swainson, 1827															
Sclerurus caudacutus (Vieillot, 1816)	I	T	M		x	x			x				x	x	-
Sclerurus macconnelli Chubb, 1919	I	T	S	x	x			x	x	x	x		x	x	-
Sclerurus rufigularis Pelzeln, 1868	I	T	S		x				x	x	x		x	x	-
Dendrocolaptidae Gray, 1840															

Taxa	Feeding habit[1]	Foraging stratum[2]	Body size[3]	LT 1	LT 2	LT 3	LT 4	RT-LJ 5	RT-LJ 6	RT-LJ 7	RT-LJ 8	RT-RJ 9	RT-RJ 10	RT-RJ 11	Threatened species[4]
Campylorhamphus cardosoi Portes, Aleixo, Zimmer, Whittaker, Weckstein, Gonzaga, Ribas, Bates & Lees, 2013	I	U/M	M					x	x				x	x	-
Campylorhamphus probatus Zimmer, 1934	I	U/M	M		x	x	x								-
Certhiasomus stictolaemus (Pelzeln, 1868)	I	M	S	x	x	x	x	x	x	x	x	x	x		-
Deconychura longicauda zimmeri Pinto, 1974 West[9]	I	M	S	x	x	x	x								-
Deconychura longicauda zimmeri Pinto, 1974 East[9]	I	M	S							x		x	x	x	-
Dendrexetastes rufigula (Lesson, 1844)	I	M	M	x	x	x	x		x			x			-
Dendrocincla fuliginosa atrirostris (d'Orbigny & Lafresnaye, 1838)	I	U/M	M	x	x	x	x								-
Dendrocincla fuliginosa rufoolivacea Ridgway, 1888	I	U/M	M					x	x	x	x	x	x	x	-
Dendrocincla merula olivascens Zimmer, 1934	I	U	M	x	x	x	x								-
Dendrocincla merula castanoptera Ridgway, 1888	I	U	M					x	x	x	x	x	x	x	-
Dendrocolaptes concolor Pelzeln, 1868	I	U/M	M	x	x	x	x								-
Dendrocolaptes hoffmannsi Hellmayr, 1909	I	U/M	M	x	x	x	x								VU
Dendrocolaptes picumnus Lichtenstein, 1820	I	M	M				x		x	x				x	-
Dendrocolaptes ridgwayi Hellmayr, 1905	I	U/M	M					x	x	x	x	x	x	x	-
Dendroplex kienerii (Des Murs, 1855)	I	M	M				x								-
Dendroplex picus (Gmelin, 1788)	I	M	M	x		x	x						x		-
Glyphorynchus spirurus inornatus Zimmer, 1934	I	U/M	S	x	x	x	x								-
Glyphorynchus spirurus paraensis Pinto, 1974	I	U/M	S					x	x	x	x	x	x	x	-
Hylexetastes uniformis Hellmayr, 1909	I	U/M	L	x	x	x	x	x		x	x	x	x	x	-
Lepidocolaptes fuscicapillus (Pelzeln, 1868)	I	C	S	x	x		x								-

Taxa	Feeding habit[1]	Foraging stratum[2]	Body size[3]	LT				RT-LJ				RT-RJ			Threatened species[4]
				1	2	3	4	5	6	7	8	9	10	11	
Lepidocolaptes layardi (Sclater, 1873)	I	C	S											x	-
Nasica longirostris (Vieillot, 1818)	I	M/C	M	x	x	x	x	x	x	x		x	x	x	-
Sittasomus griseicapillus (Vieillot, 1818)	I	M	S	x	x	x	x		x						-
Xiphocolaptes promeropirhynchus (Lesson, 1840)	I	M	L	x	x	x	x		x	x	x	x		x	-
Xiphorhynchus elegans (Pelzeln, 1868)	I	U/M	M	x	x	x	x	x							-
Xiphorhynchus guttatus (Lichtenstein, 1820)	I	U/C	M	x	x	x	x	x	x	x	x	x	x	x	-
Xiphorhynchus obsoletus (Lichtenstein, 1820)	I	U/M	M	x	x	x	x	x	x		x	x	x	x	-
Xiphorhynchus ocellatus (Spix, 1824)	I	U/M	M	x	x	x	x								-
Xiphorhynchus spixii (Lesson, 1830)	I	U/M	M					x	x	x	x	x	x	x	-
Xenopidae Bonaparte, 1854															
Xenops minutus (Sparrman, 1788)	I	U/M	S		x	x	x	x	x	x	x	x	x	x	-
Xenops rutilans Temminck, 1821	I	C	S						x		x	x			-
Furnariidae Gray, 1840															
Ancistrops strigilatus (Spix, 1825)	I	M/C	M	x	x	x	x		x	x			x		-
Automolus ochrolaemus (Tschudi, 1844)	I	U	M	x	x	x	x		x		x	x	x	x	-
Automolus paraensis Hartert, 1902 West[10]	I	U	M		x	x	x								-
Automolus paraensis Hartert, 1902 East[10]	I	U	M					x	x	x	x	x	x	x	-
Automolus rufipileatus (Pelzeln, 1859)	I	U	M	x					x		x			x	-
Automolus subulatus (Spix, 1824)	I	U	S			x									-
Berlepschia rikeri (Ridgway, 1886)	I	C	M	x			x		x						-
Philydor erythrocercum (Pelzeln, 1859)	I	M	S	x	x	x	x		x	x	x		x	x	-

Taxa	Feeding habit[1]	Foraging stratum[2]	Body size[3]	LT				RT-LJ				RT-RJ			Threatened species[4]
				1	2	3	4	5	6	7	8	9	10	11	
Philydor erythropterum (Sclater, 1856)	I	C	M		x	x	x								-
Philydor pyrrhodes (Cabanis, 1848)	I	M	M	x	x	x	x		x	x	x	x	x	x	-
Anabacerthia ruficaudata (d'Orbigny & Lafresnaye, 1838)	I	M	M		x	x			x						-
Synallaxis albescens Temminck, 1823	I	U	S				x								-
Synallaxis gujanensis (Gmelin, 1789)	I	U	S				x					x			-
Synallaxis rutilans amazonica Hellmayr, 1907	I	U	S	x		x	x								-
Synallaxis rutilans rutilans Temminck, 1823	I	U	S					x	x	x	x	x		x	-
Pipridae Rafinesque, 1815															
Ceratopipra rubrocapilla (Temminck, 1821)	F	U/M	S	x	x	x	x	x	x	x	x	x	x	x	-
Chiroxiphia pareola regina Sclater, 1856	F	U/M	S	x	x	x	x								-
Chiroxiphia pareola pareola (Linnaeus, 1766)	F	U/M	S					x	x	x				x	-
Dixiphia pipra (Linnaeus, 1758)	F	U	S					x	x	x	x	x	x	x	-
Heterocercus linteatus (Strickland, 1850)	F	U/M	S	x	x		x	x	x			x			-
Lepidothrix iris (Schinz, 1851)	F	U/M	S									x	x	x	VU
Lepidothrix nattereri (Sclater, 1865)	F	U/M	S	x	x	x	x								-
Lepidothrix vilasboasi (Sick, 1959)	F	U	S					x	x	x					VU
Machaeropterus pyrocephalus (Sclater, 1852)	F	U/M	S	x	x		x					x	x		-
Manacus manacus (Linnaeus, 1766)	F	U	S			x									-
Pipra fasciicauda Hellmayr, 1906	F	U/M	S		x	x	x		x		x				-
Tyranneutes stolzmanni (Hellmayr, 1906)	F	M	S	x	x	x	x	x	x	x	x	x	x	x	-
Onychorhynchidae Tello, Moyle, Marchese & Cracraft, 2009															

Taxa	Feeding habit[1]	Foraging stratum[2]	Body size[3]	LT				RT-LJ				RT-RJ			Threatened species[4]
				1	2	3	4	5	6	7	8	9	10	11	
Myiobius barbatus (Gmelin, 1789)	I	U/M	S	x	x	x		x	x	x	x	x	x	x	-
Onychorhynchus coronatus (Statius Muller, 1776)	I	M	S	x	x	x	x	x	x	x	x	x	x	x	-
Terenotriccus erythrurus (Cabanis, 1847)	I	M/C	S	x	x	x	x	x	x	x	x	x	x	x	-
Tityridae Gray, 1840															
Iodopleura isabellae Parzudaki, 1847	F	C	S	x											-
Laniocera hypopyrra (Vieillot, 1817)	O	M/C	M	x	x		x		x		x	x		x	-
Pachyramphus castaneus (Jardine & Selby, 1827)	I	C	S	x	x	x	x		x	x	x			x	-
Pachyramphus marginatus (Lichtenstein, 1823)	I	C	S	x	x	x	x	x	x	x	x	x	x	x	-
Pachyramphus minor (Lesson, 1830)	I	C	M	x	x	x						x		x	-
Pachyramphus rufus (Boddaert, 1783)	I	C	S				x								-
Schiffornis turdina (Wied, 1831)	O	U	M	x	x	x	x	x	x	x	x	x	x	x	-
Tityra cayana (Linnaeus, 1766)	O	C	M	x				x		x					-
Tityra inquisitor (Lichtenstein, 1823)	O	C	M		x										-
Tityra semifasciata (Spix, 1825)	O	C	M		x		x			x					-
Cotingidae Bonaparte, 1849															
Cotinga cayana (Linnaeus, 1766)	F	C	M							x	x		x		-
Gymnoderus foetidus (Linnaeus, 1758)	F	C	L			x									-
Lipaugus vociferans (Wied, 1820)	F	M/C	M	x	x	x	x	x	x	x	x	x	x	x	-
Phoenicircus nigricollis Swainson, 1832	F	C	M					x	x	x		x	x		-
Querula purpurata (Statius Muller, 1776)	F	C	L			x									-
Xipholena lamellipennis (Lafresnaye, 1839)	F	C	M		x		x	x							-

Taxa	Feeding habit[1]	Foraging stratum[2]	Body size[3]	LT				RT-LJ				RT-RJ			Threatened species[4]
				1	2	3	4	5	6	7	8	9	10	11	
Pipritidae Ohlson, Irestedt, Ericson & Fjeldså, 2013															
Piprites chloris (Temminck, 1822)	I	C	S	x	x	x	x	x	x	x	x		x	x	-
Platyrinchidae Bonaparte, 1854															
Platyrinchus coronatus Sclater, 1858	I	U/M	S		x	x	x	x	x	x		x	x	x	-
Platyrinchus platyrhynchos (Gmelin, 1788)	I	M	S	x	x	x	x	x	x	x	x	x	x	x	-
Platyrinchus saturatus Salvin & Godman, 1882	I	U	S	x		x			x	x	x	x	x		-
Rhynchocyclidae Berlepsch, 1907															
Corythopis torquatus Tschudi, 1844	I	T	S			x	x		x	x		x	x		-
Hemitriccus griseipectus (Snethlage, 1907)	I	M	S						x						-
Hemitriccus minimus (Todd, 1925)	I	C	S		x	x	x	x		x		x	x	x	-
Hemitriccus minor (Snethlage, 1907)	I	M	S	x	x	x	x		x					x	-
Leptopogon amaurocephalus Tschudi, 1846	I	U/M	S		x	x	x		x						-
Lophotriccus galeatus (Boddaert, 1783)	I	M/C	S					x	x	x	x	x	x	x	-
Mionectes macconnelli (Chubb, 1919)	O	U/M	S	x				x	x		x	x	x	x	-
Mionectes oleagineus (Lichtenstein, 1823)	O	U/C	S	x	x	x	x	x	x	x	x	x	x	x	-
Myiornis ecaudatus (d'Orbigny & Lafresnaye, 1837)	I	C	S	x	x	x	x	x	x	x	x	x	x	x	-
Poecilotriccus latirostris (Pelzeln, 1868)	I	U	S				x								-
Rhynchocyclus olivaceus (Temminck, 1820)	I	M	S			x	x		x			x	x	x	-
Todirostrum chrysocrotaphum simile Zimmer, 1940	I	C	S	x	x	x	x								-
Todirostrum chrysocrotaphum illigeri (Cabanis & Heine, 1859)	I	C	S					x	x						-
Todirostrum maculatum (Desmarest, 1806)	I	C	S				x								-

Taxa	Feeding habit[1]	Foraging stratum[2]	Body size[3]	LT				RT-LJ				RT-RJ			Threatened species[4]
				1	2	3	4	5	6	7	8	9	10	11	
Tolmomyias assimilis assimilis (Pelzeln, 1868)	I	C	S		x										-
Tolmomyias assimilis paraensis Zimmer, 1939	I	C	S					x		x	x	x	x	x	-
Tolmomyias flaviventris (Wied, 1831)	I	C	S	x	x	x	x								-
Tolmomyias poliocephalus (Taczanowski, 1884)	I	C	S	x	x	x	x	x	x	x	x	x	x	x	-
Tolmomyias sulphurescens (Spix, 1825)	I	C	S		x		x	x	x						-
Tyrannidae Vigors, 1825															
Attila cinnamomeus (Gmelin, 1789)	I	C	M	x	x	x	x							x	-
Attila spadiceus (Gmelin, 1789)	I	M/C	M	x	x	x	x	x	x	x	x	x	x	x	-
Camptostoma obsoletum (Temminck, 1824)	I	C	S	x			x		x						-
Conopias trivirgatus (Wied, 1831)	I	C	S		x						x				-
Empidonomus varius (Vieillot, 1818)	I	C	S				x								-
Inezia subflava (Sclater & Salvin, 1873)	I	M/C	S						x						-
Lathrotriccus euleri (Cabanis, 1868)	I	M	S					x		x					-
Legatus leucophaius (Vieillot, 1818)	O	C	S	x	x	x			x	x		x	x	x	-
Myiarchus ferox (Gmelin, 1789)	I	M/C	S	x	x		x			x				x	-
Myiarchus tuberculifer (d'Orbigny & Lafresnaye, 1837)	I	M/C	S	x	x	x	x	x	x	x	x	x	x	x	-
Myiodynastes maculatus (Statius Muller, 1776)	I	M/C	M				x								-
Myiopagis caniceps (Swainson, 1835)	I	C	S		x		x		x						-
Myiopagis gaimardii (d'Orbigny, 1839)	I	C	S	x	x	x	x	x	x	x	x	x	x	x	-
Myiozetetes cayanensis (Linnaeus, 1766)	I	C	S	x										x	-
Myiozetetes luteiventris (Sclater, 1858)	I	C	S	x	x	x	x	x	x	x		x	x	x	-

Taxa	Feeding habit[1]	Foraging stratum[2]	Body size[3]	LT				RT-LJ				RT-RJ			Threatened species[4]
				1	2	3	4	5	6	7	8	9	10	11	
Ornithion inerme Hartlaub, 1853	I	C	S	x	x		x	x	x	x		x	x	x	-
Pitangus sulphuratus (Linnaeus, 1766)	I	T/C	M	x											-
Ramphotrigon ruficauda (Spix, 1825)	I	M	S	x	x	x	x	x	x	x	x	x	x	x	-
Rhytipterna simplex (Lichtenstein, 1823)	I	M/C	M	x	x	x	x	x	x	x	x	x	x	x	-
Sirystes sibilator (Vieillot, 1818)	I	C	M			x									-
Sublegatus obscurior Todd, 1920	I	C	S		x						x			x	-
Tyrannopsis sulphurea (Spix, 1825)	I	C	M			x									-
Tyrannulus elatus (Latham, 1790)	O	C	S	x	x	x	x	x	x	x	x	x	x	x	-
Tyrannus melancholicus Vieillot, 1819	I	C	M				x		x						-
Zimmerius gracilipes (Sclater & Salvin, 1868)	I	C	S	x	x	x	x	x	x	x	x	x	x	x	-
Vireonidae Swainson, 1837															
Cyclarhis gujanensis (Gmelin, 1789)	I	M/C	S		x	x	x					x			-
Hylophilus semicinereus Sclater & Salvin, 1867	I	C	S	x	x	x	x	x	x	x	x	x	x	x	-
Pachysylvia hypoxantha Pelzeln, 1868	I	C	S	x	x	x	x	x	x	x	x	x	x	x	-
Pachysylvia muscicapina (Sclater & Salvin, 1873)	I	C	S	x	x	x	x		x					x	-
Tunchiornis ochraceiceps (Sclater, 1860)	I	U/M	S	x	x	x	x	x	x	x	x	x	x	x	-
Vireo chivi (Vieillot, 1817)	I	C	S	x		x	x					x			-
Vireolanius leucotis (Swainson, 1838)	I	C	S	x	x	x	x	x	x	x	x			x	-
Troglodytidae Swainson, 1831															
Campylorhynchus turdinus (Wied, 1831)	I	M/C	M	x	x	x	x		x	x	x			x	-
Cantorchilus leucotis (Lafresnaye, 1845)	I	U	S	x	x	x	x	x	x	x	x	x		x	-

Taxa	Feeding habit[1]	Foraging stratum[2]	Body size[3]	LT				RT-LJ				RT-RJ			Threatened species[4]
				1	2	3	4	5	6	7	8	9	10	11	
Cyphorhinus arada interpositus (Todd, 1932)	I	T/U	S	x	x										-
Cyphorhinus arada griseolateralis Ridgway, 1888	I	T/U	S					x	x	x	x	x	x	x	-
Microcerculus marginatus (Sclater, 1855)	I	T/U	S		x	x		x	x	x	x	x	x	x	-
Odontorchilus cinereus (Pelzeln, 1868)	I	C	S		x			x	x				x	x	-
Pheugopedius coraya (Gmelin, 1789)	I	U	S	x	x	x	x	x	x	x	x	x	x	x	-
Pheugopedius genibarbis (Swainson, 1838)	I	U	S	x	x	x	x		x	x		x		x	-
Troglodytes musculus Naumann, 1823	I	T/U	S				x					x			-
Polioptilidae Baird, 1858															
Ramphocaenus melanurus Vieillot, 1819	I	U/M	S	x	x	x	x	x	x	x	x	x	x	x	-
Turdidae Rafinesque, 1815															
Turdus albicollis Vieillot, 1818	O	U/M	M	x	x	x	x	x	x					x	-
Turdus fumigatus Lichtenstein, 1823	O	T/M	M		x		x		x		x				-
Turdus leucomelas Vieillot, 1818	O	T/C	M				x								-
Passerellidae Cabanis & Heine, 1850															
Arremon taciturnus (Hermann, 1783)	O	T	S	x	x	x	x	x	x	x	x		x	x	-
Parulidae Wetmore, Friedmann, Lincoln, Miller, Peters, van Rossem, Van Tyne & Zimmer 1947															
Myiothlypis mesoleuca (Sclater, 1866)	I	T	S				x		x					x	-
Icteridae Vigors, 1825															
Cacicus cela (Linnaeus, 1758)	O	M/C	M	x	x	x	x	x		x		x	x	x	-
Cacicus haemorrhous (Linnaeus, 1766)	O	M/C	M	x	x	x	x	x	x	x		x		x	-

Taxa	Feeding habit[1]	Foraging stratum[2]	Body size[3]	LT				RT-LJ				RT-RJ			Threatened species[4]
				1	2	3	4	5	6	7	8	9	10	11	
Icterus cayanensis (Linnaeus, 1766)	O	C	M	x	x	x	x			x					-
Psarocolius bifasciatus (Spix, 1824)	O	C	L	x	x	x	x	x	x	x	x	x	x	x	-
Psarocolius decumanus (Pallas, 1769)	O	C	L								x				-
Psarocolius viridis (Statius Muller, 1776)	O	C	L	x	x	x	x	x	x	x	x	x	x	x	-
Mitrospingidae Barker, Burns, Klicka, Lanyon & Lovette, 2013															
Lamprospiza melanoleuca (Vieillot, 1817)	O	C	M	x	x	x	x	x	x	x			x		-
Thraupidae Cabanis, 1847															
Chlorophanes spiza (Linnaeus, 1758)	O	C	S									x			-
Coereba flaveola (Linnaeus, 1758)	O	C	S				x		x		x	x	x	x	-
Coryphospingus cucullatus (Statius Muller, 1776)	I	T/C	S				x								-
Cyanerpes caeruleus (Linnaeus, 1758)	O	C	S		x		x					x	x	x	-
Cyanerpes cyaneus (Linnaeus, 1766)	O	C	S									x			-
Cyanerpes nitidus (Hartlaub, 1847)	O	C	S									x			-
Dacnis cayana (Linnaeus, 1766)	O	C	S	x		x	x	x				x			-
Dacnis flaviventer d'Orbigny & Lafresnaye, 1837	O	C	S	x											-
Hemithraupis guira (Linnaeus, 1766)	I	C	S			x			x						-
Lanio cristatus (Linnaeus, 1766)	I	C	S	x	x	x				x		x			-
Lanio luctuosus (d'Orbigny & Lafresnaye, 1837)	I	M/C	S			x			x					x	-
Lanio surinamus (Linnaeus, 1766)	I	U/M	S	x	x	x	x	x	x	x	x	x	x	x	-
Lanio versicolor versicolor (d'Orbigny & Lafresnaye, 1837)	I	C	S				x								-
Lanio versicolor parvus Berlepsch, 1912	I	C	S					x	x		x		x		-

Taxa	Feeding habit[1]	Foraging stratum[2]	Body size[3]	LT				RT-LJ				RT-RJ			Threatened species[4]
				1	2	3	4	5	6	7	8	9	10	11	
Parkerthraustes humeralis (Lawrence, 1867)	O	C	M	x	x			x	x						-
Ramphocelus carbo (Pallas, 1764)	O	U/C	S	x		x	x					x			-
Saltator coerulescens Vieillot, 1817	O	M/C	M				x		x			x			-
Saltator grossus (Linnaeus, 1766)	O	M/C	M	x	x	x	x		x		x	x		x	-
Saltator maximus (Statius Muller, 1776)	O	M/C	M	x		x	x								-
Sporophila angolensis (Linnaeus, 1766)	G	U/M	S	x	x	x	x	x	x						-
Tangara chilensis (Vigors, 1832)	O	C	S	x	x	x	x		x	x				x	-
Tangara cyanicollis (d'Orbigny & Lafresnaye, 1837)	O	C	S				x								-
Tangara episcopus (Linnaeus, 1766)	O	C	M				x					x			-
Tangara gyrola (Linnaeus, 1758)	O	C	S	x										x	-
Tangara mexicana (Linnaeus, 1766)	O	C	S	x			x			x		x	x		-
Tangara palmarum (Wied, 1821)	O	C	M	x	x	x	x		x	x	x	x	x		-
Tangara punctata (Linnaeus, 1766)	O	C	S			x							x		-
Tangara schrankii (Spix, 1825)	O	C	S		x		x								-
Tangara varia (Statius Muller, 1776)	O	C	S			x									-
Tangara velia (Linnaeus, 1758)	O	C	S	x	x	x			x	x		x	x		-
Volatinia jacarina (Linnaeus, 1766)	G	T/U	S				x								-
Cardinalidae Ridgway, 1901															
Cyanoloxia rothschildii (Bartlett, 1890)	O	U	M	x	x	x	x		x			x	x	x	-
Granatellus pelzelni Sclater, 1865	O	M/C	S	x	x	x									-
Habia rubica (Vieillot, 1817)	I	U/M	M	x	x	x	x	x			x	x		x	-

Taxa	Feeding habit[1]	Foraging stratum[2]	Body size[3]	LT				RT-LJ				RT-RJ			Threatened species[4]
				1	2	3	4	5	6	7	8	9	10	11	
Periporphyrus erythromelas (Gmelin, 1789)	O	U/M	M							x			x	x	NT
Fringillidae Leach, 1820															
Euphonia chrysopasta Sclater & Salvin, 1869	F	C	S	x											-
Euphonia minuta Cabanis, 1849	F	C	S					x						x	-
Euphonia rufiventris (Vieillot, 1819)	F	C	S	x	x	x	x		x	x	x			x	-

[1] Terborgh et al., 1990; [2] Stotz et al., 1996; [3] Wilman et al. 2014; [4] IUCN, 2017; [5] Carla Haisler Sardelli, unpublished data; [6] Ferreira et al. 2018; [7] Cavarzere, 2014; [8] Miranda, 2015; [9] Barbosa, 2010; [10] Schultz et al., 2017.

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SÍNTESE

Nossos resultados evidenciam que os padrões de distribuições das assembleias de aves amazônicas são gerados pela contribuição conjunta dos rios como barreira e das diferentes características ecológicas das espécies. O Rio Tapajós foi identificado como a maior barreira à dispersão das assembleias de aves na região de seu médio curso, apresentando uma variação de composição significativa entre suas margens, sendo o Rio Jamanxim, de menor porte, uma barreira pouco efetiva.

As distintas assembleias de aves são afetadas de maneira desigual pelo efeito dos rios como barreira, considerando o hábito alimentar e estrato de forrageio. Em relação ao hábito alimentar, as assembleias mais afetadas foram as de aves insetívoras, frugívoras e nectarívoras. Com relação ao estrato de forrageio, as aves de sub-bosque e estrato médio foram as mais afetadas. A partir de nossos resultados, concluímos que, tanto o ambiente de acesso aos recursos (estrato de forrageio), quanto quais são estes recursos consumidos (hábito alimentar), são importantes na determinação da capacidade de dispersão das espécies e na geração dos padrões de distribuição. Estas variáveis são relevantes e devem ser consideradas em novos estudos biogeográficos.

As abundâncias desiguais entre margens do Rio Tapajós encontrada para algumas espécies indica que outros processos, além do efeito dos rios como barreira e da capacidade de dispersão das espécies, podem estar moldando a distribuição atual das assembleias de aves nessa região.

Em uma escala regional, pudemos observar também um decréscimo no número de espécies entre as margens do Rio Tapajós, reproduzindo o gradiente Oeste-Leste de diversidade de espécies, um padrão biogeográfico detectado em estudos com maiores escalas geográficas. No entanto, essa diferença de riqueza e composição de espécies não foi acompanhada pela variação de biomassa entre margens, que se mostrou equivalente considerando todas as comparações. Estas evidências indicam que fatores históricos como as variações climáticas drásticas às quais o Leste amazônico esteve sujeito durante o Pleistoceno foram relevantes na estruturação atual das assembleias dessa região e na geração do gradiente Oeste-Leste de diversidade.

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APÊNDICES

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PROGRAMA DE PÓS-GRADUAÇÃO EM ECOLOGIA

AULA DE QUALIFICAÇÃO

PARECER

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Título:

"VARIAÇÃO ESPACIAL E TEMPORAL DA ASSEMBLEIA DE AVES NO MÉDIO RIO TAPAJÓS, AMAZÔNIA ORIENTAL"

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