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LARISSA CORSINI CALSAVARA

COMUNIDADE DE AVES E AS IMPLICAÇÕES NO FUNCIONAMENTO ECOSSISTÊMICO EM DIFERENTES CONFIGURAÇÕES DE FLORESTA COM ARAUCÁRIA

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Tese apresentada ao Programa de Pós-Graduação em Ciências Biológicas da Universidade Estadual de Londrina, como requisito parcial à obtenção do título de Doutor em Ciências Biológicas (Biodiversidade e Conservação de Habitats Fragmentados).

Orientador: Prof. Dr. Luiz dos Anjos

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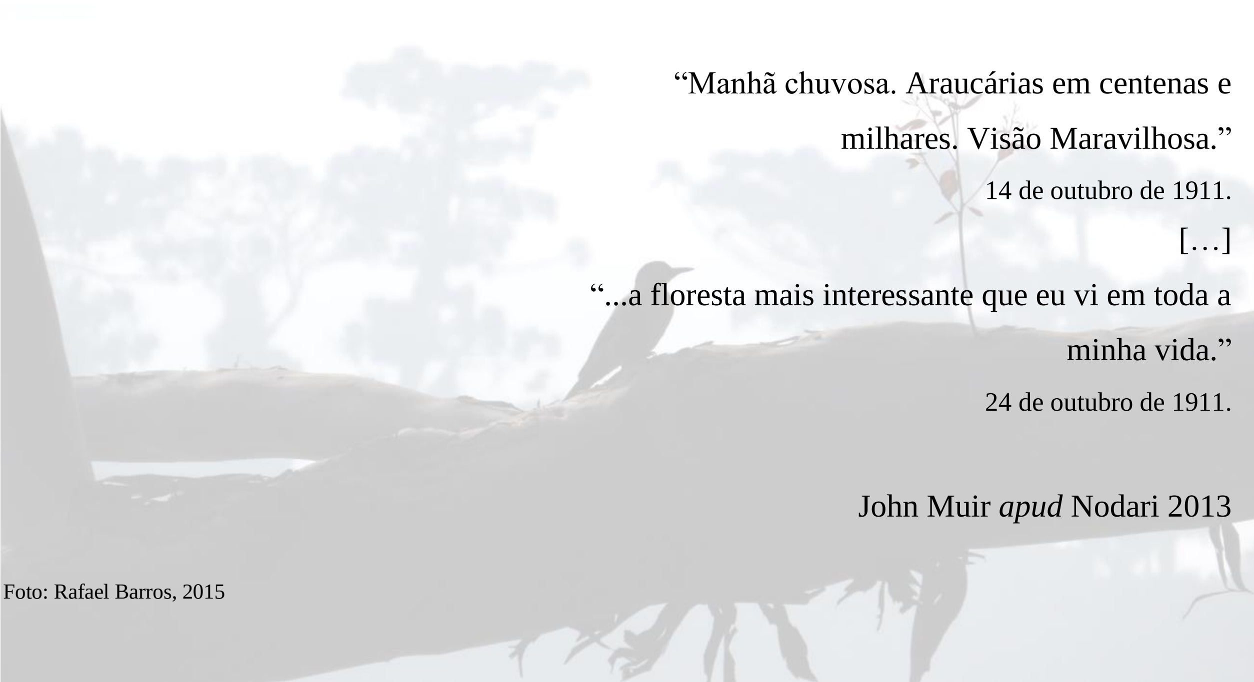

> “Manhã chuvosa. Araucárias em centenas e milhares. Visão Maravilhosa.”
>
> 14 de outubro de 1911.
>
> […]
>
> “...a floresta mais interessante que eu vi em toda a minha vida.”
>
> 24 de outubro de 1911.
>
> John Muir *apud* Nodari 2013

Foto: Rafael Barros, 2015

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RESUMO

Uma medida muito comum usada para avaliar a variação de atributos funcionais das espécies é a abordagem da diversidade funcional, seja pelo efeito que as espécies desempenham nos processos ecossistêmicos ou pela resposta das espécies quanto à mudanças do ambiente. Mudanças ambientais podem ser reflexo de processos naturais ou antrópicos, como alterações na configuração espacial de um mesmo ecossistema, o que pode influenciar na distribuição e arranjo de comunidades e dos atributos funcionais de suas espécies. A floresta com Araucária, no sul do Brasil, contempla ambos processos em sua distribuição, sendo o processo natural baseado na expansão da floresta sobre campos naturais, conhecido como nucleação. Já o processo antrópico ocorre pela ruptura da floresta contínua, conhecido como fragmentação. O foco deste estudo foi investigar a diversidade funcional de aves neotropicais da floresta com Araucária em relação a diferentes cenários na paisagem, os quais foram estruturados por ambos processos, nucleação natural e fragmentação antrópica. Aves são organismos sensíveis a mudanças ambientais e desempenham uma série de serviços ecossistêmicos. Notamos que a nucleação reduz o espaço funcional ocupado pelas espécies quando comparado à floresta contínua. Paisagens com menos habitat florestal selecionam espécies adaptadas, ou seja, a diminuição da quantidade de habitat promove poucas espécies colonizadoras; em muitos casos, elas são dispersoras de sementes e com maior capacidade de vôo. Neste caso, as aves mostraram ser organismos importantes para a manutenção da dinâmica de expansão florestal ao dispersar sementes na paisagem. A floresta contínua, além de apresentar maior quantidade de habitat, a heterogeneidade ambiental proporcionou maior número de nichos ecológicos ocupados por espécies com atributos funcionais distintos, ou seja, o espaço funcional é ampliado. Entretanto, quando a floresta contínua sofre um processo de fragmentação, novos efeitos da configuração espacial causaram perdas de espécies sensíveis, associadas à floresta conservada. Como conseqüência, a diversidade funcional diminuiu nos remanescentes florestais e a comunidade de aves foi recomposta por novas espécies oportunistas, provavelmente generalistas de borda. Portanto, concluímos que as diferenças apresentadas nos distintos cenários da floresta determinam comunidades e diversidade funcional diferentes para a avifauna. Processos naturais ou antrópicos, apesar de resultarem em fragmentos florestais espalhados na paisagem, representam conjunto de espécies e de atributos funcionais totalmente diferentes. Essas diferenças devem ser levadas em conta quando estratégias de conservação forem implementadas, uma vez que a floresta com Araucária precisa urgentemente de mais áreas protegidas.

Palavras-chave: Diversidade funcional. Riqueza de espécies. Nucleação florestal. Fragmentação florestal. Montagem de comunidades.

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ABSTRACT

A very common measure used to assess the variation of functional species traits is the functional diversity approach, which analysis the effect performed by species on ecosystem processes, or species response to changes in environment. Environmental changes can be consequences of natural or anthropic processes, i.e., changes in spatial configuration in a same ecosystem, which can influence community arrangement and their functional species traits. Araucaria forest, southern Brazil, includes both processes in its distribution. The natural process is based on forest expansion over natural grasslands, known as nucleation. The anthropic process occurs by the rupture of continuous forest, known as fragmentation. Our focus in this study it was to investigate functional diversity of neotropical birds in Araucaria forest in relation to different scenarios in the landscape, which were structured by both processes, natural nucleation and anthropic fragmentation. Birds are organisms sensitive to environmental changes and perform a series of ecosystem services. We noticed that nucleation reduces the functional space occupied by species when compared to continuous forest. Landscapes with less forest habitat select adapted species, that is, decreasing values of habitat amount promote few colonizing species; in many cases, they are seed dispersers and have greater flight capacity. In this case, birds provided to be important organisms for maintaining the dynamics of forest expansion by dispersing seeds in the landscape. Continuous forest, in addition to presenting a greater habitat amount, environmental heterogeneity provided a greater number of ecological niches occupied by species with different functional traits, and the functional space was expanded. However, when continuous forest undergoes a fragmentation process, new effects of spatial configuration caused losses of sensitive species, associated with the conserved forest. As a consequence, functional diversity decreased in forest remnants and bird community was recomposed by new opportunistic species, probably edge generalists. Therefore, we conclude that the differences presented in different forest scenarios determine different communities and functional diversity for bird communities. Natural or anthropic processes, although they result in forest fragments spread across the landscape, they represent a set of species totally different about their functional traits. These differences must be taken into account when conservation strategies are implemented, since Araucaria forest urgently needs more protected areas.

Keywords: Functional diversity. Species richness. Forest nucleation. Forest fragmentation. Community assembly.

SUMÁRIO

1. INTRODUÇÃO

O início do século XVIII marca o começo do histórico da interferência antrópica sobre a floresta com Araucária por meio dos primeiros viajantes e fazendeiros que se instalaram no território sul brasileiro (Koch e Côrrea 2010). As viagens na região ficaram conhecidas mais tarde como Tropeirismo, e seus pioneiros relatavam viajar por trechos da floresta sem ver a luz do Sol, devido a copa alta e entrelaçada dos pinheiros de Araucária (Koch e Côrrea 2010). Essa floresta contínua, até então "virgem", começou a ser interrompida quando as longas viagens demandavam de pontos específicos na estrada para descanso e abastecimento. Com o tempo, estes pontos de acampamento desenvolveram-se em vilas e até cidades pequenas, os primeiros indícios de clareiras artificiais na floresta (Koch e Côrrea 2010).

Em meados do século XIX, a floresta com Araucária passava por um novo estágio de transformação, consolidava-se o processo de ocupação por imigrantes europeus, principalmente nos estados de São Paulo, Paraná, Santa Catarina e Rio Grande do Sul (Koch e Côrrea 2010). Durante esse processo de ocupação, a exploração da floresta por recursos naturais e a expulsão de povos indígenas nativos marcaram o início do desenvolvimento urbano. A floresta subtropical dominada por pinheiros despertava encanto nos imigrantes, predominantemente alemães e italianos, antes acostumados por florestas temperadas da Europa, muito homogêneas e pouca diversa em espécies quando comparadas ao novo mundo. Seus relatos tinham o objetivo de cativar mais povos para aderir à colonização (Nodari 2013). Também era o início de um olhar científico naturalista, o qual descreviam as características da floresta naquele tempo. Entre os escritos, o alemão Hermann Bruno Otto Blumenau divulgou em sua obra:

"A beleza das florestas é arrebatadora e, em sua majestade, quase sufocante [...] além de sua riqueza em madeira, as florestas oferecem outros vegetais úteis, que podem ser coletados em maior ou menor escala. A variedade de árvores é tão numerosa, que uma vida é curta demais para poder conhecê-las todas.[...]" (Blumenau, 1850. p. 35-38 *apud* Nodari 2013).

Os ingleses contribuíram ao detalhar o sub-bosque da floresta em uma das expedições da construção da ferrovia que interligava Paraná e Mato Grosso. Thomas P. Bigg-Wither relatou a copa emergente dos pinheiros de Araucária, com formato de cogumelos, que se sobressaia ao dossel inferior, semelhante a uma floresta tropical, este composto por palmeiras, samambaias gigantes e emaranhado de cipós e bambus (Bigg-Wither, 1974 *apud* Nodari 2013). No entanto, a relação estreita da floresta com os campos naturais, uma das paisagens marcantes da floresta com Araucária foi descrita por Auguste de Saint-Hilaire, um imigrante francês (Nodari 2013). Essa paisagem mistura ecossistemas muito diferentes e se extende sobre um ecótono marcado por um mosaico floresta-campo (processo conhecido como expansão florestal ou nucleação, veja Matte et al. 2015). Na região de Campos Gerais, no Paraná, o francês escreveu:

> "[…] esses campos constituem inegavelmente uma das mais belas paisagens que já percorri desde que cheguei à América [...] até onde a vista pode alcançar, descortinam-se extensas pastagens; pequenos capões onde sobressai a valiosa e imponente araucária. Surgem aqui e ali nas baixadas, o tom carregado de sua folhagem contrastando com o verde claro e viçoso do capinzal" (Saint-Hilaire, 1978, p. 15-16 *apud* Nodari 2013).

O olhar naturalista destes europeus contemplava uma biodiversidade única, jamais vista antes, fadada a um cenário de desaparecimento e exploração intensa no futuro (Koch e Côrrea 2010). A chegada da instalação de madereiras juntamente com a industrialização da erva-mate, marcaram o fim do século XIX e o decorrer do século XX com o processo de destruição florestal em massa. O crescimento econômico irresponsável da época dizimou as vastas áreas de floresta pristina que antes ocupavam cerca de 200.000 km^2 no sul do Brasil (Carvalho 2011). O foco pouco conservacionista e meramente econômico proporcionou empregos para os colonos, principalmente quando a Primeira Guerra Mundial eclodiu (Koch e Côrrea 2011). A madeira de qualidade dos pinheiros e imbuias colocou o Brasil em primeiro lugar nas exportações internacionais (Carvalho 2011).

Apesar da crescente devastação, havia uma corrida urgente da ciência para levantar o conhecimento das espécies enquanto havia tempo. O botânico Gerdt Hatschbach (1923 – 2013), nascido em Curitiba, catalogou pelo menos 1.500 espécies de plantas da floresta com Araucária (Koch e Corrêa 2010). Na década de 60 em diante, surgiram os estudos de Roberto M. Klein, os quais resgataram a atenção para a floresta com Araucária e os aspectos dinâmicos do pinheiro (Klein 1960, Reitz e Klein 1966, Reitz et al. 1983) assim como Hueck (1972). Porém os estudos não ficaram apenas restritos a comunidade vegetal. Em 1895, o naturalista alemão Hermann F. A. Von Ihering publicou um dos primeiros estudos científicos de aves do Rio Grande do Sul, com uma certa relação com a floresta com Araucária aos arredores do município de Taquara (*apud* Nomura 2012), porém com tom descritivo. Estudos sobre ecologia de comunidade de aves surgiram na década de 80, ao comparar a avifauna de florestas naturais com plantações homogêneas de Araucária (Rodrigues et al. 1981). Adiante, estudos sobre a dinâmica floresta-campo e as influências sobre espécies de aves começaram em 1999 com Anjos e Boçon. O estudo avaliou pela primeira vez a composição da avifauna em manchas naturais de floresta imersas nos campos comparada à floresta contínua conservada na região de Campos Gerais, Paraná (Anjos e Boçon 1999). O mosaico floresta-campo nas terras altas do nordeste do Rio Grande do Sul também foi investigado por Hartz et al. (2012) ao avaliar espécies migratórias e o papel ecológico da frugivoria. Paulatinamente, mais estudos que integravam aves e a floresta com Araucária foram sendo publicados, principalmente sobre cenários de perturbação antrópica, como a fragmentação florestal (e.g. Volpato et al. 2010, Anjos et al. 2011, Scherer-Neto e Toledo 2012).

A fragmentação florestal, ou seja, o processo antrópico de retalhar um habitat que em sua origem era contínuo, atrelada à perda de habitat, juntas tornaram-se a principal ameaça à biodiversidade da floresta com Araucária, responsáveis pelo desaparecimento de 97% do ecossistema (Koch e Côrrea 2010). O último estudo detalhado deste cenário estimou no estado do Paraná, cerca de 3 milhões de hectares formados por remanescentes da floresta com Araucária, porém, somente metade destes hectares estão em estágio médio ou avançado de sucessão (Castella e Britez 2001). Contudo, a fragmentação florestal não é o único processo que origina fragmentos na floresta com Araucária. Especificadamente, na paisagem mosaico floresta-campo, é comum encontrar fragmentos naturais de floresta que invadem e se expandem sob os campos em um longo processo de sucessão ecológica (Duarte et al. 2007). O processo de expansão florestal, também conhecido como nucleação (Yarranton e Morrison 1974), pode acontecer na mesma paisagem juntamente com o processo de fragmentação florestal, e apesar de ambos compartilharem a mesma unidade básica, ou seja, o fragmento florestal, ambos processos se desenvolvem em direções opostas e possuem características distintas (Matte et al. 2015). Por um lado, a fragmentação da floresta é caracterizada pela redução e ruptura de cobertura florestal da paisagem antes distribuída de forma contínua, processo este originado por causas antropogênicas (Haddad et al. 2015). Neste contexto, os fragmentos remanescentes possuem formatos e bordas artificiais (e.g. retângulos ou linhas retas), são circundados geralmente por uma matriz de agricultura e estão localizados próximos a estradas ou rodovias (Matte et al. 2015). Por outro lado, a expansão da floresta relaciona-se com o aumento da cobertura florestal em uma matriz não florestada, ou melhor, totalmente campestre, processo este natural e relacionado à fatores bióticos e abióticos locais (Pillar 2003). Estes fragmentos ou manchas naturais, geralmente, são menores em tamanho e com formatos irregulares, circundados por uma campina com muitas gramíneas, alguns arbustos e rochas (Matte et al. 2015).

Embora, a floresta com Araucária esteja exposta à mudanças ambientais há muitas décadas, sejam por processos naturais ou antrópicos, estudos ecológicos têm direcionado o foco para além dos danos à diversidade taxonômica apenas. Ou seja, comunidades biológicas são conjuntos de espécies que apresentam uma gama de atributos ecológicos que suportam os processos ecossistêmicos (Mayfield et al. 2010). Neste sentido, a diversidade funcional (ou diversidade de atributos funcionais) tornou-se a ferramenta base para analisar o conjunto desses atributos ecológicos das espécies (Mayfield et al. 2010). Segundo Cianciaruso et al. (2009) a diversidade de atributos funcionais das espécies significa medir as próprias características, que são os componentes dos fenótipos dos organismos que influenciam os processos na comunidade. Os atributos funcionais podem ser as características morfométricas e/ou comportamentais, por exemplo: massa corpórea, medidas morfológicas dos indivíduos, dieta, estratégia de forrageio, preferência de habitat, entre outros (Schleuter et al. 2010). Alterações no habitat podem causar vários efeitos sobre os recursos utilizados pela fauna. Portanto, estudos sobre a comunidade faunística podem ajudar nesta investigação, como o grupo das aves (e.g. Luck et al. 2013). Quando existe alteração ambiental, como por exemplo a fragmentação florestal, as aves especialistas tendem a ser mais sensíveis, principalmente as insetívoras de sub-bosque (Anjos et al. 2015). Por outro lado, as espécies generalistas podem ser favorecidas, pois possuem atributos ecológicas que facilitam a resistência à estas alterações ambientais, ou a colonização de habitats que foram modificados (Aleixo 1999).

Neste sentido, como a floresta com Araucária sofreu forte processo de degradação, é esperado alterações na diversidade funcional com possível perda de alguns atributos funcionais nas comunidades de aves. Neste estudo estas alterações na diversidade funcional de aves foram avaliadas a partir de três cenários diferentes: (I) a rara floresta contínua;

(II) fragmentos florestais que remanesceram após a fragmentação florestal; (III) manchas florestais naturais que se expandem sob a matriz campestre pela nucleação. Esperamos neste estudo, compreender todos estes cenários da floresta, porém a partir da abordagem de ecologia de comunidade de aves, juntamente com a diversidade funcional. Dentre as perguntas desta tese, estão:

- Como processos distintos, fragmentação e nucleação, influenciam a riqueza e composição das comunidades de aves da floresta com Araucária? (Capítulo 1).
- Como as comunidades de aves são afetadas pela nucleação e fragmentação quanto à diversidade funcional? (Capítulo 1).
- Como é a resposta dos índices de diversidade funcional baseados em atributos funcionais de aves em um gradiente natural de expansão da floresta sobre os campos naturais? (Capítulo 2).
- Como atributos relacionados à alimentação, deslocamento e biomassa das espécies de aves respondem a um gradiente natural de expansão da floresta sobre os campos naturais? (Capítulo 2).

Sendo assim, esperamos contribuir nos campos da ecologia e conservação da floresta com Araucária ao estudar a funcionalidade de aves neste ecossistema ainda pouco investigado e altamente ameaçado (Carlucci et al. 2011).

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2. Capítulo 1

Does forest expansion and fragmentation impact in the same way bird functional diversity?

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Abstract

Accessing community assembly into an ecosystem with different scenarios provides support for one the most emerging issues in ecology, the relation between biodiversity arrangement and how this reflects on functional diversity. Community assembly can be driven by natural or anthropic processes in forest ecosystems, which could reflect in a different distribution of species traits. Especially in Araucaria forest there are two distinctive and independent ecological processes: i) Natural forest expansion and succession over grasslands (nucleation process) and ii) continuous forest disruption by fragmentation (fragmentation process). In this study we aimed to analyze the effect of those processes in neotropical bird communities in relation to taxonomic and functional diversity. Our interest is analyzing functional bird trait distribution in Functional richness and Functional dispersion in 48 sites at South Brazil according to processes related to forest landscape configuration. Also, whether functional metrics reflect different ecological patterns in null model approach, as functional convergence and functional divergence. As main result, we observed that local communities of forest nucleation represent a functional space more restrict, which means few species survive the environmental filter and ecological functions are poorly diversified. Furthermore, species richness is low and species composition showed to be very dissimilar of continuous forest in mature stage. Despite forest fragmentation sites present higher similarity of species richness and composition to continuous forest, fragmentation effects on birds resulted on loss of species and functional traits due to disturbance, reducing functional diversity values. However, with time, we argue that functional diversity could be higher, because the environmental heterogeneity caused by fragmentation effects could replace bird species, which can add novel functional traits. Then, our results suggest that different forest scenarios arrange bird communities in different ways in terms of the functional trait distribution. Therefore, even both processes result in forest fragments, conservation strategies can include functional perspective of the species, in addition to carefully analyzing the landscape configuration of each forest fragment.

Keywords: bird community, functional trait distribution, functional dispersion, null models, Araucaria forest.

Introduction

Ecological processes involved in assembly of biological communities have often been explored by the life-history traits approach (Mouchet et al. 2010). Communities are arranged according to species ability to respond to environmental changes, to reproduce, to acquire resources, or to disperse in local or regional landscapes, i.e. species fitness (Cadotte et al. 2011, Mason and De Bello 2013, Bregman et al. 2016). Species fitness is directly involved to ecological niche occupation, which is represented by a multidimensional functional space where species and individuals of a community are distributed according to environmental limitations (Schleuter et al. 2011). These effects on community assembly can reflect in some ecological patterns, such as environmental filter and competition (Perrone et al. 2017), which ones can be detected by functional diversity measurements (Mouchet et al. 2010). Environmental filtering promotes functional convergence, as biotic and abiotic pressures selects functionally similar species (Botta-Dukát and Czúcz 2016). On the other hand, interspecific competition promotes functional divergence as competition for resources selects species occupying different niches (MacArthur and Levins 1967, Botta-Dukát and Czúcz 2016). Taken together, communities can be assembled by natural or anthropic processes.

Anthropic process, such as forest fragmentation is a complex theme, which has been explored by decades, since early studies (e.g. Bierregaard et al. 1992, Turner 1996), or incorporating temporal scales (Laurance et al. 2002), and throughout more recent large scale approaches (Haddad et al. 2015, Lucas et al. 2019). Also, forest fragmentation is constantly associated to habitat loss, when the landscape is fully filled by many small forest remnants. And smaller forest remnants cause decreasing species richness (Fletcher et al. 2018). However, not only low size, but high isolation should lead higher extinction risk and higher species turnover, when compared to larger and connected forest remnants (Lucas et al. 2019). In birds, species persistence in fragmented landscapes is positively associated with habitat amount and connectivity of forest remnants (Ferraz et al. 2007). Further, fragmentation effects should drive different species composition in remnants in relation to continuous forest (Banks-Leite et al. 2012), strongly influenced by matrix habitat dynamic (Deikumah et al. 2013). As fragmented landscapes dominate, studies have also investigated the consequences of reduced forest cover on community and the impacts on functional diversity (e.g. De Coster et al. 2015). In particular, specialist and generalist in diet are affected differently as showed for Passerines in southern Brazil, when continuous and fragmented forest are compared (see Anjos et al. 2019). In fact, functional diversity of specialists even being higher than generalists in continuous forest, significantly decrease in fragmented forest implying in loss of ecological functions (Anjos et al. 2019). Nevertheless, fragmentation is not the only process that can lead fragments in the landscape. In the present study, we evaluate a third scenario found at southern Brazil, where bird communities are assembled in natural forest fragments.

At southern Brazil, there is an ecosystem known as Araucaria forest (Koch and Côrrea 2010). This forest can expand over grasslands by a natural process, the nucleation process (Yarranton and Morrison 1974, Duarte et al. 2007). It occurs from a seminal group of forest plant species that colonize grassland areas, which compose an initial nuclei for establishment of Araucaria forest patches (Yarranton and Morrison 1974, Duarte et al. 2007). *Araucaria angustifolia* (Bertol.) Kuntz, a heliophyte pine tree, is one among the colonizers and promoters of a natural succession process (Graeff 2014). In large temporal scales, these natural forest patches can connect the landscape and become continuous forest (Graeff 2014) in a forest succession trajectory. Landscape effects can influence bird species richness, once patch size is positively correlated (Anjos and Boçon 1999). However, as nucleation process generates forest patches, bird community can be assembled by different species composition when compared to continuous forest. In other words, early forest stages could show bird species totally different from a mature forest stage. For example, seed dispersers birds are more common in forest-grassland mosaic than the interior of continuous forest (Hartz et al. 2012). Moreover, nucleation process can also act directly in trait distribution across species, which can influence bird functional diversity.

In this context, nucleation is the Araucaria forest expansion over grasslands, where new fragments are formed naturally in the landscape. Fragmentation, on the other hand, is a subdividing process of an existing forest already. Furthermore, with nucleation there is a gain of habitat in the landscape and with fragmentation a loss of habitat. In this way, these processes not only generate changes in the landscape configuration, but also changes in habitat amount. Both can reflect differences in bird richness, species composition and functional diversity. Shortly, our study is aimed to investigate how bird communities are arranged by two distinctive and independent processes in an ecosystem trajectory: nucleation and fragmentation, both found in Araucaria forest (Matte et al. 2015). Araucaria continuous forest is very threatened, it just has left 3% from the original distribution area (Koch and Corrêa 2010), thus forest remnants with large variations in size are the current scenario, a result of intense logging that began in the twentieth century (Graeff 2014). Therefore, fragmentation sites should have bird communities similar to continuous forest, once in a recent past they were abruptly transformed into forest remnants. Conversely, we expect that nucleation sites should be more different from continuous forest, because they will be gradually colonized by bird species from nearby sources, such as a large forest patches or a continuous forest. Considering that both processes, natural or anthropic, can determine community assembly, different mechanisms, such as species colonization or persistence, should reflect on different effects in bird functional diversity (Fig. 1). Therefore, this study was aimed at investigating two questions: (1) how distinctive processes drive richness and composition of bird communities in Araucaria forest? (2) how bird trait diversity is distributed in communities shaped by distinctive processes at Araucaria forest?

Material and methods

Study area description

South Brazil is characterized by a subtropical forest known as Araucaria forest or “Mixed Rainforest” (IBGE 2006). Biogeographical features of Araucaria Forest are influenced both by present climate conditions and by historical events (Supplementary Material). Araucaria forests occur at higher altitudes (from 500 to 1,500 m a.s.l) with high precipitation during the summer and moderate temperatures throughout the year, ranging from 13º to 25ºC (Graeff 2014). Winter season is an exception, when temperatures can drop to 0ºC. Rarely, snowfalls are known to occur during the winter, particularly in regions of high altitudes (Graeff 2014).

At the limits of Araucaria forest distribution there are the ecotones formed by the transition of antagonistic phytophysiognomies: the forest-grassland mosaic (Graeff 2014). In open areas, it is relatively common to find pure araucaria tree clusters, which characterize their capacity to expand into natural grasslands (Duarte et al. 2007), and sometimes form mosaics of forest patches within grasslands, a type of natural grassland (Graeff 2014). These forest patches can be formed by a natural process called nucleation (Yarranton and Morrison 1974). At the beginning of the nucleation process, forest patches are small, but with time they might expand becoming larger, if a series of environmental variables were favorable (see Pillar 2003). At large temporal scales, older forest patches can possibly connect the landscape giving rise to a continuous forest landscape. In parallel, the loss and fragmentation of Araucaria continuous forest began at the end of the 19th century (Koch and Côrrea 2010) and this forest is now heavily endangered and undergoing severe human disturbance (Koch and Côrrea 2010). Up until the mid-twentieth century, the ecosystem covered about 20 million hectares in total (Reitz and Klein 1966 *apud* Rosot 2007). In 2004, Castella and Britez estimated that the number decreased to 3 million hectares of forest remnants, but 1.6 million hectares are in mid or advanced stages of succession, and only 275.000 are fragments over 50ha (Fig. 2). See supplementary material for more details.

Classification of forest treatments

As Araucaria forest is formed by different scenarios, such as, continuous forest, fragmented forest and the nucleated forest, we classified them as forest treatments: i) Forest nucleation - natural forest patches expansion and succession over grasslands; ii) Fragmentation process – forest remnants resulting from human disturbance; iii) Control – continuous forest at the climax stage of ecological succession. We based our forest classification according to Matte et al. (2015). Forest remnants originating from a fragmentation process, and forest patches resulting from nucleation have many distinctive features, although both are apparently forest fragments (Matte et al. 2015). To distinguish them, it is noticed that in the fragmentation process, the remnants are larger in size, artificial shape at their borders, like straight lines, higher values of edge contrast, usually they are surrounded by agricultural matrix and are located close to urban areas (Matte et al. 2015). In the nucleation process, forest patches tend to have an irregular shape, are smaller in size and are distributed in a matrix of natural fields and rocks (see Matte et al. 2015 for details).

In addition, the forest nucleation local sites are located in two distinct geographic regions (Fig. 2), and we subdivided them into Nucleation-North (Fig. 2g) and Nucleation-South (Fig. 2j) and analyzed them separately. This subdivision is necessary because forest nucleation at North zone is based on the core area of Araucaria forest distribution, and it is evolutionarily older and closer to large blocks of continuous forest. Opposite pattern from forest nucleation at South zone, where it is much more isolated from continuous forest because is based at the limit of forest distribution and it is a recent formation.

Experimental design

We compiled a dataset on the composition of bird species for 48 sites located within the Araucaria forest (Fig. 2). For 40 of these study regions, data were obtained from literature (Anjos and Boçon 1999, Mähler 2012, Calsavara 2016, Anjos et al. 2018). For the other eight sites, bird species composition was obtained from different studies which were presented in a data paper (Hasui et al. 2018, see appendix A). Since for each study site, methods, sample efforts, observers and year of survey were different, we chose to use presence and absence data (see appendix B). In order to control all the differences pointed out above, and the data has a lack of information on the sampling coverage of each method, we decided to evaluate the effectiveness of species richness by the mean of richness estimators. That is, we calculate the mean from four non-parametric species richness estimators to evaluate if sites were well sampled for each forest treatment. Our criterion is that each forest treatment should present a mean of at least 80% of richness estimators. These estimators were: Chao, First order jackknife, Second order jackknife and Bootstrap. All of them belong to *specpool* function, package 'Vegan' (Oksanen et al. 2013). As the 48 sites distributed in four categories showed 80% of richness estimate, we have decided to maintain all these local sites (Table A3, appendix C). Also, we tested autocorrelation using a Mantel test (r = 0.7241, p = 0.001).

Also, we have checked species nomenclature based on BirdLife database (2017).

Taxonomic diversity

To explore dissimilarities in bird species composition of different forest treatments, we used principal coordinates analysis (PCoA, Gotelli and Ellison 2011) based on the Sørensen dissimilarity measure in 'Vegan' package (Oksanen et al. 2013). To test for significant differences in composition, we used a permutational multivariate analysis of variance (Permanova with Adonis function in 'Vegan'; Oksanen et al. 2013) using 1000 permutations. We used the axis of greater explanation of PCoA and by analysis of variance (ANOVA; Gotelli and Ellison 2011) we checked the differences between forest treatments. Later, Tukey was used as post-hoc test (Gotelli and Ellison 2011). All assumptions were checked.

To investigate changes in species richness between forest treatments, we used a Generalized linear model with a negative binomial distribution (in 'MASS' package; R Core Team 2019) after checking overdispersion of model variance (Crawley 2013). We evaluated residuals by diagnostic plots. We tested difference of models fit using likelihood ratio test (LRT), with a chi-square approximation (Zuur et al. 2009). And finally, we used multiple comparisons of means by Tukey contrasts in 'multcomp' package (Hothorn et al. 2016).

Bird functional traits and functional space

Once we determined our tropical bird community dataset, we gathered data for different functional traits: diet, foraging vertical strata, foraging substrate, body mass (in grams) and morphometric measures (tail, wing and bill length, bill width and bill depth, all in millimetres) from the literature (Del Hoyo et al. 2019, Rodrigues et al. 2019). Morphometric measurements were obtained at the Museu de Zoologia da Universidade de São Paulo – MZUSP, using 2-5 specimens per species. However, morphometric measures were not available for several species. In this case, we used measurements from Rodrigues et al. (2019) (see Table S1, supplementary material). We evaluated redundancy among all functional traits by correlation plot (Fig. A1).

We used two metrics to describe the functional space: functional richness (FRic) and functional dispersion (FDis) (Moulliot et al. 2013). FRic calculates the functional volume occupied by a local community compared with a regional pool. This measure reflects the convex hull volume, and only the species distributed at the limits are required for its calculation (Mouchet et al. 2010). Then, with FRic we will realize how much the total functional space is been occupied by each different forest treatment. Also, FRic can be easily influenced by species richness (Mouchet et al. 2010).

FDis is a complementary metric to FRic, however, it represents the spread of the species from the center of the functional space, as it calculates the community mean distance to a centroid (Laliberté et al. 2013). It has been shown that species richness has small effects on FDis (Mouchet et al. 2010), thus differences in FDis will not be sensible to differences in species richness among communities. With FDis we will analyze how disperse the species are in relation to their functional traits, while for FRic, only outliers species count.

FRic and FDis were calculated using ‘dbFD’ function on ‘FD’ package (Laliberté et al. 2014) using presence-absence data. To distinguish differences among each forest treatment we chose Kruskal-Wallis test (McKight and Najab, 2010) for FRic, because it was non-normally distributed. And, thus and Dunn’s test, with Bonferroni correction as post-hoc test (Gotelli and Ellison, 2011). For FDis we used parametric test ANOVA and Tukey post-hoc test (Gotelli and Ellison, 2011).

Null models

Because our sites were located across a very large region of the south of Brazil (about 920 Km between the farthest sample sites), there were significant differences in the local species pool both in terms of number of species and identity. For this reason, we tested whether observed FRic and FDis values were significantly different (lower or greater) from expected functional values based on a list of species at the regional scale (species pool). If results were lower than expected, it means bird trait diversity has suffered functional convergence (Botta-Dukát and Czúcz 2016), if results were higher, functional divergence (Botta-Dukát and Czúcz 2016).

We calculated the species pool for each study region by using the species distribution obtained from BirdLife maps as potential species list. We only considered species that fell within a 25 km radius around each study region (Fig. 2) and species classified as forest habitat or as forest edge (Del Hoyo et al. 2019). We randomized the community matrix so that the columns (with species) were shuffled, randomizing only the species composition per sample site and maintaining a fixed species richness by site. To calculate functional diversity metrics must exist at least one species in at least one sample site. Thus, we created 9999 iterations, since about 11% of these randomizations accidentally generate species with absence in all 48 sites. At last, we choose randomly 999 iterations. After this step, we calculated the functional metrics for each iteration, fixing a specific number of species per site, to control the differences of sample effort between sites. This fixed number is the result of each different sampling effort for each site (appendix B). To calculate the probability of observed values, we used the ranking position of observed value in the expected distribution. We used the packages 'picante' (Kembel et al. 2010), 'reshape2' (Wickham 2012) and 'FD' (Laliberté et al. 2014) for analysis of null models.

All the analyzes were performed on software R version 3.5.2 (R core team 2019).

Results

Richness and species composition

We recorded 242 bird species considering all 48 sites. We found clear differences in bird composition, with a large data variation concentrated mainly on axis 1 of PCoA (38.16%, Fig. 3). Permanova analysis (F model = 11.55, $R^2 = 0.4405$, df = 3, p-value < 0.0001) indicates a significant difference between the four treatments of Araucaria forest. Indeed, only one species is common across the 48 sites, *Turdus rufiventris* (Vieillot, 1818).

We found that species richness varied between forest treatments (Fig. 4a, LRT = -184.16, $X^2 = 43.975$, df = 1, p-value < 0.001). Differences in species richness were mainly due to the control, which had a higher number of species and Nucleation-South was the lowest in number of species. In addition, we also found different bird composition for all treatments when the first PCoA axis 1 was tested (ANOVA, F = 134.2; df = 3; p-value < 0.001), with the exception of control and fragmentation treatments, which had similar bird composition (Fig. 4b).

Functional diversity

We observed significant differences in FRic between treatments (Kruskal-Wallis chi-squared = 26.5; df = 3; p-value < 0.001), with control areas and Nucleation-North having the highest functional richness (Fig. 5a). Although FDis was different among forest treatments (ANOVA, F = 12.41; df = 3; p-value < 0.001), it was mainly because Nucleation-South presented lower values when compared with other forest treatments (Fig. 5b).

We found that out of the 48 analyzed sites, 15 sites had lower functional diversity than randomly expected and two sites were higher than expected (Table 1). Seven sites were lower than expected by chance for both functional metrics (Table 1). Most of these sites were either Nucleation or Fragmentation forest treatments, indicating that for these sites deterministic processes (e.g., environmental filter and competition) are involved in determining community structure.

Discussion

Our study evaluated the difference between natural and anthropogenic processes over species richness, composition and functional diversity. As distinctive processes can delineate multiple outcomes in tropical bird community, we found that species richness mediates functional diversity. In forest-grassland dynamics, species richness and species composition are different when compared to continuous forest (mature stages) and forest remnants, especially in Nucleation-South. We realized that this exclusive set of species in nucleation (as an early forest stage) are essential for the maintenance and survival of Araucaria forest when the forest expands over grasslands. Later, we highlight the importance of considering local scale aspects, like short distance between forest patches and large forest area. So, during the nucleation process in Araucaria forest (forest succession), few bird species with novel traits are added to the community with time, driving up the values of species richness and functional diversity towards the late forest stages. Forest remnants showed species composition similar to continuous forest, that seems coherent, since every forest remnant is the result of the sudden disruption of forest. However, it brought uncertainties with a wide variability in species richness and functional diversity. Among them, negative effects include loss of species, by local extinction of susceptible species, or replacement and competition of novel species attracted to disturbed habitats.

It is important to mention that nucleation process is concentrated in two regions, Nucleation-South at extreme South of Araucaria forest distribution (Fig. 2j) and the other is located about 440 km to North, Nucleation-North (Fig. 2g). Nucleation-North has twice the number of species than Nucleation-South and the similarity of species composition seems to be a transition between continuous forest and Nucleation-South (Table 1, Fig. 3). We explain this case by the presence of a continuous forest site very close to forest patches immersed in natural grasslands. Continuous forest acts as a source of migrants, which ones can potentially colonize the forest patches. That is, if stable bird communities exist at the "source", this can lead colonizers to forest islands, according to the theory of metacommunities (Leibold et al. 2004). In addition, the rescue effect predicts local species extinctions, i.e. more individuals are available to compose the metacommunities (Brown and Kodric-Brown 1977). In theory as more sites are vacated, higher the immigration rate will be, and the probability of local colonization is supported by physical and biological conditions, such as forest cover size, habitat availability, food resources and even the loss or low occurrence of predators (Gotelli 1995).

Nucleation-South, precisely at highlands, are not located close enough to a continuous forest as a source of species supply. Without colonizers, higher is the chance of local extinction occur. Furthermore, environmental conditions are stricter, winter temperatures are minimal (about 6.7° C according to WorldClim 2019). Furthermore, Hartz et al. (2012) detected less migratory species in core of Araucaria continuous forest (comparing forest edges) than in forest patches. In any case, the maintenance of bird community is made by the movement of species among forest patches. Also, Araucaria tree can play as a nurse tree role, beyond promoting the establishment of colonizer forest species, and probably, it can attract bird seed dispersers due its branches work well as perches (Duarte et al. 2007). It suggests that some particular and similar traits favor potential colonizers. Thus, within each studied region, functional convergence is stronger in Nucleation-South sites than Nucleation-North, selecting non-adapted species to environmental conditions, which decreases FRic and FDis (Raevel et al. 2012).

Forest remnants in our study present various sizes and shapes and may have received distinct historical disturbance influences. All these factors, including edge effect can greatly influence bird species richness and composition (Karadimou et al. 2016, Pfeifer et al. 2017). According to Mattes et al. (2015), forest remnants showed higher values of edge contrast when compared to natural patches of nucleation. In our case, species richness response was very heterogeneous and species composition was not significantly different to continuous forest (Fig. 4). Therefore, we support investigating edge effect to clarify how bird community is been assembled in forest remnants. In the literature, we detected that is possible that a non-random loss of dominant species in the community (i.e., those that are more susceptible to extinction in the presence of environmental disturbance), will lead to an increase in resource availability allowing the colonization of species even from outside the community (Sasaki et al. 2009). In practice, bird generalist species can be favored because they have ecological features that facilitate resistance to these environmental changes (as drought and light), or the colonization of habitats that have been modified (Morante-Filho et al. 2016), and increasing species turnover. Pfeifer et al. (2017) pointed out bird density is higher at the forest edge. According to Collins et al. (2017), long-term fragmentation in Brazil can diverge plant composition over the time gradually, because edge effect influence is associated with the dynamic structure of the matrix type (e.g. grains agricultural or silviculture). For consequence, bird functional diversity is driven by agricultural transformation in Tropical agroecosystems (Tscharntke et al. 2008). As our forest remnants presents different type of matrix, bird trait and species composition can be easily influenced. Also, secondary effects such as grazing and forest logging (Koch and Côrrea 2010) can critically influence species and trait composition (Cleary et al. 2007).

We found functional convergence in Nucleation-South and Fragmentation sites, however, with higher proportion in forest remnants (Table 1). Fragmentation should lead to functional convergence of species because it will manage to select species that are capable of coping with the resultant environmental variation (Flynn et al. 2009, Bregman et al. 2016, Prescott et al. 2016). This selection of resistance species to fragmentation will also affect functional diversity, because species will present repetition of functional traits and may indicate how functionally similar species are (Mori et al. 2013). For example, species' functional distances from the center of the functional space will be lower (FDis). In fact, one of the main negative effects of fragmentation is the loss of forest specialist birds, which can lead to the loss of the ecological functions performed by them (Anjos et al. 2019). However, even if extinctions do occur, functional diversity in the community could remain unchanged (Hidasi-Neto et al. 2012, Edwards et al. 2013), with changes only in trait composition and functional integrity (De Coster et al. 2015). We would like to point out sites that used mist net as the sampling method were the ones that presented observed values of functional diversity lower than expected. The method could be influencing our result, since mist nets capture mainly understory species. Indeed, sites associated to PCoA axis 2 (Fig. 3) are forest remnants where mist net was applied.

Conversely, with time, a second filter could be selecting species and functional traits. Because functional similarity could lead to interspecific competition, species will coexist by using different resources (e.g. ecological niches) leading to functional divergence (MacArthur and Levins 1967, Botta-Dukát and Czúcz 2016), which one supports higher values of functional diversity (Table 1, F17 and F18). Indeed, predicting future trajectories of diversity response in real ecosystems is extremely changeable (Mayfield et al. 2010). Species with unique traits appeared more often on continuous forest and Nucleation-North, which one is supplied by species and functions from a source of continuous forest (Fig. 4 and 5). In turn, continuous areas have the potential to harbor more species than a forest patches immersed in a natural grasslands landscape, or a forest remnant that has suffered its habitat disruption (forest remnants).

Conclusion

This study was groundbreaking in detecting ecological patterns of distinctive processes at the forest, but with adverse ecological effects in bird communities. Low species number and unique composition corroborate with low functional diversity, starting with a restricted distribution of functional traits in nucleation (early stages of forest), and over time new species and complementary functions are added to the ecosystem. This assembly process can be accelerated by landscape features such as the proximity of forest patches to continuous forests. In contrast, anthropogenic disturbance, as fragmentation, for example, may modify a continuous forest, usually the climax stage of a natural succession, in a fragmented forest landscape, where complex processes of local extinctions and re-colonization occur in the forest remnants (Laurance 2010). The consequences for functional diversity also reflect functional convergence, however, the intensity of the disturbance can deplete species and ecological functions that were found only in mature stages of forest. We consider of high importance to investigate such details in order to trace the identity of species and functions that are lost. All species are important for ecosystem processes, however, we defend focus on core forest species, because they are associated to the threatened Araucaria forest, and the loss damage can be irreversibly replaced. Also, depending on the spatial configuration of the most species-rich remnants, they may be impoverished by the extinction debt by time (Lira et al. 2012).

The use of knowledge on bird ecological functions in these remnants and also in different landscapes with natural changes are fundamental for management and conservation measures. Birds are key elements in the intrinsic and indirect relationship with the forest and respond sensitively to environmental changes. They clarify the environment-fauna relationship within ecology, since among the ecological functions performed by birds, many of them are ecosystem services, that is, they are ecological functions that humanity also benefits from, for example, pollination and insect pest control (Sekercioglu et al. 2016). In conclusion, functional diversity of fragmentation sites is uncertain, while nucleation sites are exclusive communities in species composition and provide the maintenance of Araucaria forest. We call for more efficient conservation actions to expand Araucaria forest in conservation units. Associating ecology with conservation practices is a huge challenge today for tropical underdeveloped countries, such as Brazil, however, an efficient inspection about forest fragmentation and habitat loss is emergency, as Araucaria forest can recover itself by the natural nucleation process. We hope that with a larger forest distribution will ensure the protection of biodiversity and ecological functions of an extinction endangered ecosystem.

Declarations

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- Author contributions – First author conceived the manuscript idea and experimental design, collected, compiled and analyzed the data, wrote and edited the manuscript. Second author conceived the experimental design, contributed to data analysis and edited the manuscript. Third and fourth authors helped partially in data analysis and edited the manuscript. Fifth author collected the data and edited the manuscript. Sixth conceived the experimental design and edited the manuscript. And last author conceived the idea, collected the data, wrote and edited the manuscript.

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Figures

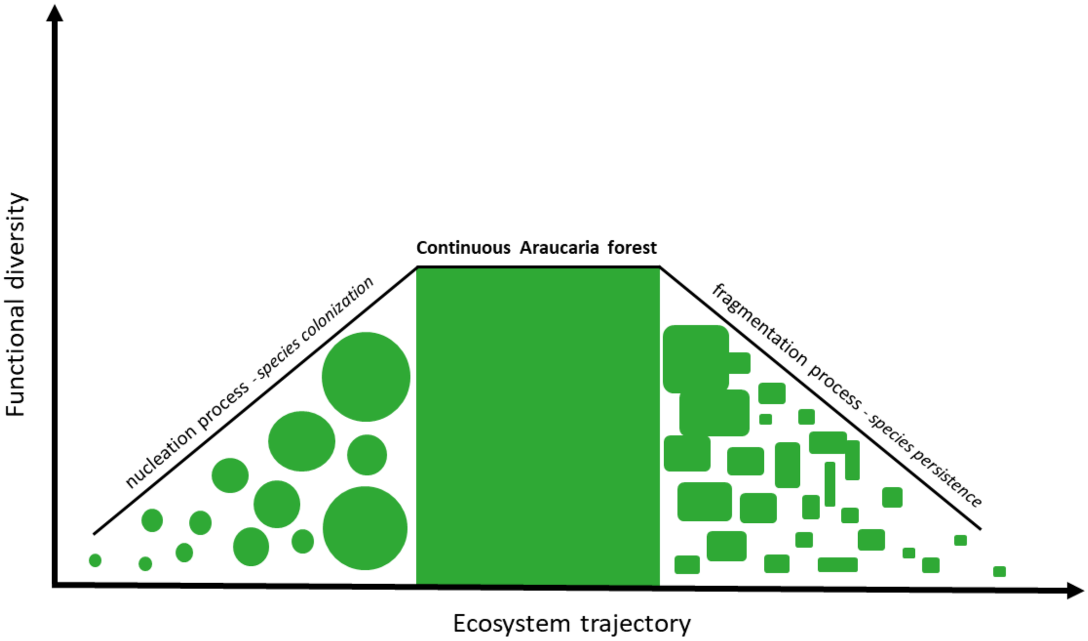

Figure 1.

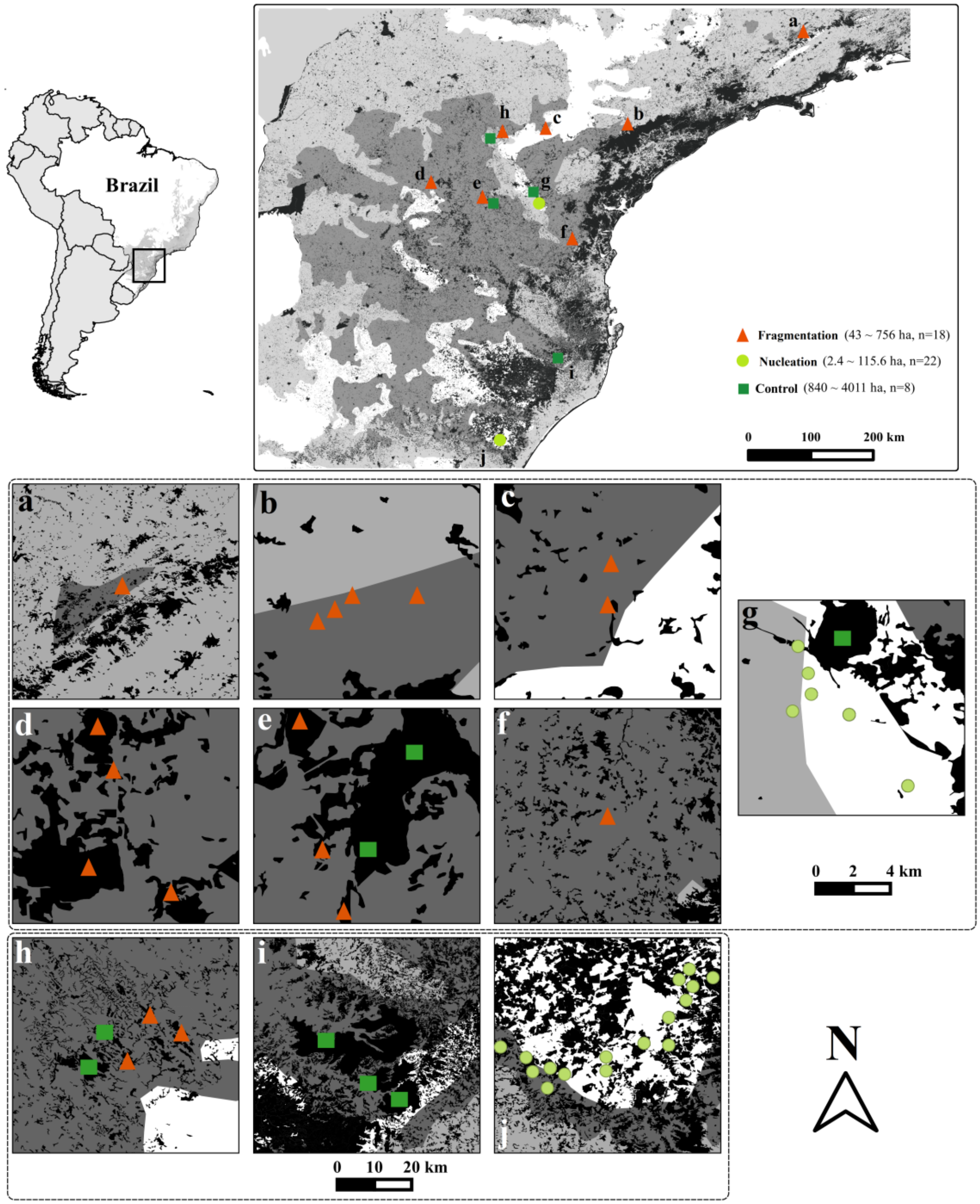
Brazil
a
b
c
d
e
f
g
h
i
j
▲ Fragmentation (43 ~ 756 ha, n=18)
● Nucleation (2.4 ~ 115.6 ha, n=22)
■ Control (840 ~ 4011 ha, n=8)
0 100 200 km
0 2 4 km
0 10 20 km
N

Figure 2.

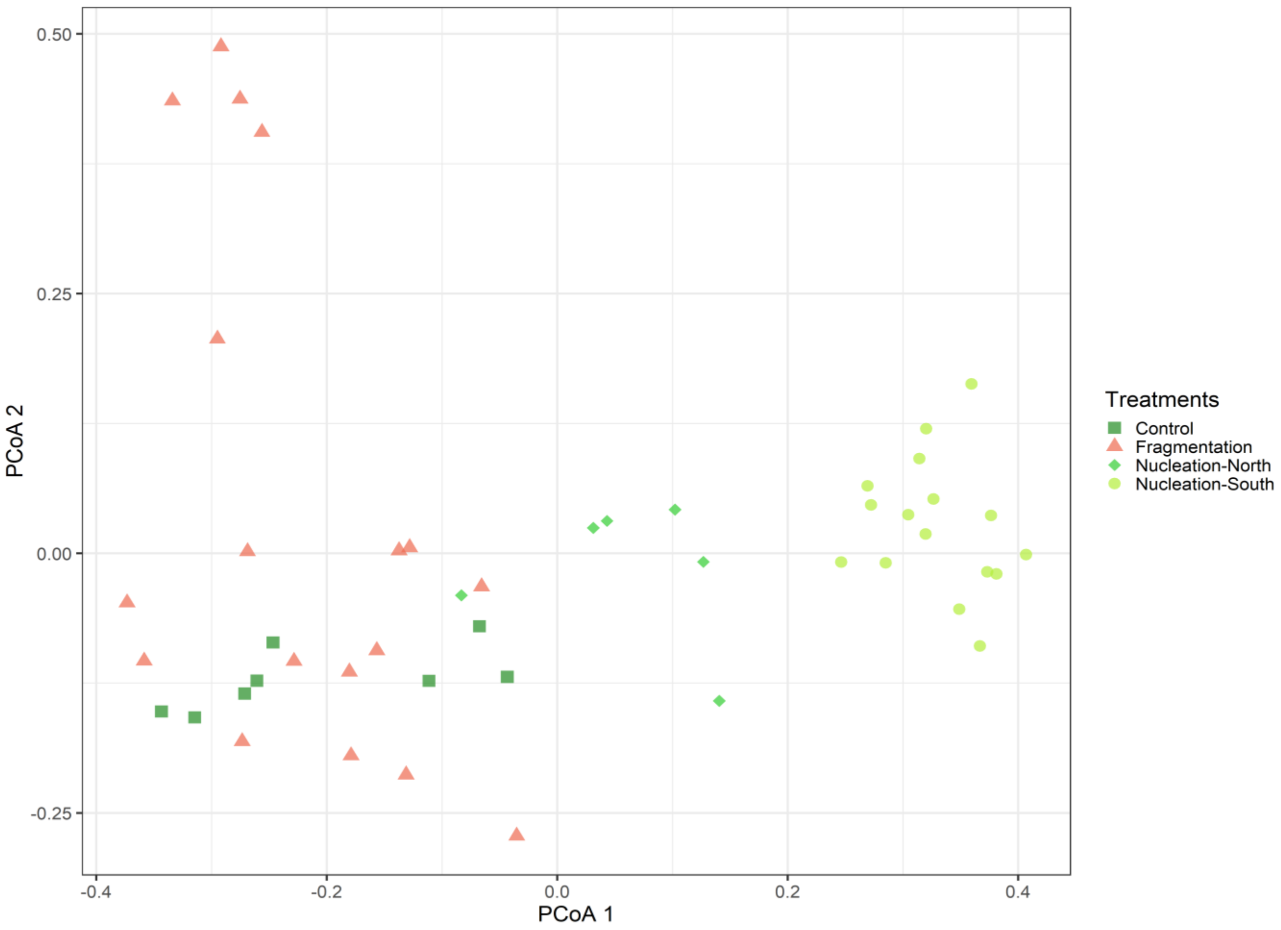
0.50
0.25
0.00
-0.25
PCoA 2
-0.4
-0.2
0.0
0.2
0.4
PCoA 1
Treatments
Control
Fragmentation
Nucleation-North
Nucleation-South

Figure 3.

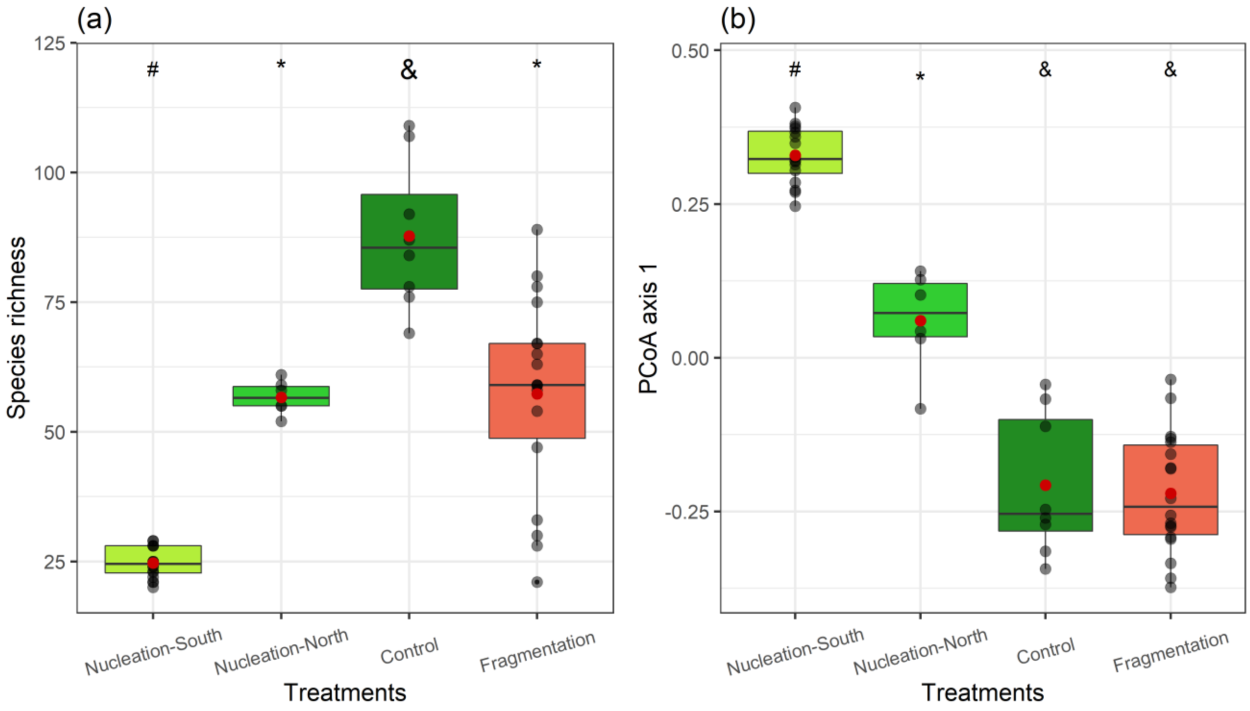

Figure 4.

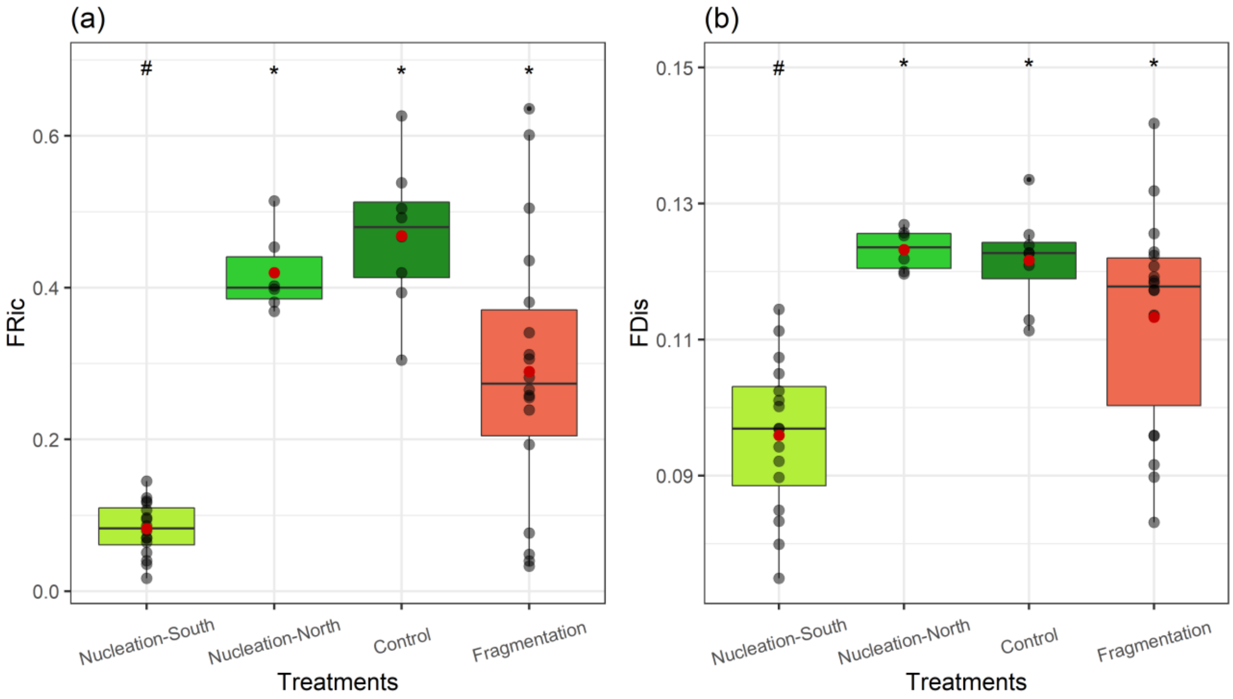

Figure 5.

Figure legends

Figure 1. Conceptual diagram showing two distinctive processes of Araucaria forest ecosystem trajectory, South Brazil. From left to right: green spheres represent nucleation process, that is, forest patches expand into the landscape (Yarranton and Morrison 1974) and over long time they will become climax and continuous forest (single green rectangle). Colonization of novel species increases functional diversity until a stable stage in continuous forest. In sequence, several green rectangles show disruption of forest resulting in forest remnants after disturbance. This process happens in a much shorter period when compared to nucleation. Here, species persistence decreases with time, as well functional diversity, and species richness management depends on spatial configuration of landscape.

Figure 2. Map showing the distribution of the Atlantic Forest in Brazil, South America. Magnified map shows Araucaria forest original distribution and current forest cover. Location of study regions are shown according to the letters. Orange triangles indicate fragmentation regions (forest remnants), light green circles indicate nucleation regions (natural forest patches) and green squares indicate continuous forest regions (control). Site location of each study region is magnified bellow with the number of local sampled sites for each region.

Figure 3. Principal coordinate analysis (PCoA) was computed using just presence and absence bird data among the 48 sample sites of Araucaria forest at South Brazil. First axis explained 38.16% of data variation. Each sample site was painted according three different treatments of forest: fragmentation in orange triangles (forest remnants); continuous forest in dark green squares (control); and nucleation (natural forest patches) was subdivided in two sub-categories, Nucleation-North in ligh green circles and Nucleation-South in olive green lozenges.

Figure 4. All treatments of Araucaria forest at South Brazil in relation to bird species richness (**a**) and first axis (38.16% data variation) of Principal coordinate analysis (PCoA) about bird species composition (**b**). In (**a**) GLM negative binomial showed higher species richness for continuous forest (control). In (**b**) species composition was not different only between fragmentation and continuous forest (control).

Figure 5. Functional diversity metrics calculated by each Araucaria forest treatment at South Brazil. (**a**) FRic represents differences in Functional richness of bird traits in the functional space. Only Nucleation-South was different from remaining treatments, showing the lowest mean. (**b**) FDis represents differences in Functional dispersion of bird traits in the functional space. As well as FRic results, only Nucleation-South was different from remaining treatments with the lowest mean.

Table 1.

Study region	Site id	Treatments	Local richness	Regional richness	FRic	p-value FRic	FDis	p-value FDis
e	C1	Control	69	254	0.305	0.002	0.111	0.17
i	C8	Control	92	229	0.626	0.636	0.134	0.024
j	N12	Nucleation-South	21	199	0.040	0.004	0.085	0
j	N13	Nucleation-South	24	199	0.070	0.008	0.097	0.054
j	N14	Nucleation-South	28	199	0.064	0	0.092	0.03
j	N15	Nucleation-South	20	199	0.017	0	0.075	0
j	N20	Nucleation-South	22	199	0.035	0	0.080	0
j	N22	Nucleation-South	29	199	0.051	0	0.083	0.002
d	F4	Fragmentation	63	254	0.265	0.006	0.113	0.86
d	F6	Fragmentation	59	254	0.255	0.002	0.126	0.458
h	F10	Fragmentation	65	263	0.312	0.006	0.119	0.806
b	F11	Fragmentation	21	279	0.033	0	0.096	0.088
b	F12	Fragmentation	30	279	0.040	0	0.083	0.002
b	F13	Fragmentation	28	279	0.049	0	0.096	0.06
b	F14	Fragmentation	33	279	0.077	0	0.090	0.006
f	F15	Fragmentation	89	258	0.193	0	0.092	0
c	F17	Fragmentation	59	259	0.601	0.024	0.132	0.062
c	F18	Fragmentation	67	259	0.636	0.036	0.142	0

Table legends

Table 1. Species richness and functional diversity for Araucaria forest treatments, South Brazil. Araucaria forest treatments represent different forest process: Fragmentation (forest remnant) and Nucleation (natural forest patches) was subdivided in two sub-categories, Nucleation-North and Nucleation-South. Continuous forest is represented as ‘control’. Each treatment has a identity code (Site id) and it is localized in a speciphic study region (classified in letters). Species richness is informed in two scales: local and regional. Regional species richness for Potential list (used in null model approach) was compiled using BirdLife species distributions shapefiles. Functional richness (FRic) and Functional dispersion (FDis) represent functional diversity metrics. P-values of randomizations of null models are separated for both functional diversity metrics, blue colors represent values lower than expected by chance and red colors represent greater values than expected by chance.

SUPPLEMENTARY MATERIAL

Does forest expansion and fragmentation impact in the same way bird functional diversity?

Larissa Corsini Calsavara, Cristina Banks-Leite, Marcos Robalinho Lima, José Ricardo Pires Adelino, Jan Karel Felix Mähler, Sandra Maria Hartz, Luiz dos Anjos

Dynamic between natural grasslands and Araucaria forest in the past

In Southern Brazil, there is a very particular forest ecosystem, Araucaria forest. Moreover, the large abundance of pine trees, especially *Araucaria angustifolia* (Bertol.) Kuntze has originated its name (Graeff 2014). Climate conditions are restricted on high pluviosity and moderate temperatures, especially lower during the winter (Castella and Britez 2004). Araucaria forests have a rich and dark soil because of the high production of humus due to high humidity and low temperatures. These conditions slow down the decomposition process, which leads to the storage of favorable nutrients and mineral components that allow the occurrence of high plant species diversity (Hueck 1972). Araucaria forests are characterized by high floristic diversity, pronounced stratification, well developed understory (e.g. presence of herbaceous plants such as, shrubs, arborescent ferns, small trees and palm trees) and a high occurrence of epiphyte species (Castella and Britez 2004). Moreover, *Araucaria angustifolia* (Bertol.) Kuntze is considered a very long-lasting “pioneer”, that can germinate under shade, but its seedling development should take place in clearings or open areas (Hueck 1972). This pine tree attracts many frugivorous bird species to its parallel branches to ground (Hartz et al. 2012), it is relatively common to find pure araucaria clusters in natural grasslands, creating a mosaic landscape (Hueck 1972). These forest patches are formed by a natural process called nucleation (Yarranton and Morrison 1974).

Based on studies by Behling (1995 and 2002), with palynological data (pollen grains) from Southern Brazil (2002), he could explain the expansion of Araucaria forest over the dominant grassland landscape at the time (nucleation process). In 1995, Behling states that grassland areas predominated throughout the late Pleistocene and Lower and Middle Holocene. During this period the climate was colder and drier, and only in the Upper Holocene did araucaria pine clusters begin to develop at lower altitudes, such as valleys, where humidity and temperature conditions were favorable, expanding forest patches over the natural grassland. In the Holocene, the process of araucaria nucleation (Duarte et al. 2007), i.e., an early stage of forest succession, would have been interrupted in regions where frequent burning and inappropriate soil conditions existed (Hueck 1972). This is the landscape that persists nowadays in South America (Behling 2002), mainly where the latitude and altitude are higher.

Araucaria forest was formed millions of years ago (Robinson et al. 2018), and in warmer regions, there is a usual formation of continuous Araucaria forest, when forest patches connect themselves. However, continuous forest is under strong anthropic disturbance caused by forest fragmentation, selective logging, agricultural and cattle development (Castella and Britez 2004). These threats started in mid-twentieth century, served by a rampant and poorly organized urban development, which removed up to one million m^3 of wood per year for exportation (Hueck 1972). Despite the threat of extinction (12.6% of the forest remnants, Ribeiro et al. 2009), there are still rare regions with unchanged landscape, conserving this grassland-forest dynamic, so essential for ecosystem survival (Wilson et al. 2019). Conservation measures are urgent, as current protected areas cover only 2.5% of the forested territory and the surviving microrefuges present only in higher altitude areas, according to future climate forecasts, with consecutive losses and significant (Wilson et al. 2019).

Functional data exploitations

To visualize if functional traits were very redundant, we plotted a correlation plot after checking multicollinearity for all possible pairs. We accessed for each functional trait, the VIF value. Hopefully, no functional trait presented VIF value above 10 (Fig. A1). We used 'rcorr' function from 'Hmisc' package (Hollander and Wolfe 1973).

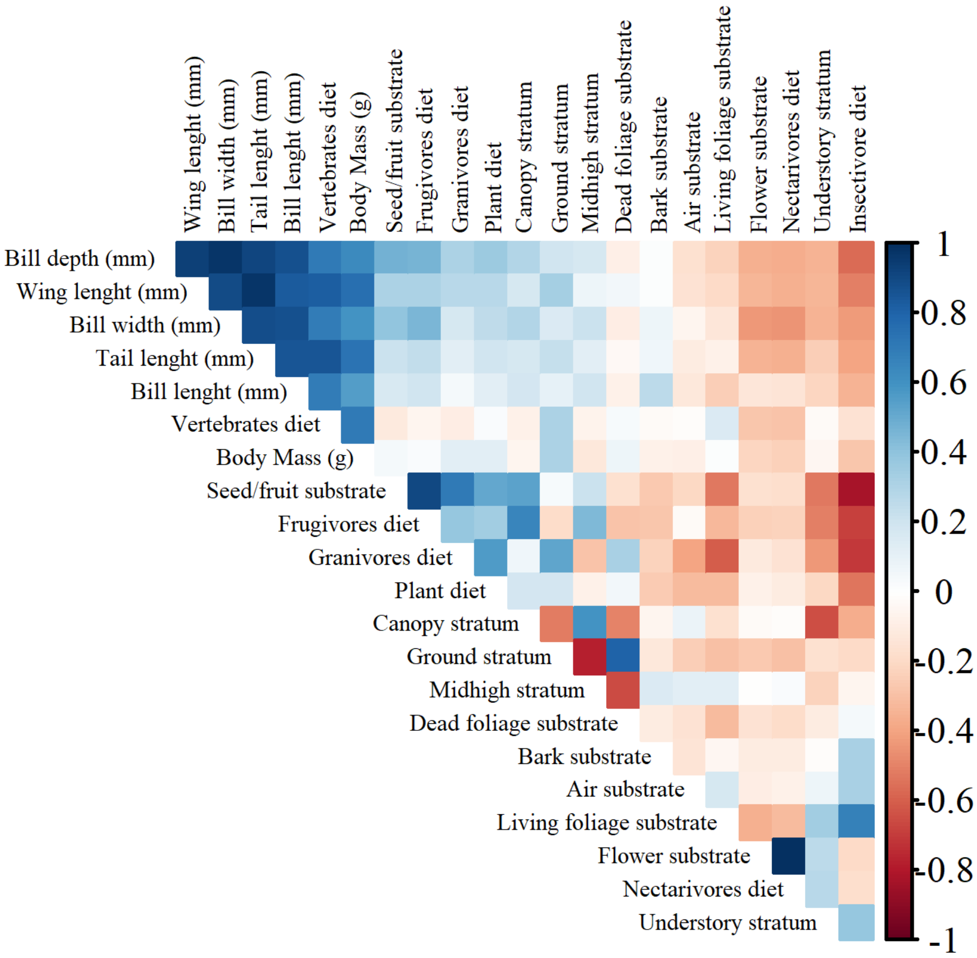

Figure A1. Correlation plot about functional traits of bird communities of Araucaria forest in South Brazil. Color gradient represents positive (blue) and negative (red) correlations. We have checked collinearity and correlation among functional traits.

Tabela S1. Species morphometric measures from Rodrigues et al. 2019. Species names are based on BirdLife nomenclature (2017).

Species	Body mass (mean in g)	Bill length (mean in mm)	Bill width (mean in mm)	Bill depth (mean in mm)	Wing length (mean in mm)	Tail length (mean in mm)
Agelaioides badius	40.59	18.37	7.11	8.22	88.9	81.67
Amazilia lactea	4.95	18.36	2.98	2.25	48.1	29.56
Amazilia versicolor	4.48	16.46	3.12	2.13	49.9	30.7
Anabazenops fuscus	33.67	21	8.97	8.02	88.12	80.23
Antilophia galeata	21.03	9.64	7.91	4.58	79.69	61.26
Anumbius annumbi	39.12	18.35	4.8	5.3	84	79.67
Aphantochroa cirrochloris	7.05	22.54	4.99	3.45	58.83	46.29
Arremon flavirostris	26.66	13.74	7.74	7.86	75.75	66.66
Arremon semitorquatus	25.05	12.23	8.75	7.47	70.33	69.98
Asemospiza fuliginosus	25.28	12.02	9.61	7.63	62.37	56.35
Buteo brachyurus	434.5	31.74	15.47	17.04	295	148.5
Cantorchilus leucotis	20.28	19.28	4.18	3.94	63.42	45.24
Caracara plancus	944.4	44.58	27.43	27.71	343.19	277.4
Casiornis rufus	20.98	15.28	7.14	4.85	82.17	75.85
Chlorophanes spiza	17.14	16.19	7.18	5.11	56.88	53.26
Cichlocolaptes holti	39.8	23.14	7.54	7.34	94	80.82
Clibanornis rectirostris	45.38	27.3	11.65	7.97	97.5	91
Colaptes campestris	163.5	34.55	13.75	10.65	164	120.81
Columbina minuta	32.06	10.77	3.93	3.43	73.87	53.98
Coryphospingus pileatus	15.08	12.1	5.98	6.3	62.68	57.12
Crotophaga ani	99.31	30.25	16.13	20.52	146.31	177.15
Cyanocorax cyanopogon	100.25	30.2	14.16	11.59	128.4	137.5
Cyanoloxia brissonii	21.34	15.03	10	12.48	74.35	67.59
Cyanoloxia glaucocaerulea	18.35	12.47	9.47	9.86	69.48	65.16
Dysithamnus xanthopterus	16.64	13.85	8.71	5.49	62	51.33
Elaenia albiceps	17.67	10.9	9.4	4	73.1	62.35

Elaenia obscura	26.67	11.92	5.94	4.15	85.81	79.66
Eupetomena macroura	7.91	20.41	3.93	2.62	70.22	78.02
Eupsittula aurea	89.56	18.05	12.5	19.38	131.25	149
Formicivora rufa	12.29	13.49	4.16	3.91	48.75	54.65
Geothlypis aequinoctialis	12.29	12.88	6.28	4.55	56.47	54.64
Heliothryx auritus	5.15	20.02	3.87	2.59	62	49.2
Herpsilochmus atricapillus	9.66	13.99	7.25	4.37	50.2	52.79
Herpsilochmus longirostris	19.14	18.03	4.89	4.14	60.91	57.3
Hirundinea bellicosa	25.86	16.07	7.95	4.6	72	86
Hylocharis cyanus	3.11	17.68	3.77	2.61	47.56	29.53
Hylophilus amaurocephalus	9.11	11.19	6.04	5.02	53.69	49.9
Icterus pyrrhopterus	32.06	19.35	8.29	6.34	86.63	90.46
Knipolegus cyanirostris	16.12	13.95	6.33	4.39	78.36	69.72
Malacoptila striata	43.85	22.84	11.97	10.1	95.45	90.71
Microspingus cabanisi	17.95	12.02	7.1	6.51	66.67	66.79
Myiarchus tyrannulus	26.59	18.64	9.75	6.37	92.41	86.6
Myiobius atricaudus	8.53	8.46	6.73	3.36	61.89	57.92
Myiothlypis flaveola	13.22	13.24	6.14	3.99	64.8	63.47
Neopelma chrysolophum	15.22	8.43	6.67	3.9	67	55.57
Neopelma pallescens	17.41	12.61	8.18	4.79	74.88	60.46
Onychorhynchus swainsoni	19	15.69	10.75	4.62	80	68.17
Ortalis squamata	432.26	27.98	17.42	12.87	191.74	224.67
Orthogonys chloricterus	38.1	18.04	9.55	9.3	96.1	85.84
Phaeomyias murina	9.11	8.84	4.88	2.91	53.88	50.12
Phaethornis ruber	2.8	22.41	3.56	2.25	35.9	31.88
Phylloscartes difficilis	8.85	11.81	8.48	4.57	55.71	48.6
Piculus flavigula	55.5	22.2	8.75	7.05	109.6	57.13
Picumnus albosquamatus	11.52	12.04	4.7	4.73	55.69	33.66
Pipraeidea bonariensis	37.13	12.34	7.62	7.32	91.59	70.37
Platyrinchus leucoryphus	17.95	11.34	12.17	4.47	74	47.32
Pyrocephalus rubinus	18.33	11.94	7.47	4.15	75.83	56.63
Ramphocelus carbo	27.76	17.4	12.51	9.28	81.76	81.44
Rhopias gularis	12.06	11.9	5.34	3.55	53.4	27.63
Saltator maxillosus	52.58	20.18	13.5	14.17	101.67	96.71
Satrapa icterophrys	20.52	15.04	5.04	4.1	84.88	79.07
Serpophaga nigricans	8.97	10.64	6.4	2.8	59.27	55.07
Sicalis flaveola	17.99	9.77	6.22	6.92	61.39	57.21
Sicalis luteola	14.63	10.29	7.1	7.2	71.32	53.22
Sporophila angolensis	14.28	12.74	11.22	11.28	61.5	56.1
Sporophila caerulescens	10.49	8.86	6.26	6.6	55.96	47.51

Sporophila falcirostris	13.46	9.83	9.68	8.65	48	41.48
Sporophila leucoptera	13.62	9.95	8.65	9.07	51	51.09
Stephanoxis loddigesii	3.44	18.06	3.05	1.95	49.28	46.63
Synallaxis scutata	12.79	13.48	5.55	4.38	56.73	63.56
Tangara flava	19.44	13.68	7.9	6.07	72.75	53.94
Tangara ornata	41.28	14.6	9.02	8.13	88.43	69.28
Tangara palmarum	37.52	14.93	9.62	7.33	93.22	75.92
Thalurania furcata	4.59	20.96	4.66	1.94	58.21	38.55
Thamnophilus torquatus	22.73	16.01	6.81	5.74	67.62	67.59
Thlypopsis sordida	55.43	11.87	8.16	5.86	98.71	66.22
Tyrannus savana	30.71	11.95	6.89	5.37	108.48	198.12

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Appendix A

Table A1. Spreadsheet organized with information from studies compiled by Hasui et al. (2018) on Araucaria forest sampling sites used in the current study. Site id: each sample site has a identity code used in this study. ID codref: identification of each sample site in Hasui et al. (2018) study. Bib Ref: bibliographic reference. Method: Sampling method used to survey birds. Number nets: Number of the nets opened in each survey. Net size: Length of each net used during samples (in meters). RN total effort: Sampling effort: total effort of sampling in each location using mist net (number of mist nets*number of sampling hours). Number point counts: number of point counts visited during each survey. Point count temporal replicates: Number of visits in each point count. PE total effort: Sampling effort: number of points*number of temporal replicates. Country: English name of the country. State: code for each state. Municipality: name of the municipality where the sample was taken. Site: local name of the study area. Habitat: Brief local description of where studies were done according to publications or to unpublished and updated data.

Site id	ID codref	Bib Ref	Method	Number nets	Net size	RN total effort	Number point counts	Point count temporal replicates	PE total effort	Country	State	Municipality	Site	Habitat
F11	1705	Martensen, A. C. 2008. Conservação de aves de sub-bosque em paisagens fragmentadas: importância da cobertura e da configuração do habitat. Dissertação de Mestrado. Universidade de São Paulo, São Paulo, Brasil.	Mist net	10	12	689	NA	NA	NA	Brazil	SP	RIBEIRAO GRANDE	Fragmento Boiadeiro	Several
F12	1708	Martensen, A. C. 2008. Conservação de aves de sub-bosque em paisagens fragmentadas: importância da cobertura e da configuração do habitat. Dissertação de Mestrado. Universidade de São Paulo, São Paulo, Brasil.	Mist net	10	12	688	NA	NA	NA	Brazil	SP	CAPAO BONITO	Fragmento Cromossomo	Several
F13	1716	Martensen, A. C. 2008. Conservação de aves de sub-	Mist net	10	12	712	NA	NA	NA	Brazil	SP	RIBEIRAO GRANDE	Fragmento Paulo Nunes	Secondary forest

		bosque em paisagens fragmentadas: importância da cobertura e da configuração do habitat. Dissertação de Mestrado. Universidade de São Paulo, São Paulo, Brasil.												
F14	1718	Martensen, A. C. 2008. Conservação de aves de sub-bosque em paisagens fragmentadas: importância da cobertura e da configuração do habitat. Dissertação de Mestrado. Universidade de São Paulo, São Paulo, Brasil.	Mist net	10	12	689	NA	NA	NA	Brazil	SP	RIBEIRAO GRANDE	Fragmento Radialista	Secondary forest
F15	Bovo_58	Scherer Neto, P., and M. C. B. Toledo. 2012. Bird community in na Araucaria forest fragment in relation to changes in the surrounding landscape in Southern Brazil.Iheringia Série Zoologia 102(4):412–422.	Mist net		NA	20160	NA	NA	NA	Brazil	PR	TIJUCAS DO SUL	Araucaria	Secondary forest
F16	Costa_24	Toledo, M. C. B. 1993. Avifauna em duas reservas fragmentadas de Mata Atlântica, na Serra da Mantiqueira-SP. Dissertação de Mestrado. Escola Superior de Agricultura Luis de Queiroz, Piracicaba, São Paulo, Brazil.	Point counts		NA	NA	NA	NA	NA	Brazil	MG	WENCESLAU BRAZ	Reserva Pedra Branca	Secondary forest
F17	0	NA	Line transect		NA	NA	NA	NA	NA	Brazil	PR	JAGUARIAÍVA	PE Cerrado	Secondary forest
F18	0	NA	Line transect		NA	NA	NA	NA	NA	Brazil	PR	JAGUARIAÍVA	35-PR06	Secondary forest

Appendix B

Table A2. Information related with sample effort, localization and methods from 48 sites of Araucaria forest, South Brazil. Araucaria forest treatments represent different forest configurations: fragmentation (forest remnants), continuous forest (control) and nucleation (forest patches), subdivided in nucleation-north and nucleation-south. Each treatment has a identity code (Site id) and it is localized in a speciphic study region (classified in letters). Longitude and Latitude represents geographic coordinates of central location where bird sampling was realized. Size: size of sample site in hectares. Year: year when bird sampling was realized. Method: method used during the survey. Quantity: Columm represents the number of poit counts visited during each survey or number of mist nets used. Radius/time: diameter used in the radius of point count or number of hours that mist net was used during the survey. Days: number of days the method was used. Hours (approximately): number of hours the method was used.

Study region	Site id	Treatment	Longitude	Latitude	Size (ha)	Year	Method	Quantity	Radius/time	Days	Hours (approximately)	Font
e	C1	Control	-50.5922639	-25.4154861	4011	2013	Point_count	6pts (2x)	100m/15'	4	12h	Calsavara 2016
h	C2	Control	-50.5502556	-24.2996806	968	2014	Point_count	6pts (2x)	100m/15'	4	12h	Calsavara 2016
h	C3	Control	-50.5797222	-24.3558333	1000	2004-2005	Point_count	6pts	100m/15'	8	12h	Anjos et al. 2018
g	C4	Control	-49.8147222	-25.3033333	840	2004-2005	Point_count	6pts	100m/15'	8	12h	Anjos et al. 2018
e	C5	Control	-50.5831556	-25.3798139	3500	2004-2005	Point_count	6pts	100m/15'	8	12h	Anjos et al. 2018
i	C6	Control	-49.3769722	-28.0497472	1000	2004-2005	Point_count	6pts	100m/15'	8	12h	Anjos et al. 2018
i	C7	Control	-49.4601778	-28.0198306	1500	2004-2005	Point_count	6pts	100m/15'	8	12h	Anjos et al. 2018
i	C8	Control	-49.6004361	-27.8884833	1800	2004-2005	Point_count	6pts	100m/15'	8	12h	Anjos et al. 2018
g	N1	Nucleation-North	-49.8310583	-25.2993917	40	1991	Point_count	12 (6 random pts)	100m/20'	12	24h	Anjos and Boçon 1999
g	N2	Nucleation-North	-49.8258917	-25.3140083	20	1991	Point_count	10 (6 random pts)	100m/20'	12	24h	Anjos and Boçon 1999
g	N3	Nucleation-North	-49.7982861	-25.3421611	9	1991	Point_count	7 (6 random pts)	100m/20'	12	24h	Anjos and Boçon 1999
g	N4	Nucleation-North	-49.8337889	-25.3387333	10.5	1995	Point_count	Active search	NA	4	20h	Anjos and Boçon 1999
g	N5	Nucleation-North	-49.8241278	-25.3285306	10	1995	Point_count	Active search	NA	4	20h	Anjos and Boçon 1999
g	N6	Nucleation-North	-49.764125	-25.3871139	6.5	1995	Point_count	Active search	NA	4	20h	Anjos and Boçon 1999
j	N7	Nucleation-South	-50.1942333	-29.1135917	2.4	2008-2011	Point_count	1pt (3x)	50m/15'	2	1h30'	Mähler 2012

j	N8	Nucleation-South	-50.5417278	-29.3909194	3.2	2008-2011	Point_count	1pt (3x)	50m/15'	2	1h30'	Mähler 2012
j	N9	Nucleation-South	-50.5756056	-29.3780528	4.7	2008-2011	Point_count	1pt (3x)	50m/15'	2	1h30'	Mähler 2012
j	N10	Nucleation-South	-50.5915611	-29.4337528	4.7	2008-2011	Point_count	1pt (3x)	50m/15'	2	1h30'	Mähler 2012
j	N11	Nucleation-South	-50.4216139	-29.3528361	5.8	2008-2011	Point_count	1pt (3x)	50m/15'	2	1h30'	Mähler 2012
j	N12	Nucleation-South	-50.1936972	-29.1457444	7.8	2008-2011	Point_count	1pt (3x)	50m/15'	2	1h30'	Mähler 2012
j	N13	Nucleation-South	-50.2072167	-29.1282361	9.8	2008-2011	Point_count	1pt (3x)	50m/15'	2	1h30'	Mähler 2012
j	N14	Nucleation-South	-50.4232333	-29.3797639	10.8	2008-2011	Point_count	1pt (3x)	50m/15'	2	1h30'	Mähler 2012
j	N15	Nucleation-South	-50.2468	-29.2300056	21.7	2008-2011	Point_count	3pts	50m/15'	2	1h30'	Mähler 2012
j	N16	Nucleation-South	-50.6267972	-29.3922417	48.8	2008-2011	Point_count	3pts	50m/15'	2	1h30'	Mähler 2012
j	N17	Nucleation-South	-50.2535361	-29.3112444	49.9	2008-2011	Point_count	3pts	50m/15'	2	1h30'	Mähler 2012
j	N18	Nucleation-South	-50.1144028	-29.1252444	53.6	2008-2011	Point_count	3pts	50m/15'	2	1h30'	Mähler 2012
j	N19	Nucleation-South	-50.7183389	-29.3196222	72.3	2008-2011	Point_count	3pts	50m/15'	2	1h30'	Mähler 2012
j	N20	Nucleation-South	-50.3194167	-29.310125	87	2008-2011	Point_count	3pts	50m/15'	2	1h30'	Mähler 2012
j	N21	Nucleation-South	-50.6437806	-29.3516917	113	2008-2011	Point_count	3pts	50m/15'	2	1h30'	Mähler 2012
j	N22	Nucleation-South	-50.2047389	-29.1937889	115.6	2008-2011	Point_count	3pts	50m/15'	2	1h30'	Mähler 2012
e	F1	Fragmentation	-50.6263222	-25.3338833	678	2014	Point_count	6pts (2x)	100m/15'	3	9h	Calsavara 2016
e	F2	Fragmentation	-50.6054778	-25.4317333	259	2013	Point_count	6pts (2x)	100m/15'	3	9h	Calsavara 2016
e	F3	Fragmentation	-50.6156417	-25.4009056	81	2014	Point_count	5pts (2x)	100m/15'	4	11.5h	Calsavara 2016
d	F4	Fragmentation	-51.5576	-24.9721444	485	2015	Point_count	6pts (2x)	100m/15'	3	9h	Calsavara 2016
d	F5	Fragmentation	-51.5632806	-25.0628806	376	2015	Point_count	5pts (2x)	100m/15'	3	7.5h	Calsavara 2016
d	F6	Fragmentation	-51.5540056	-24.9975278	43	2015	Point_count	5pts (2x)	100m/15'	3	7.5h	Calsavara 2016
d	F7	Fragmentation	-51.5206306	-25.0646389	272	2014	Point_count	6pts (2x)	100m/15'	3	9h	Calsavara 2016
h	F8	Fragmentation	-50.3603778	-24.2631583	1026	2015	Point_count	6pts (2x)	100m/15'	4	12h	Calsavara 2016
h	F9	Fragmentation	-50.4849528	-24.3237361	756	2015	Point_count	6pts (2x)	100m/15'	4	12h	Calsavara 2016
h	F10	Fragmentation	-50.4335278	-24.2183139	619	2015	Point_count	5pts (2x)	100m/15'	4	11.5h	Calsavara 2016
b	F11	Fragmentation	-48.3280556	-24.0961111	6.5	2004-2005	Mist_net	10 nets (12m)	NA	NA	689h	Martensen 2008
b	F12	Fragmentation	-48.2927778	-24.0947222	49	2004-2005	Mist_net	11 nets (12m)	NA	NA	688h	Martensen 2008
b	F13	Fragmentation	-48.3383333	-24.1019444	6.5	2004-2005	Mist_net	12 nets (12m)	NA	NA	712h	Martensen 2008
b	F14	Fragmentation	-48.3452778	-24.1094444	8.8	2004-2005	Mist_net	13 nets (12m)	NA	NA	689h	Martensen 2008
f	F15	Fragmentation	-49.2319444	-25.9663889	13	1988-1994	Mist_net	NA	NA	NA	20160h	Scherer Neto and Toledo 2012

a	F16	Fragmentation	-45.4	-22.56	10	1991-1992	Point_count	NA	NA	NA	NA	Toledo 1993
c	F17	Fragmentation	-49.6539033	-24.1567633	139	2015	Line_transect	NA	NA	NA	NA	Not published. Data avaiable in Hasui et al. 2018
c	F18	Fragmentation	-49.655935	-24.183925	186	2015	Line_transect	NA	NA	NA	NA	Not published. Data avaiable in Hasui et al. 2018

Appendix C

Table A3. Species richness and mean of four richness species estimators for forest treatments of Araucaria forest, South Brazil. The estimators are: Chao (chao), First order jackknife (jack1), Second order jackknife (jack2) and Bootstrap (boot). Each species richness estimator presents percentage (%) and standard error (se) respectively. Number of samples are informed by forest treatment individually (n). Forest treatments are: Nucleation-RS (forest patches), Nucleation-PR (forest patches), Fragmentation (forest remnants) and Control (continuous forest).

Treatments	**Species richness**	**chao**	**% chao**	**chao.se**	**jack1**	**% jack1**	**jack1.se**	**jack2**	**% jack2**	**boot**	**% boot**	**boot.se**	**n**	**Mean**
Control	178	201.30	88.42	10.44	208.63	85.32	14.45	220.09	80.88	193.10	92.18	9.48	8.00	**86.70**
Fragmentation	222	266.27	83.37	14.78	280.56	79.13	26.94	301.37	73.66	250.15	88.75	16.94	18.00	**81.23**
Nucleation-PR	109	118.23	92.19	5.17	129.00	84.50	12.58	131.13	83.12	119.60	91.14	8.07	6.00	**87.74**
Nucleation-RS	47	47.00	100.00	0.00	47.00	100.00	0.00	45.37	103.60	47.48	98.99	0.79	16.00	**100.65**

3. Capítulo 2

Habitat amount drives functional diversity of bird communities at forest-grassland mosaic

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ABSTRACT

The effects of forest amount decreasing have been widely studied in fragmented forest landscapes. In contrast, we investigated here bird communities in a natural process of forest expansion over grassland in a mosaic landscape composed by forest-grassland in southern Brazil. Our approach is on the variations of functional diversity with increasing of forest amount. We focus on differences of functional diversity metrics (Functional evenness - FEve, Functional divergence - FDiv, Functional dispersion - FDis, Functional specialisation - FSpe and Functional originality - FOri) and ecological traits (diet, flight displacement and biomass). All bird community was studied, but we performed additional analyses only for the Passerine group and separately for Suboscines and Oscines passerines. Our system is composed by 8 continuous forest sites and 16 forest patches sites (2.4 - 4011ha). We measured habitat amount gradient considering patch size plus forest proportion in a limited radius. We found that habitat amount benefits dominance of functionally unique species in Suboscines (higher FDis and FOri), while it is negatively associated in Oscines (lower FDis and FOri). As habitat amount increases, the habitat becomes more complex and suitable for understory insectivorous birds. Functional traits analysis showed, for Suboscines, lower flying capacity and biomass, and larger bills are associated to less habitat amount, typical features in colonizer species as edge and canopy insectivores. For the other hand, Oscines species in less habitat amount showed higher flying capacity and small bills, which promotes omnivores species that can disperse seeds in more open landscapes. We emphasize that functional traits reflect the adaptation of species to habitat and they are intrinsically related to ecosystem functioning of forest-grassland mosaic. We also highlight that phylogenetically distinct groups could help to better understand functionality variations associated to habitat amount.

Keywords: Passeriformes, functional evenness, functional dispersion, community-weighted mean, functional trait diversity, Araucaria forest.

Introduction

Birds have become a target group in community ecology research by belonging to diverse diet guilds and by occupying a range of habitats in many places at the world (Kissling et al. 2012, Sekercioglu et al. 2016). Furthermore, birds have ecological plasticity which makes them able to face different environmental restricted conditions, such as, arid landscapes, by particular physiological adaptations (Seymour et al. 2015), or periods of depressed resources, by migration behaviour (Hartz et al. 2012), for example. This ecological plasticity reflects in filling of different ecological niches (MacArthur and Levins 1967, Prescott et al. 2016), and when combined with functional diversity approach, it becomes a key predictor for understanding ecosystem processes (e.g. Bregman et al. 2016). Discriminated into indices, the functional diversity quantifies the multidimensional space occupied by a community, and how functional traits of species are distributed on it (Moulliot et al. 2013). Functional traits can represent ecological functions, i.e., the effect that species play on environment (e.g. Karp et al. 2013). Additionally, functional traits also can influence species response to environmental changes pressure (Mori et al. 2013).

Among environmental changes, many studies associate species decline to habitat loss (e.g. de Coster et al. 2015, Morante-Filho et al. 2015). Moreover, negative effects are also evident when changes in habitat configuration are investigated at the landscape scale (Haddad et al. 2017). Dias et al. (2016) investigated landscape factors in a context of natural restoration of forest fragments, and they observed that bird communities are arranged by landscape context, as forest fragment size and forest cover percentage, instead of restoration time in Atlantic rainforest. Although forest fragmentation is associated to habitat loss, controversies still exist about negative effects of fragmentation *per se* on diversity (Fahrig 2017), i.e., the configuration of remaining habitat arrangement on the spatial scale may favour diversity (Smith et al. 2011). Fahrig (2013), launched the hypothesis which the main determinant of species richness is the habitat amount in a local landscape, regardless of habitat configuration. However, habitat amount has been exploited in loss situations, examining the effect of habitat increasing on natural systems has not received much attention.

In Brazil, there are landscapes formed by forest and grasslands which allow to evaluate the habitat amount effect, in case, forest habitat, over different groups of organisms. This type of landscape occurs in highest altitudes at southern Brazil, between 500 and 1,500m, where exist mosaics of natural grasslands and Araucaria forest clusters (Koch and Côrrea 2010), a transition zone at Atlantic rainforest biome. Those regions are characterized by the expansion of forest over grasslands, in a temporal trajectory of ecological succession, which is known as nucleation (see Duarte et al. 2006). The forest patches, with varied sizes, usually from 5-100ha, have an initial phase when individuals of pioneer species colonize grasslands zones (Yarranton and Morrison 1974). One of those colonizer species is the Araucaria pine tree (*Araucaria angustifolia* (Bertol.) Kuntze), heliophite and with seeds dispersed by animals (Duarte et al. 2007). Pioneer individuals promote forest formation by helping to establish other plant species in a new community, called nuclei (Duarte et al. 2007). In a temporal and spatial trajectory, nuclei can culminate in a continuous forest formation if environmental conditions are suitable (Pillar 2003).

In this study, we evaluated functional diversity of bird communities in a gradient of habitat amount in the mosaic of forest-grassland of southern Brazil. The gradient englobes since forest patches distributed over natural grasslands into continuous forest. It is known that higher habitat availability is associated to the number of species and their functional traits (Karadimou et al. 2016). Thus, we expect that forest habitat amount measure, which includes the size of forest patch plus the habitat amount around a fixed radius, will be positively related to bird functional diversity. That means, our hypothesis is as habitat amount increases, more resources will be available, and that will benefit individuals and species movement. For consequence, bird community will show greater abundance evenness and redundant functional traits. Also, beyond functional diversity response, we evaluated trait response related to species feeding, displacement and biomass. Our hypothesis is species with shorter bills (proportional measures), higher flight capacity (greater wing length) and smaller biomass (low body mass value) will be associated to less forested patches. For both approaches, functional metrics and trait response, we analysed all species community together firstly, and later, only passerines Suboscines and Oscines (Order Passeriformes) as bird groups separately. This procedure was adopted because only in passerines was found variation on functional diversity comparing continuous and fragmented forests (see Anjos et al. 2019). Indeed, we also performed separated analyses for Oscines and Suboscines passerines because the first group is more associated to forest while the second is associated to open areas as grasslands (Sick 1997).

METHODS

Study area

This study covered several regions in southern Brazil, with 24 sample sites in total (Fig. S1). We based our regions choose on Araucaria forest distribution, and exactly 16 from those local sites are concentrated in the ecotone region, where the forest expands over grasslands at southern Brazilian Atlantic rainforest (Fig. S1 - E). The variation size of these 16 sites is between 2.4 - 115.6 ha). The other 8 sites, varying in size between 840 - 4011ha, are distributed closer to forest core region, where the forest type is more continuous (Fig. S1 - A, B, C, D). The minimum distance among sites is 2 km.

Bird fieldworks

We obtained contacts record of bird species in different study regions throughout the southern region of Brazil (Fig. S1). For all study regions, local sites were sampled by the fixed point count method (Bibby 1992), following 15 minutes per point, and considering species identified both by listening and by vision. Samplings have started shortly after sunrise. Each bird individual, group or couple of same species was registered as one contact during the sampling. In this study, we used the contact record as a measure for representing species abundance. The final species list has included only exclusively forest or forest-edge species (del Hoyo et al. 2019).

In the forest-grassland landscape, the radius of point count was 50m, and each point was 200m distant from each other. Each site was sampled for two mornings and the number of point counts varied according to forest area size. Sites smaller than 20ha have only one point count, and sites larger than 20ha have three point counts. Although there is a difference in number point counts, the sampling effort was standardized according to MacNally and Horrocks (2002). Thus, at smaller sites, samples respected the time of 15 minutes, and then the observer remained for another two hours counting the species, with intervals of 5 to 10 minutes between the counting. To avoid pseudo-replication of species already registered previously, we added to the bird list only contacts of new species. At the end of each morning's sampling, the effort sampling totalized in 45 minutes at each site. Sampling was carried out during spring and summer of the years 2008-2011.

In continuous forested landscapes, the radius of point count was 100m. All sites in this landscape were able to establish 6 point counts, separated by 200m spatially, which were sampled in a single morning. Sampling was carried out during spring and summer of the years 2004-2005. These data are published in Anjos et al. (2018). Only two sites were sampled in different years and were not published, su4 in December 2013 and su6 in October 2014 (Table S1).

Forest proportion radius

Firstly, we used the tool from Google Earth Engine to download the maps collection 3 for three Brazilian states: Paraná, Santa Catarina and Rio Grande do Sul. These maps are available in an online geospatial data platform at *MapBiomas*. To do the raster downloads, we considered the year of beginning bird sampling at each study region. Then, they were transformed into binary information, according to the legend code classification for pixel values 'forest formation' (code 3).

In order to define which radius scale would better explain the response variables, that is, the functional diversity metrics and trait functional response, we evaluated the variation of species contacts according to the habitat amount, expressed by forest proportion. We used number of contacts, since all functional metrics are based on species richness and abundance, with one exception, FRic, which only uses species richness. To calculate the habitat amount, we used the 'land.metrics' function of SpatialEco package (Evans 2015) in radii of 200m to 2,000m (since the minimal distance between sites is 2,000m) with intervals of 200m (e.g., 200m, 400m, 600m, etc.) around the central point of bird sampling.

Later, we applied mixed linear models (Zuur et al. 2009) with maximum likelihood estimation, using the 'lme4' package (Bates et al. 2014) with log transformation in response variable to normalize the residues (Table S2). In addition, we have included species richness as a random effect. We used this approach, as more than one species was recorded at different sites, causing a dependency effect between the samples. We obtained 10 candidate models that were compared using the Akaike Information criterion (AICc to correct small sample size). We selected the model with the lowest AICc value (see Burnham and Anderson 2002). We checked residual model to deal with assumptions of normality and homoscedasticity.

Functional traits of bird communities

We selected functional traits related to diet, foraging stratum and morphometric measures to better reflect the species response under changes in habitat (Table S3). We think that these traits may reflect the environmental variations across the habitat amount gradient. That is, small fragments can attract small species, which are specialists in insects that forage near to the forest edge or tree canopy. Unlike continuous forest, with larger habitat, would be more common to find larger frugivorous and species foraging at the forest interior. We gathered these traits from the description of species ecology in already published literature (del Hoyo et al. 2019, Rodrigues et al. 2019). The diet was subcategorized in insects, vertebrates, nectar, fruits, seeds and plants. The foraging stratum was subcategorized in soil, understory, half-canopy and canopy top. We perform bird morphometric measurements, such as bill length, tail and wing, bill width and height (all in millimetres) the Zoology Museum of University of São Paulo (MZUSP, 2015), and we used the average of 5 specimens. We used 2-4 specimens when the species did not have a minimum of 5. For species that were not measured in the MZUSP, we complemented the data with the information available at Rodrigues et al. (2019). We also used the body mass trait, measured in grams (del Hoyo et al. 2019). We used the total 14 functional traits to calculate functional diversity metrics for all species and Oscines. For Suboscines, we excluded the nectar and plants trait, since anyone species explore these resources.

Functional diversity metrics

We used functional diversity metrics to access ecological response of all species, Suboscines and Oscines in a habitat amount gradient. The metrics are: Functional evenness (FEve), Functional divergence (FDiv), Functional dispersion (FDis), Functional specialization (FSpe) and Functional originality (FOri). All of them are related to abundance data. FEve represents the homogeneous distribution of each species abundance and their functional traits in the functional space (Villéger et al. 2008). FDiv represents the divergence of most abundant species in relation to a community centroid, also considering functional traits (Villéger et al. 2008). FDis calculates species distance in relation to community centroid at the functional space, and most abundant species receive weight (Laliberté and Legendre 2010). FSpe represents the trait specialisation by calculating the euclidean mean distance among species in relation to a centre point of community (Moulliot et al. 2013). FOri evaluates how unique the traits could be by comparing a mean distance between neighbour species (Moulliot et al. 2013). As traits used show different dimensions, for all metrics we created Gower distance matrix between pair species (Gower 1966). In addition, functional quality space was evaluated (Maire et al. 2015), and we reduced it using only five axes for better power of explanation in Principal Coordinate Analysis (PCoA). We calculated functional diversity using functions like ‘quality_funct_space’ and ‘multidimFD’ (Maire et al. 2015). As species richness is not our focus, analysis related to taxonomic and functional diversity were performed in parallel (see Supplementary material).

Functional traits composition of community

To assess the functional response of ecological traits to an increasing habitat amount, we used traits related to phenotypes (Luck et al. 2012), as measures of proportion: bill length in relation to width and also to height of bill (millimetres) to relate to diet, ratio of wing length to tail length (millimetres) to relate to flight displacement and body mass values alone (grams) to relate to biomass. All these traits are continuous measures. We used these measures to calculate the trait mean weighted by abundance of each species (Community weighted mean – CWM, Ricotta and Moretti 2011), by the 'functcomp' function in the 'dbFD' package (Laliberté et al. 2014). Furthermore, this analysis was extended to distinctive phylogenetic bird groups in Passerines Order: Suboscines and Oscines (SACC – Remsen et al. 2020). As both groups share a common ancestral, and they have different evolutive history (see Remsen et al. 2020), then probably, morphometric traits could be similar between each other. For example, forest specialists can present more precise response to habitat amount gradient. In other words, as the landscape becomes more forested by nucleation process, biomass could increase or decrease.

Statistical analysis

We used beta regressions to better understand the associations between functional diversity metrics to habitat amount gradient. We choose beta regression approach because functional metrics are scaled between intervals of 0 to 1, and they represent rates, i.e., beta distribution (see Ferrari and Cribari-Neto, 2004). For CWM, we used linear regressions.

All dependent variables were log transformed (log(x +1)) before building all the models to provide normality assumptions, with exception of species richness. In this case, species richness is a variable of counting data, then we checked overdispersion and homoscedasticity after using generalized linear model with negative binomial residual distribution (Crawley 2013).

Moreover, we computed species rarefaction curves to analyse sample effort for nucleation and forest continuous landscape. Also, we checked spatial correlation with Moran's I test, analysing sample unit dependency (Supplementary Material).

All graphic and statistical procedures were performed by R software, version 3.5.2 (R core team 2019).

RESULTS

Firstly, we have recorded 125 bird species in 24 local sites. Within the passerine groups, we have recorded 58 species for Suboscines, and 30 species for Oscines. Most common species were *Elaenia mesoleuca* Deppe, 1830 (179 contacts), *Vireo olivaceus* (Linnaeus, 1766) (94 contacts) and *Setophaga pitiayumi* Vieillot, 1817 (89 contacts). Further, insect specialists represented 53% of all community. Species richness increased according to habitat amount gradient (Table 1 and Fig. S3a, $Z = 7.619$; gl = 23; $p < 0.001$).

The greatest scale effect to evaluate habitat amount to bird contacts was 1,200m, as a radius measure surrounding each local site (AICc = 0,8; ΔAICc = 0,0; peso = 0.343, Table S2). In total, the 24 sites covered a habitat amount gradient between 4 - 97%.

Habitat amount effect on functional metrics

We did not find a significative pattern when functional metrics were regretted to habitat amount for all species (Fig. 1). However, we found significative relationships for FDis and FOri in Suboscines (Fig. 2) and significative differences for FDis, FSpe and FOri in Oscines (Fig. 3). In Suboscines, FDis and FOri presented a positive relation, i.e., most abundant species with unique functional traits are often in sites with higher forest amount (Fig. 2, Pseudo $R^2 = 0.144$; $p < 0.05$ e Pseudo $R^2 = 0.191$; $p < 0.05$, respectively). We found a different pattern for Oscines, which habitat amount negatively affected FDis, FSpe and FOri (Fig. 3). FDis showed that most abundant species have dispersed more based on their functional traits in sites less forested (Pseudo $R^2 = 0.514$; $p < 0.001$). While FSpe showed that species with traits linked to specialisation (Pseudo $R^2 = 0.394$; $p < 0.001$) and FOri with exclusive traits (Pseudo $R^2 = 0.27$; $p < 0.001$) are more often in sites less forested.

Trait functional response

For all bird community, habitat amount was positively related to wing length by tail length ($R^2 = 0.274$; $p < 0.01$) and biomass ($R^2 = 0.229$; $p < 0.05$). However, the proportion between bill length by bill width ($R^2 = 0.438$; $p < 0.001$) and bill length by bill height ($R^2 = 0.194$; $p < 0.05$) were negatively related to habitat amount. Thus, species with longer bills, with shorter wings and low biomass were more common in sites with less forest habitat amount (Fig. 4).

For Suboscines, all functional traits were significantly correlated to habitat amount: wing length by tail length ($R^2 = 0.60$; $p < 0.001$) and biomass ($R^2 = 0.326$; $p < 0.001$) increased. Bill length by bill width ($R^2 = 0.438$; $p < 0.001$) and bill length by bill height ($R^2 = 0.423$; $p < 0.001$) decreased (Fig. 5).

Within analysed traits in Oscines, only wing length by tail length was negatively associated to habitat amount ($R^2 = 0.394$; $p < 0.001$). And bill length by bill height positively associated ($R^2 = 0.171$; $p < 0.05$) (Fig. 6).

DISCUSSION

Forest habitat amount influenced distinctive results in functional diversity metrics when Suboscines and Oscines are compared, and it showed no effect on all species of community. In the case of Suboscines, higher habitat amount values favoured a non-uniform abundance distribution of species functional dissimilar (Fig. 2, greater FDis). The dynamic of new ecological niches with an increase of forest proportion and habitat heterogeneity generates dominance of few species for consequence. It is known that forest in advanced stages, beyond show higher habitat availability, they could be more stable, structurally complex and with uniform resource distribution (Barlow et al. 2007), which provided unique traits diversity (greater FOri). Sites more forested are an indication of a vertical structure in relation to forest strata, with developed understory that provides new spaces of ecological niche. Then, we observed that with time, forest expansion will structure the habitat offering these novel niches, which are occupied by species in later stages of forest. In this sense, functional redundant species from Suboscines, probably canopy insectivores colonize the forest-grassland landscape easily.

Investigating deeply the functional trait response of all species, we noticed that the relationships were remarkably similar in Suboscines (Fig. 4 e 5). Possibly because Suboscines represent 46% of all community. This group is insectivore in majority, therefore, their functional traits reflect in a profile of species with smaller bills, longer wings and larger biomass when habitat amount increases. Wing length is related to flight capacity (Luck et al. 2012), however, this trait could be associated to body mass, in other words, large species have long wings. Higher biomass is linked to higher demand for food resources, as frugivorous (Galetti et al. 2013). For the other hand, at low habitat amount sites, we observed species that need to have an ability to optimize resources, and most of the cases they are insectivores or omnivores, close result of Anjos and Boçon (1999) for forest patches in grasslands. For example, species catching insects in canopy trees or forest edge showed longer tails in relation to wings for doing acrobatics foraging at air (Sick 1997). As a result, these species showed to be the colonizers in sites with more edge, soon, sites with less continuous forest. *Lathrotriccus euleri* (Cabanis, 1868) is an example which tolerates edge effect and *Myiarchus swainsoni* Cabanis & Heine, 1859 that frequently forages on canopy trees (del Hoyo et al. 2019).

Nevertheless, for Oscines, species dominance of dissimilar traits decreased as habitat amount increases, i.e., repeated traits were more common among species (lower FDis). In this way, sites less forested showed greater values of FDis, FSpe and FOri, a negative relation to habitat amount (Fig. 3). Anjos and Boçon (1999) studied bird species in a forest-grassland landscape in Araucaria forest, and they observed omnivores which feed themselves with fruits and insects were more common, that could contribute for compensatory density in this region. Comparing to our results, in forest-grassland landscape predominate less species than continuous forest, however the abundance is high (Fig. 3 e S3). Therefore, in Araucaria forest, insectivores are the majority in community, however, it is possible that Oscines from sites with lower habitat amount that include fruits in their diet are further species in functional space. Thus, this functional complementary conducted for a specialisation and originality of ecological functions in forest-grassland landscapes.

Oscines showed decreasing wing-tail ratio and increasing bill length-height ratio to higher habitat amount values (Fig. 6). Effect opposite for Suboscines. Shorter wings require shorter flight displacement as areas with higher habitat amount. At forest-grassland landscape, flying into a field matrix requires greater flight performance, therefore higher wing length. Another detail is the diet, in addition to insects, species also feed seeds, fruits and even small vertebrates. For example, *Cyclarhis gujanensis* (Gmelin, 1789) is a species that benefits itself from a variety of resources, as well as *Tangara preciosa* (Cabanis, 1850). Both are food generalists with greater flying capacity and with their short bills can more frequently access the forest-grassland landscape and end up dispersing seeds (Anjos and Boçon, 1999). This result is supported by Hartz et al. (2012), which showed that seed dispersers species are more common in this landscape (Duarte et al. 2011).

CONCLUSION

Our study dedicated to evaluating the differences in functional responses in a natural system to habitat amount gradient at Araucaria forest. As habitat amount increases, contrary to our expectations, we found less homogeneity in bird abundance, with greater dominance of functionally distinct species. In addition, we found that flight movement, diet and biomass helped to clarify the profile of species and ecological functions, such as insect control and seed dispersal, which are conducted in the growing gradient of forest. We emphasize that higher bird species richness and functional complementarity in more forested sites are essential supplying species in less forested sites, a relationship that helps in diversity and functioning maintaining of forest-grassland mosaic. Our results provide evidence that the habitat use between Suboscines and Oscines groups is different, and these groups are probably little competing to each other on a spatial scale. This result reinforces that species distribution is associated to limiting factors of environment and to the capacity of species adaptation. We also highlight the importance of investigating functional response in different clades of species, since the results of each group can be hushed when all species are analysed together, especially if the community is rich and diverse.

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Data availability: Our data will be deposited in [url].

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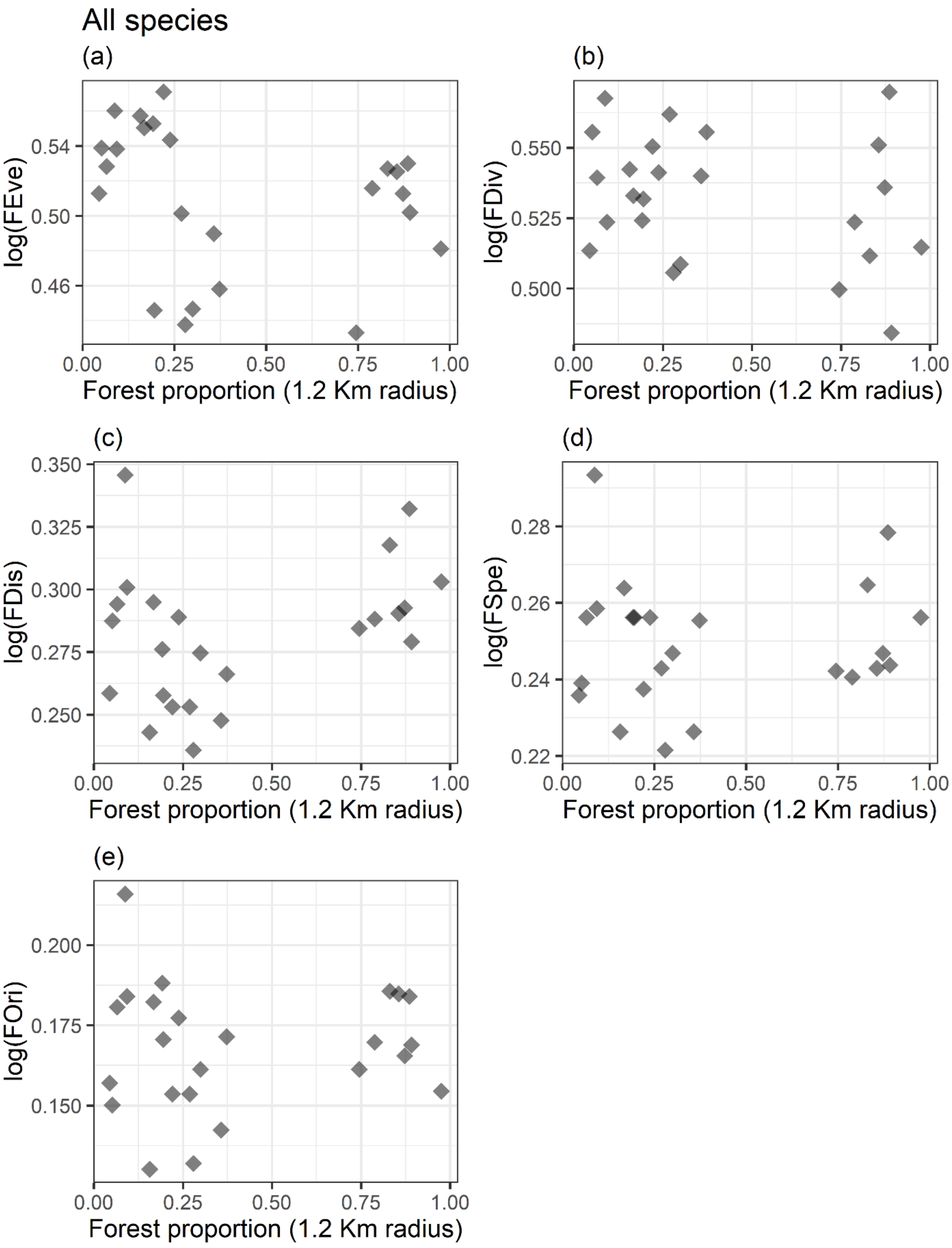
Tables and figures

Table 1. Richness and species contacts for each local sample site at Araucaria forest, South Brazil. Each sample site is identified by a code (ID) and habitat amount represents the forest proportion in a 1,200m radius plus patch area size.

ID	Landscape	Richness	Contacts	Habitat forest amount
su1	Continuous	39	106	0.745
su2	Continuous	55	142	0.789
su3	Continuous	51	135	0.831
su4	Continuous	33	91	0.856
su5	Continuous	47	143	0.873
su6	Continuous	50	123	0.886
su7	Continuous	31	132	0.892
su8	Continuous	47	163	0.976
su9	Forest-grassland	29	45	0.045
su10	Forest-grassland	23	43	0.052
su11	Forest-grassland	24	52	0.065
su12	Forest-grassland	25	52	0.088
su13	Forest-grassland	26	48	0.093
su14	Forest-grassland	21	39	0.157
su15	Forest-grassland	24	40	0.168
su16	Forest-grassland	21	62	0.192
su17	Forest-grassland	25	71	0.195
su18	Forest-grassland	20	68	0.221
su19	Forest-grassland	24	35	0.238
su20	Forest-grassland	22	64	0.269
su21	Forest-grassland	29	90	0.279
su22	Forest-grassland	29	83	0.3
su23	Forest-grassland	28	75	0.357
su24	Forest-grassland	28	71	0.373



All species

(a)
log(FEve)
0.54
0.50
0.46
0.00
0.25
0.50
0.75
1.00
Forest proportion (1.2 Km radius)
(b)
log(FDiv)
0.550
0.525
0.500
0.00
0.25
0.50
0.75
1.00
Forest proportion (1.2 Km radius)
(c)
log(FDis)
0.350
0.325
0.300
0.275
0.250
0.00
0.25
0.50
0.75
1.00
Forest proportion (1.2 Km radius)
(d)
log(FSpe)
0.28
0.26
0.24
0.22
0.00
0.25
0.50
0.75
1.00
Forest proportion (1.2 Km radius)
(e)
log(FOri)
0.200
0.175
0.150
0.00
0.25
0.50
0.75
1.00
Forest proportion (1.2 Km radius)

Figure 1. Beta regressions of functional diversity metrics based on all bird species in relation to habitat amount gradient of Araucaria forest, South Brazil. In (a) Functional evenness - FEve; (b) Functional divergence – FDiv; (c) Functional dispersion – FDis; (d) Functional specialisation – FSpe; (e) Functional originality - FOri.

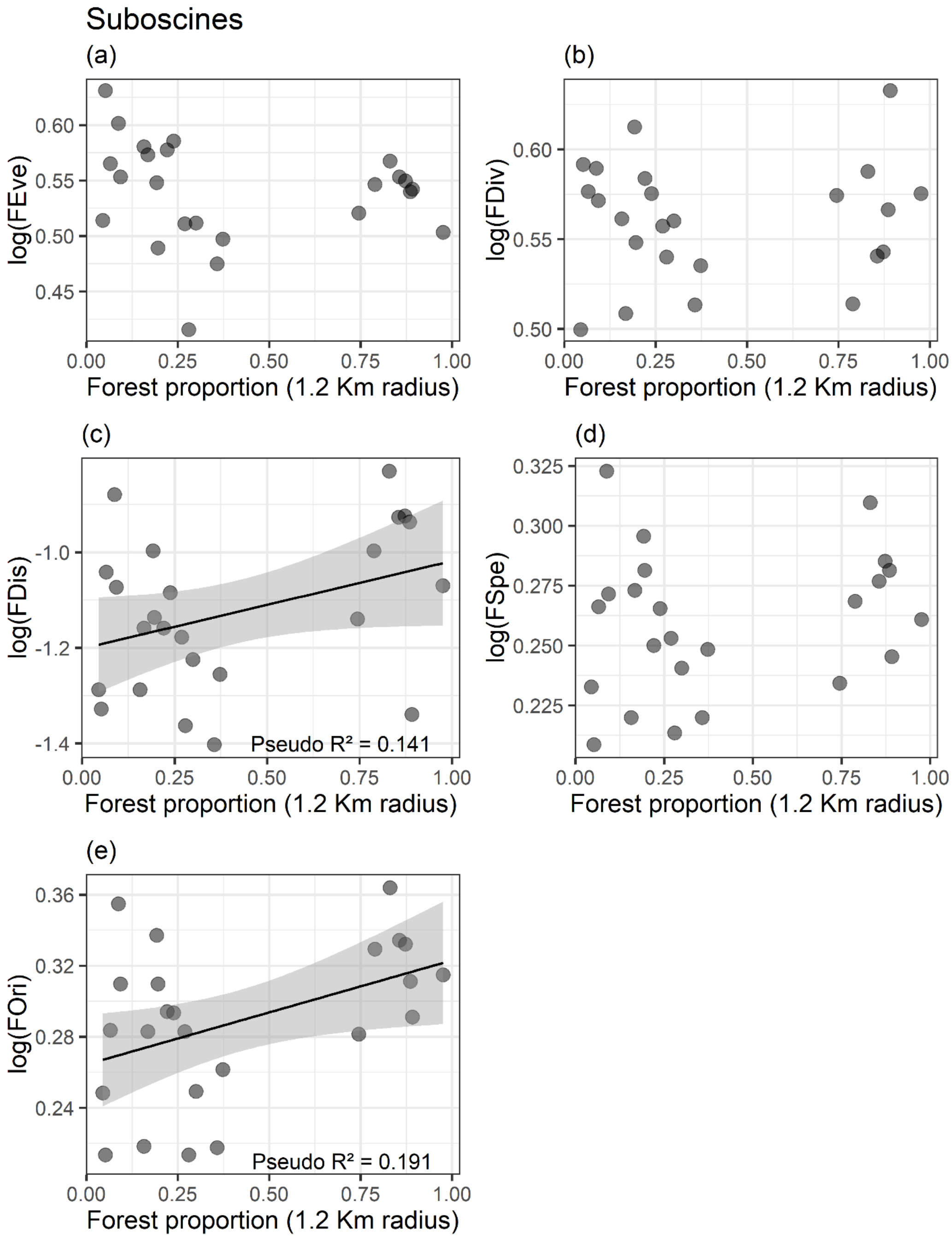


Figure 2. Beta regressions of functional diversity metrics based on all species Suboscines in relation to habitat amount gradient of Araucaria forest, South Brazil. In (a) Functional evenness - FEve; (b) Functional divergence – FDiv; (c) Functional dispersion – FDis; (d) Functional specialisation – FSpe; (e) Functional originality - FOri. Solid lines represent the determination coefficient Pseudo R^2, all significant ($p < 0.05$) and with confidence intervals of 95% (grey area).

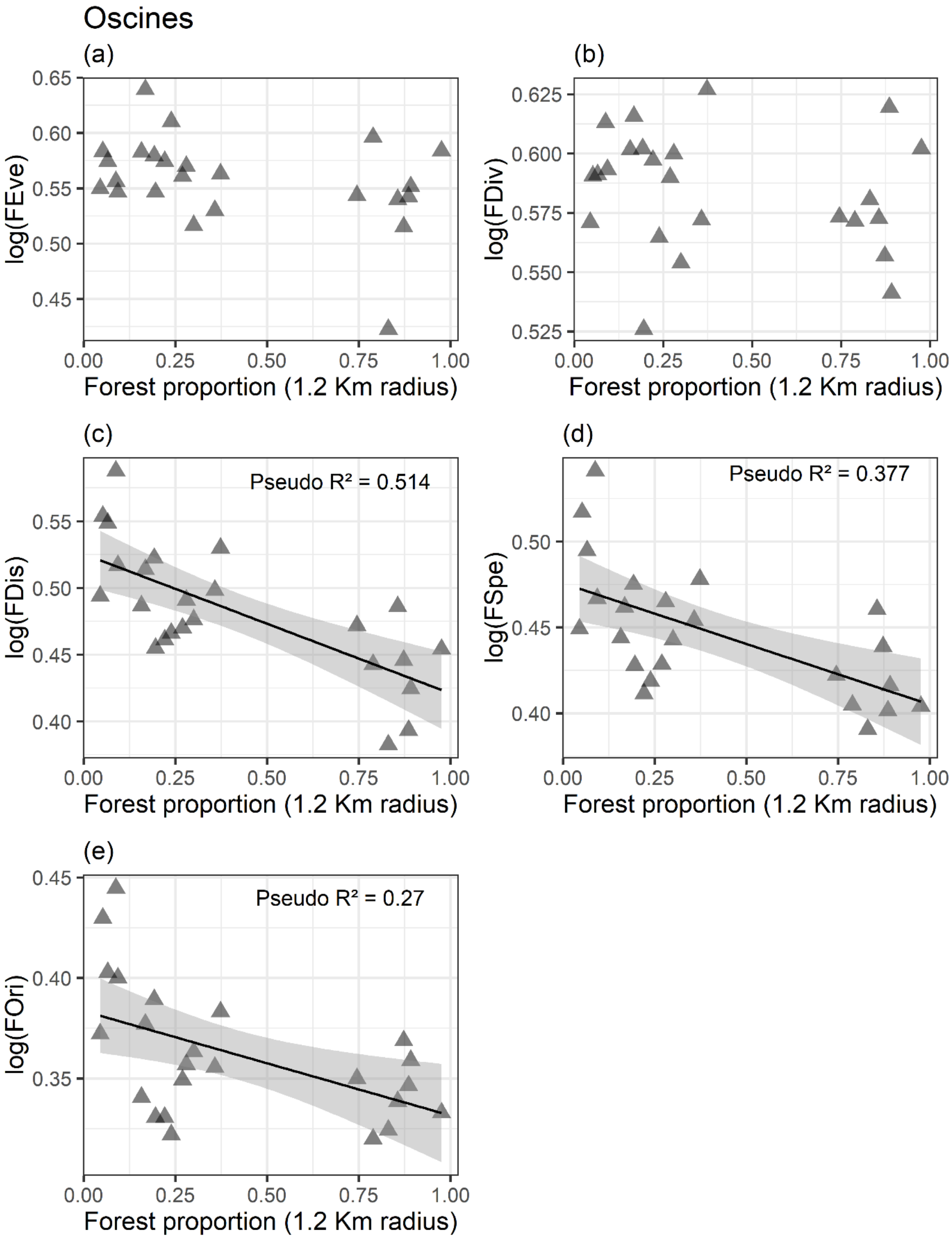


Figure 3. Beta regressions of functional diversity metrics based on all species Oscines in relation to habitat amount gradient of Araucaria forest, South Brazil. In (a) Functional evenness - FEve; (b) Functional divergence – FDiv; (c) Functional dispersion – FDis; (d) Functional specialisation – FSpe; (e) Functional originality - FOri. Solid lines represent the determination coefficient Pseudo R^2, all significant ($p < 0.001$) and with confidence intervals of 95% (grey area).

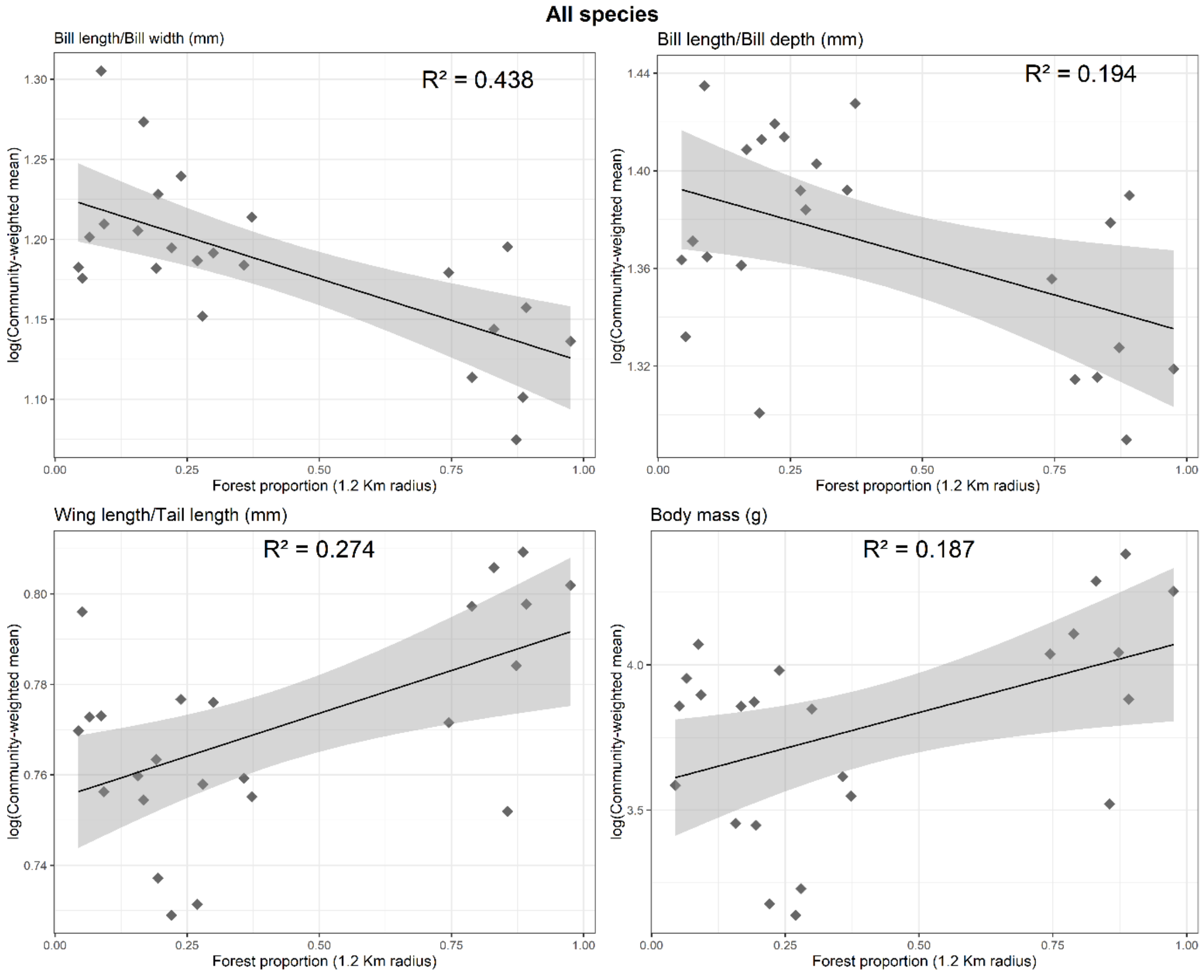


Figure 4. All species community. Linear regressions between morphometric proportion measures and biomass of all bird species to habitat amount gradient at Araucaria forest, South Brazil. Functional traits are: i) bill length by bill width (mm); ii) bill length by bill height (mm); iii) wing length by tail length (mm); iv) body mass values (g). Solid lines represent the

determination coefficient R^2, all significant ($p < 0.05$) and with confidence intervals of 95% (grey area).

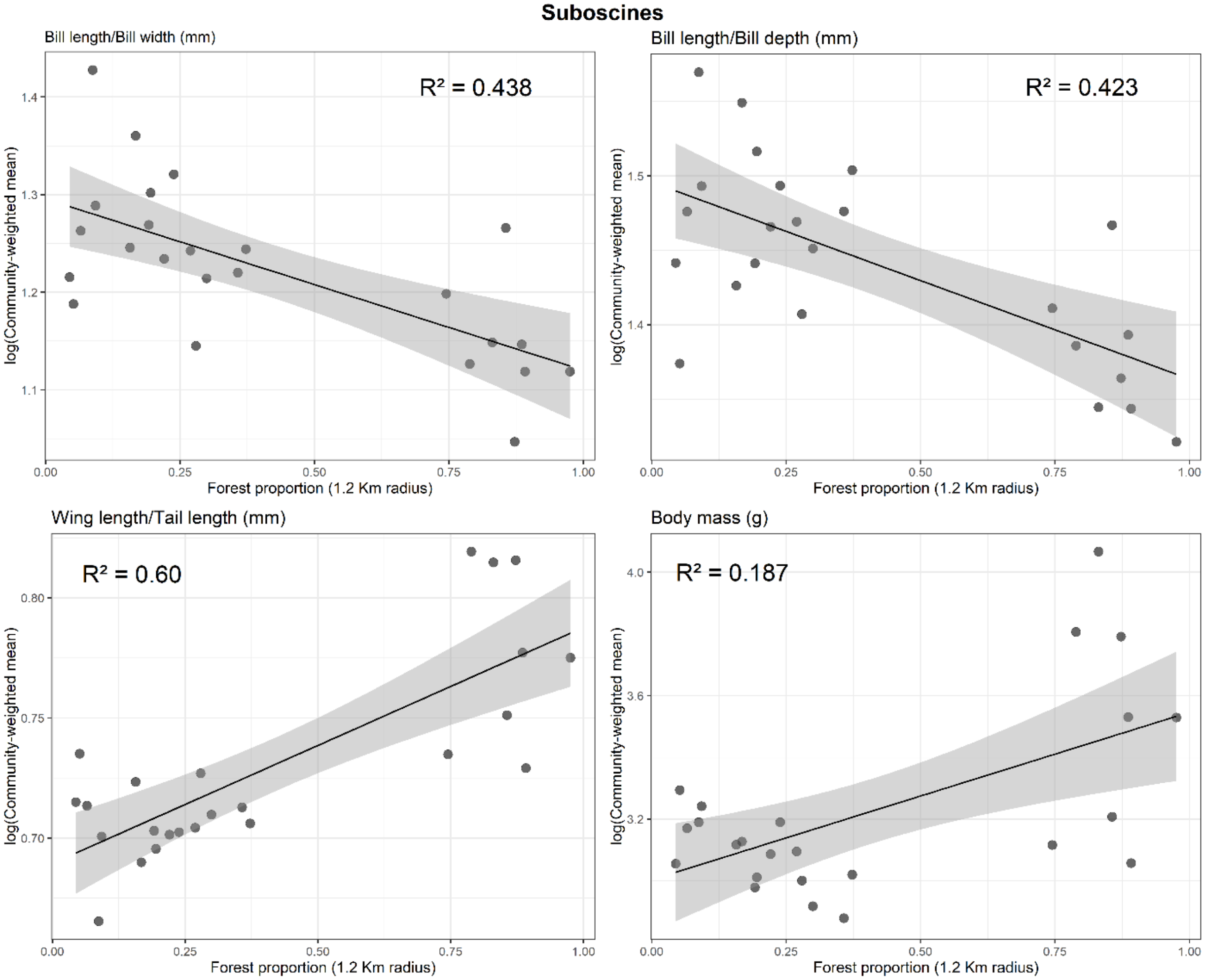


Figure 5. Passerines Suboscines species. All species community. Linear regressions between morphometric proportion measures and biomass of Suboscines bird species to habitat amount gradient at Araucaria forest, South Brazil. Functional traits are: i) bill length by bill width (mm); ii) bill length by bill height (mm); iii) wing length by tail length (mm); iv) body mass values (g). Solid lines represent the determination coefficient R2, all significant ($p < 0.001$) and with confidence intervals of 95% (grey area).

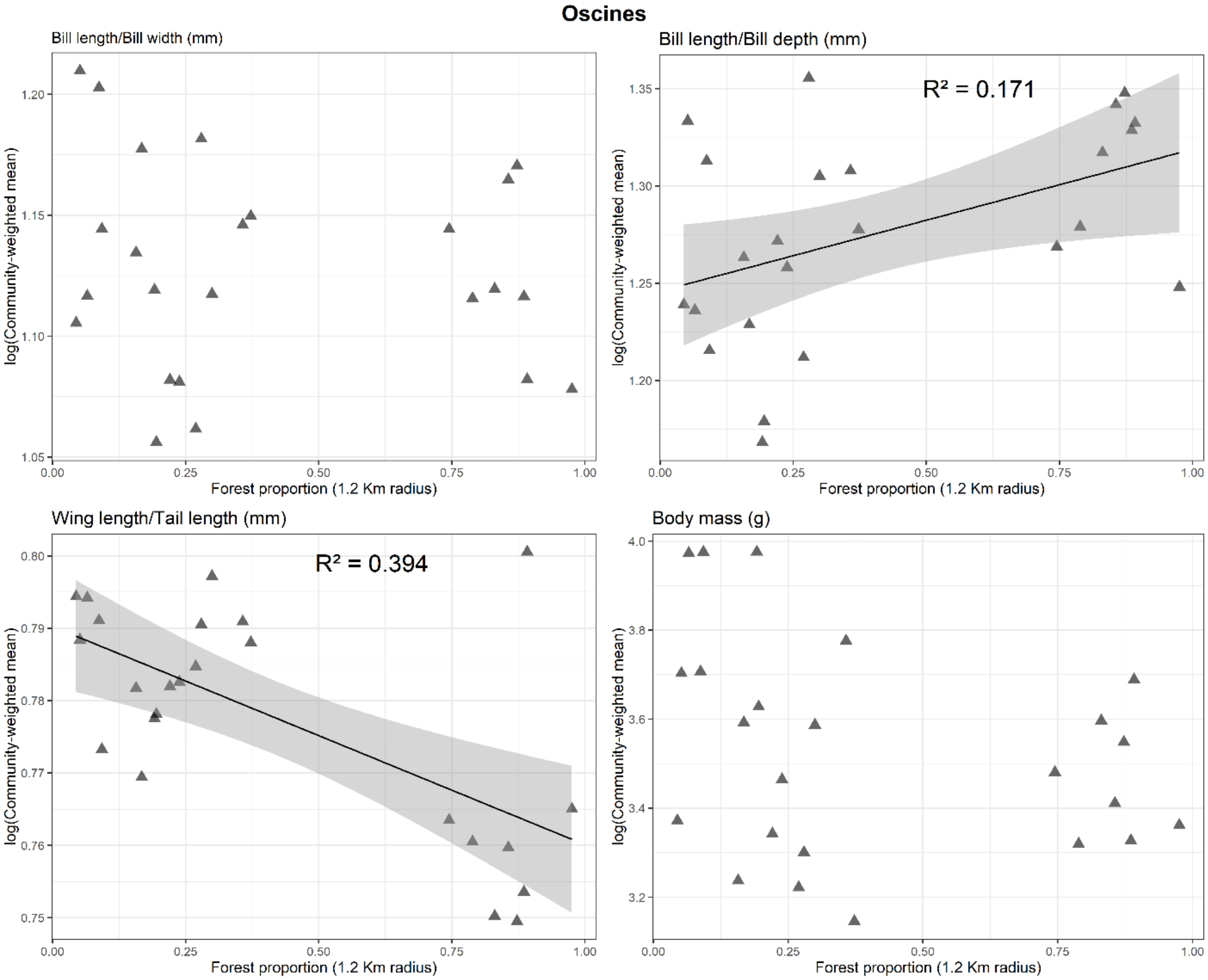


Figure 6. Passerines Oscines species. All species community. Linear regressions between morphometric proportion measures and biomass of Oscines bird species to habitat amount gradient at Araucaria forest, South Brazil. Functional traits are: i) bill length by bill width (mm); ii) bill length by bill height (mm); iii) wing length by tail length (mm); iv) body mass values (g). Solid lines represent the determination coefficient R2, all significant ($p < 0.05$) and with confidence intervals of 95% (grey area).

SUPPLEMENTARY MATERIAL

Habitat amount drives functional diversity of bird communities at forest-grassland mosaic

Larissa Corsini Calsavara, Jan Karel Felix Mähler, Sandra Maria Hartz e Luiz dos Anjos

Map

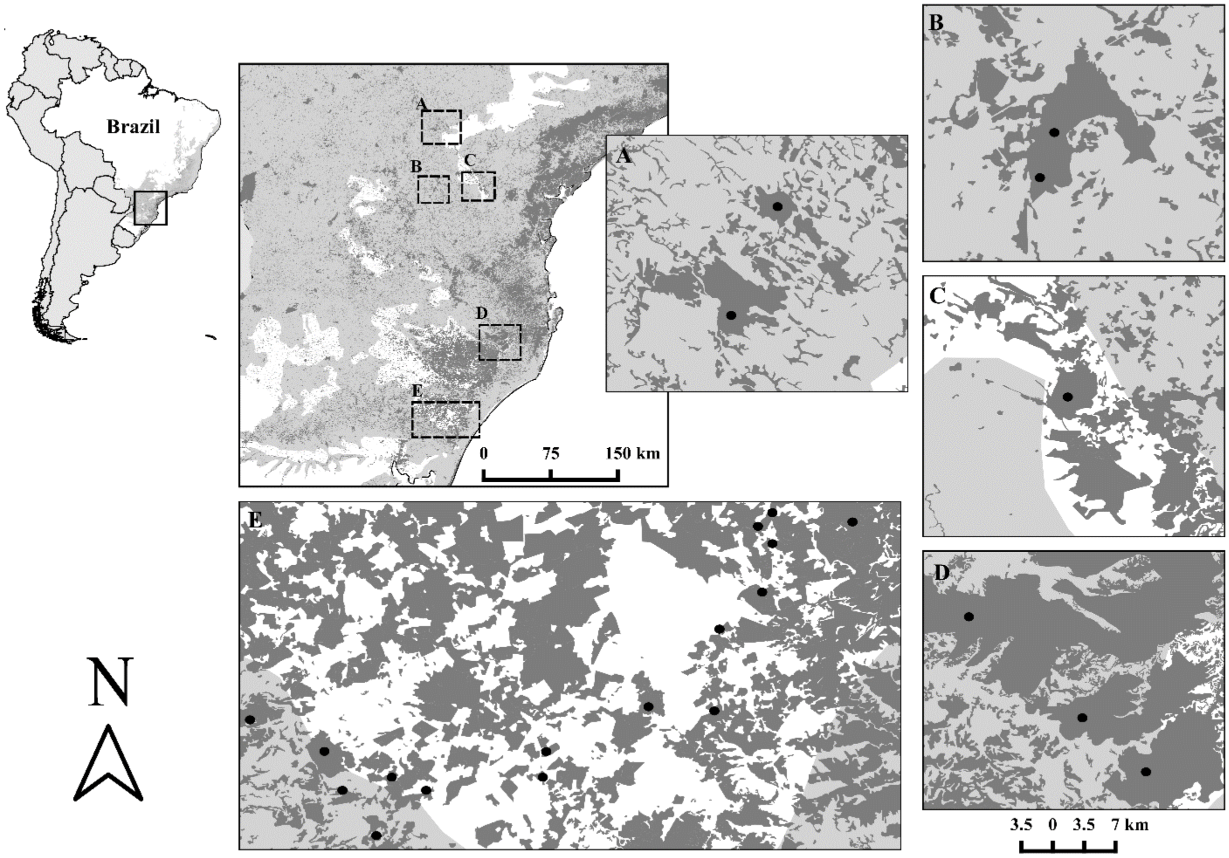


Figure S1. Map with 5 study regions (letters) distributed at Araucaria forest, South Brazil. Lighter grey colour represents original distribution of Atlantic rainforest, dark grey colour represents nowadays distribution of Atlantic rainforest remnants and white colour represents natural grasslands. Areas A, B, C and D are landscapes where continuous Araucaria forest local sites are situated (8 sites in total) and E represents the mosaic of Araucaria forest-grassland at southern Atlantic rainforest biome (16 sites in total).

Rarefaction curves

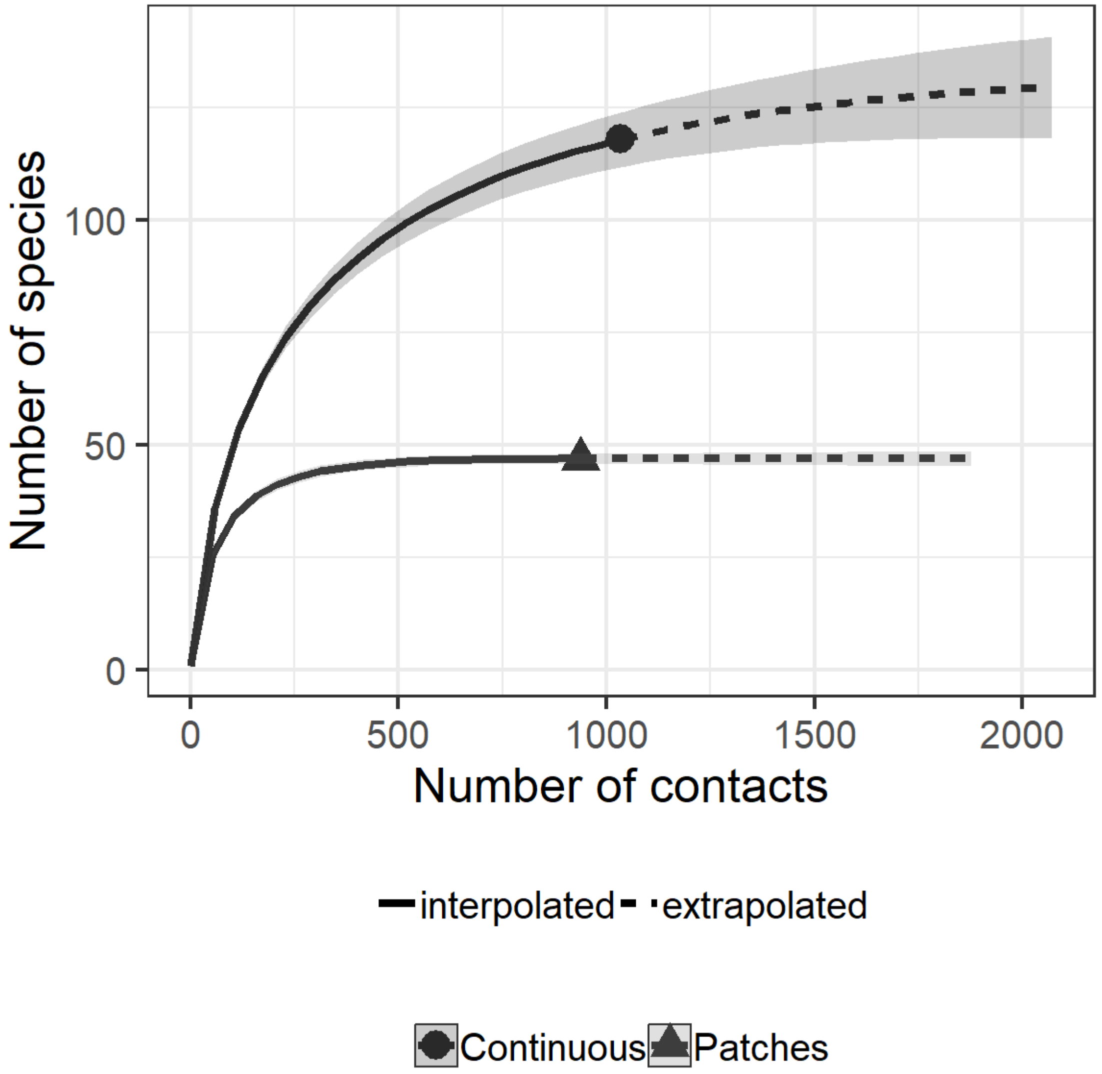


Figure S2. Rarefaction curves for number of species according to number of bird contacts from two similar sampling effort applied: Continuous and Patches. Dashed lines represent the extrapolated curve if sampling effort had been greater. Grey areas represent 95% of confidence interval for Continuous landscape and Patches (forest-grassland landscape).

Autocorrelation test

To ensure that contacts of recorded species were not under spatial autocorrelation effect, we verified it using Moran's I test (package 'ape', Paradis et al. 2004) the model residues, according to Prescott et al. (2016). The Moran's I test showed that there is no spatial autocorrelation ($p > 0.05$).

Table S1. General information about each local sample site at Araucaria forest, South Brazil. ID represents a code to identify each site. Landscape indicates what type of landscape each site is situated. Longitude and latitude represent together the central point of geographic coordinates where bird sampling was performed in each site. Size represents the physical dimension of each site, it was calculated in hectares (ha). Year of bird sampling. Method applied for bird sampling. Number of point counts used in each site. Size radius (meters) and time (minutes) of each site. Total days of bird sampling.

ID	**Landscape**	**Longitude**	**Latitude**	**Size (ha)**	**Year**	**Method**	**Total of point counts**	**Radius/time**	**Days**
su1	Continuous	-49.37697	-28.04975	1000	2004-2005	Point count	6pts	100m/15'	1
su2	Continuous	-49.81472	-25.30333	840	2004-2005	Point count	6pts	100m/15'	1
su3	Continuous	-50.57972	-24.35583	1000	2004-2005	Point count	6pts	100m/15'	1
su4	Continuous	-50.59226	-25.41549	4011	2013	Point count	6pts	100m/15'	1
su5	Continuous	-50.58316	-25.37981	3500	2004-2005	Point count	6pts	100m/15'	1
su6	Continuous	-50.55026	-24.29968	968	2014	Point count	6pts	100m/15'	1
su7	Continuous	-49.46018	-28.01983	1500	2004-2005	Point count	6pts	100m/15'	1
su8	Continuous	-49.60044	-27.88848	1800	2004-2005	Point count	6pts	100m/15'	1
su9	Forest-grassland	-50.42323	-29.37976	10.8	2008-2011	Point count	1pt (3x)	50m/15'	2
su10	Forest-grassland	-50.19423	-29.11359	2.4	2008-2011	Point count	1pt (3x)	50m/15'	2
su11	Forest-grassland	-50.42161	-29.35284	5.8	2008-2011	Point count	1pt (3x)	50m/15'	2
su12	Forest-grassland	-50.54173	-29.39092	3.2	2008-2011	Point count	1pt (3x)	50m/15'	2
su13	Forest-grassland	-50.57561	-29.37805	4.7	2008-2011	Point count	1pt (3x)	50m/15'	2
su14	Forest-grassland	-50.1937	-29.14574	7.8	2008-2011	Point count	1pt (3x)	50m/15'	2
su15	Forest-grassland	-50.59156	-29.43375	4.7	2008-2011	Point count	1pt (3x)	50m/15'	2
su16	Forest-grassland	-50.6268	-29.39224	48.8	2008-2011	Point count	3pts	50m/15'	2
su17	Forest-grassland	-50.25354	-29.31124	49.9	2008-2011	Point count	3pts	50m/15'	2
su18	Forest-grassland	-50.2468	-29.23001	21.7	2008-2011	Point count	3pts	50m/15'	2
su19	Forest-grassland	-50.20722	-29.12824	9.8	2008-2011	Point count	1pt (3x)	50m/15'	2

su20	Forest-grassland	-50.31942	-29.31013	87	2008-2011	Point count	3pts	50m/15'	2
su21	Forest-grassland	-50.20474	-29.19379	115.6	2008-2011	Point count	3pts	50m/15'	2
su22	Forest-grassland	-50.64378	-29.35169	113	2008-2011	Point count	3pts	50m/15'	2
su23	Forest-grassland	-50.1144	-29.12524	53.6	2008-2011	Point count	3pts	50m/15'	2
su24	Forest-grassland	-50.71834	-29.31962	72.3	2008-2011	Point count	3pts	50m/15'	2

Local landscape models

Table S2. Comparison of linear mixed effects models for number of species contacts. Each model had as an independent variable the habitat amount, or forest proportion calculated in different radius zones around the central point of each local site. We used species richness as a random variable. We used AICc selection criteria to choose the most parsimonious model. Best model is in bold.

Models	Radius (m)	AICc	ΔAICc	df	weight
m6	**1,200**	**0.8**	**0**	**4**	**0.343**
m7	1,400	2.1	1.2	4	0.186
m8	1,600	2.7	1.9	4	0.132
m9	1,800	2.9	2.1	4	0.122
m5	1,000	3.5	2.7	4	0.09
m4	800	4.1	3.3	4	0.066
m10	2,000	5.5	4.6	4	0.034
m3	600	5.9	5.1	4	0.027
m2	400	12.9	12	4	<0.001
m1	200	28.1	27.3	4	<0.001

Functional traits

We used functional traits with different dimensions, i.e., ordinal data and continuous data (Table S3). The categories ‘diet’ and ‘foraging stratum’ were ordered with numbers that represent a hierarchy, from 0-3, for preference of resources acquired by birds or preference for foraging strata frequented in the forest. 0 = never, 1 = rarely, 2 = regularly, 3 = frequent. All trait information was gathered from literature (del Hoyo et al. 2019).

Table S3. Description of all functional traits of bird species based on Luck et al. (2012).

Categories	Traits	Dimension	Description
Diet	**Insects**	Ordinal	Food resource preference
	Vertebrates	Ordinal	
	Fruits	Ordinal	
	Seeds	Ordinal	
	Nectar	Ordinal	
	Plants	Ordinal	
Foraging stratum	**Ground**	Ordinal	Preference of the most frequent foraging stratum in the habitat
	Understory	Ordinal	
	Midhigh	Ordinal	
	Canopy	Ordinal	
Biomass	**Body mass (g)**	Continuous	It relates the resource amount used in metabolic rate
Morphometric measures	**Bill length (mm)**	Continuous	Related to diet, foraging strategy and habitat adaptation
	Bill width (mm)	Continuous	
	Bill height (mm)	Continuous	
	Wing length (mm)	Continuous	Related to displacement, foraging strategy and habitat adaptation
	Tail length (mm)	Continuous	

Functional richness and standard effect size (SES)

In this case, we evaluated the gradient of habitat amount effect on functional richness FRic (Villéger et al. 2008). FRic is a functional diversity metric which considers only presence of traits distributed in functional space (Villéger et al. 2008). It represents the convex hull volume occupied by a community. FRic is sensitive to outliers, therefore, functionally dissimilar species occupy the volume extreme limits (Villéger et al. 2008). We know that FRic can be influenced by species richness. For that reason, we shuffled the presence and absence matrix in a way that frequency of occurrence and species richness would be maintained. We did this using the independent swap algorithm (‘independent swap’, Gotelli 2000). We generate 999 null communities. Subsequently, we calculated the standardized effect size for FRic, named as SESFRic (SES, Gotelli and Rohde 2002), which is calculated by comparing observed values with random values by the 'spicy' package (Kembel et al., 2010), according to following procedure:

$$SES = FD_{observed} – \text{mean } (FD_{expected}) / \text{standard desviation } (FD_{expected})$$

Where FD is functional diversity. Negative values indicate that communities are functionally less diverse, and positive values indicate communities that are functionally more diverse than expected by chance.

Our result indicated a positive relationship between species richness and FRic as habitat amount increases, favouring the addition of novel functional traits in the communities (Fig. S3a, Z = 7.619; gl = 23; $p < 0.001$ and Fig. S3b Pseudo $R^2 = 0.519$; $p < 0.001$ respectively). SESFRic showed all sites are functionally less diverse when the randomization of total functional richness is taken into account (Fig. S3c).

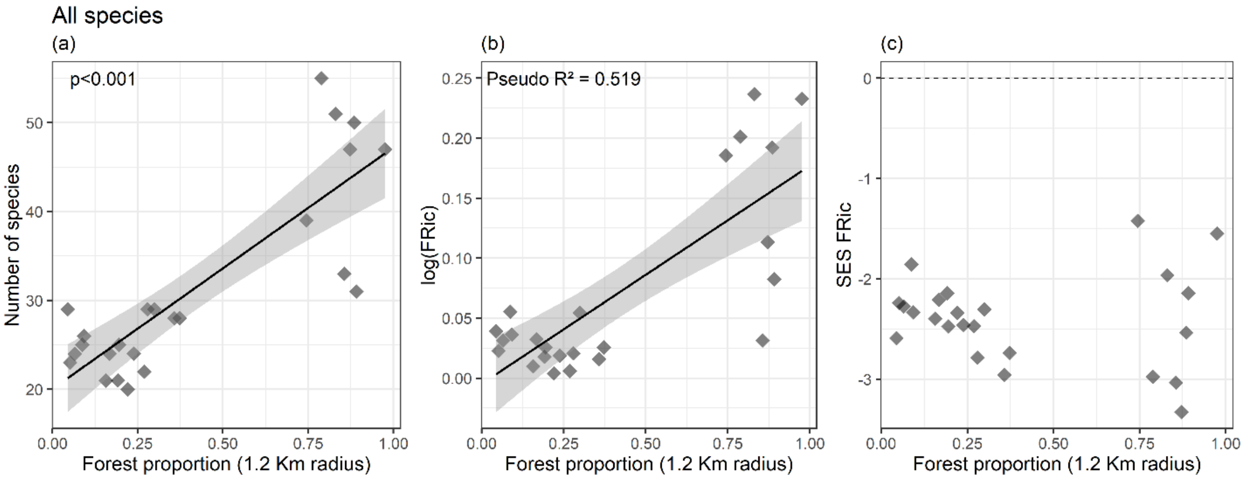


Figure S3. Bird species richness and functional richness metrics calculated for habitat amount at Araucaria forest, South Brazil. In (a) species richness is positively associated to habitat amount

(Z = 7.619; $p < 0.001$). In (b), functional richness (FRic) showed a positive and significant relationship (Pseudo $R^2 = 0.519$; $p < 0.001$). In (c) standardized effect size (SES) was calculated for FRic metric. Results below dashed line represent sites with lower values than expected for functional diversity randomly. For all figures, the grey areas represent 95% of confidence intervals.

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4. CONCLUSÃO GERAL

Estudamos ecologia de comunidade de aves e os efeitos da diversidade funcional em diferentes cenários da floresta com Araucária. Ambos os capítulos abordam o mosaico floresta-campo, no sul do Brasil. Este mosaico representa o processo de expansão natural da floresta sobre os campos (nucleação), o qual resulta na modificação da configuração espacial da floresta, e esta por sua vez influencia no arranjo de comunidades de aves e na distribuição de seus atributos funcionais. Este processo de expansão foi abordado no capítulo 1 como uma categoria de tipo florestal, e no capítulo 2 como a quantidade de habitat florestal em forma de gradiente imersa na paisagem de campos naturais. Ambas as abordagens foram comparadas à floresta contínua, interpretada como um cenário florestal com habitat sem interrupções pela matrix, e como o estágio tardio no processo de sucessão ecológica. Nosso resultado principal revelou que a configuração do habitat é determinante na montagem da comunidade de aves e adaptações de grupos de espécies quanto à floresta nucleada espalhada sobre os campos. Ou seja, as espécies de aves desempenham menos funções ecológicas em manchas florestais, provavelmente devido à quantidade de habitat disponível, um filtro ambiental que seleciona espécies colonizadoras, sendo as generalistas e dispersoras de sementes as mais comuns. Já a floresta contínua, apresentou maior riqueza de espécies e composição de espécie diferente, com comunidades que ocupam maior espaço funcional. Isto é, a alta diversidade e quantidade de nichos ecológicos no habitat (como a presença de um sistema fonte de espécies) proporcionou um acréscimo de espécies tardias e que desempenham funções complementares e originais, como as especialistas em insetos de sub-bosque.

No capítulo 1, além da nucleação e floresta contínua, também abordamos um processo relacionado à perturbação humana, a fragmentação florestal. A fragmentação levou a floresta contínua a uma disrupção do habitat, representada por um complexo mosaico de remanescentes florestais e matriz antrópica, como agricultura ou estradas. Os remanescentes florestais influenciam comunidades por um novo arranjo espacial da paisagem, porém agora esse processo é artificial e antrópico, sendo determinado por um intervalo de tempo mais curto. Juntamente com a nucleação das manchas naturais de floresta, floresta contínua e fragmentação dos remanescentes florestais, temos um conjunto de processos que alteram a configuração espacial da floresta com Araucária. Como resultado, as comunidades de aves dos remanescentes florestais após fragmentação mostraram:

- Similaridade na composição de espécies e da diversidade funcional com floresta contínua;
- Redução do número de espécies e funções ecológicas pela perda de espécies sensíveis (extinção local);
- Substituição do número de espécies e funções ecológicas, provavelmente por espécies tolerantes a efeitos de borda;

No capítulo 2, as espécies de aves foram investigadas em um gradiente de quantidade de habitat que abrangia tanto nucleação quanto floresta contínua. Também subdividimos a comunidade em grupos filogenéticos (Passeriformes Suboscines e Oscines) e avaliamos a resposta funcional de atributos funcionais quanto à alimentação, capacidade de vôo e biomassa. Os resultados mostraram que:

- As espécies de Suboscines representaram maiores valores de dispersão e originalidade funcional em sítios mais florestados;
- As espécies de Oscines representaram maiores valores de dispersão, especialidade e originalidade funcional em sítios menos florestados;

- Espécies de Suboscines possuem maior capacidade de vôo e massa do corpo em sítios mais florestados, enquanto os bicos pequenos significam uma alimentação de insetos mais específica;
- Espécies de Oscines possuem maior capacidade de vôo e bicos mais largos e curtos em sítios menos florestados, reflexo de espécies que se alimentam de frutos e grãos e dispersam sementes.
- A adaptação ao habitat entre os grupos filogenéticos Suboscines e Oscines determinou uma distribuição diferente das espécies quanto a seus atributos funcionais ao longo do gradiente de quantidade de habitat; de modo que os Oscines foram mais comuns em sítios menos florestados e Suboscines mais comuns em sítios mais florestados.

Portanto, nossos resultados mostram que as aves são sensíveis às mudanças na configuração do habitat, como os distintos cenários da floresta com Araucária e a quantidade de habitat florestal na paisagem. Embora ambos processos, nucleação e fragmentação, resultem em fragmentos florestais na paisagem, ambos mostraram diferenças na montagem de comunidade de aves. Ao incorporar atributos funcionais, obtivemos detalhes importantes quanto à adaptação das espécies à dinâmica do processo de nucleação natural, e quanto à fragmentação como processo antrópico que afeta negativamente a diversidade funcional de aves em habitats fragmentados. Esta incerteza no arranjo da comunidade pode colocar em risco funções ecológicas únicas encontradas exclusivamente em florestas de estágio tardio, uma vez que todo remanescente florestal é potencialmente semelhante a floresta contínua quanto a riqueza, composição e diversidade funcional de aves. Enfim, afirmamos que as diferenças entre os processos devem ser levadas em conta em medidas de conservação para amenizar os danos à avifauna e as consequências à diversidade funcional.

ANEXOS

Anexo A

Dados do capítulo 1

Appedix D. Presence and absence of bird species. List of species birds sampled in 48 sites of Araucaria forest, South Brazil. Bird nomenclature is based on BirdLife International (2017).

Species	C1	C2	C3	C4	C5	C6	C7	C8	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	N14	N15	N16	N17	N18	N19	N20	N21	N22	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18
Amaurospiza moesta	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Amazilia lactea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
Amazona aestiva	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Amazona vinacea	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0
Anabacerthia amaurotis	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anabacerthia lichtensteini	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
Anabazenops fuscus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Anumbius annumbi	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aramides saracura	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aratinga auricapillus	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Arremon semitorquatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
Attila rufus	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
Automolus leucophthalmus	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	0	0
Baryphthengus ruficapillus	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	1	0	0	0	0	0	0	0	1	0	0
Basileuterus auricapilla	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	1	1
Batara cinerea	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0
Brotogeris tirica	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Cacicus chrysopterus	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	1	1	0	1	0	1	0	1	0	0	1	0	0	0	1	1	0	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0
Cacicus haemorrhous	0	1	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0
Campephilus robustus	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0
Camptostoma obsoletum	1	1	0	1	1	1	0	1	0	1	0	1	1	1	0	1	0	0	1	0	0	1	0	0	0	0	0	1	0	1	1	1	0	0	1	0	1	0	0	0	0	0	0	0	1	0	1	1

Campylorhamphus falcularius	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
Capsiempis flaveola	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Caracara plancus	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Celeus flavescens	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Chamaeza campanisona	1	1	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0
Chamaeza ruficauda	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chiroxiphia caudata	1	1	1	1	1	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1
Chlorostilbon lucidus	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	1	1
Cichlocolaptes holti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Cissopis leverianus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Claravis pretiosa	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Clibanornis dendrocolaptoides	1	0	0	1	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
Cnemotriccus_fuscatus	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0
Coccyzus americanus	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Coereba flaveola	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Colaptes campestris	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Colaptes melanochloros	0	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0	1
Colibri serrirostris	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Colonia colonus	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Columbina talpacoti	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
Conirostrum speciosum	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0
Conopophaga lineata	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	0	1
Conopophaga melanops	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Contopus cinereus	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0
Coryphospingus cucullatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Corythopis delalandi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Cranioleuca obsoleta	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0
Cranioleuca pallida	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Crypturellus obsoletus	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	1	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	1	1
Crypturellus parvirostris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1

Crypturellus tataupa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
Cyanocorax chrysops	1	1	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1
Cyanocorax coeruleus	0	0	0	0	1	1	1	1	0	1	1	1	0	0	1	1	1	0	1	0	0	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyanoloxia brissonii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Cyclarhis gujanensis	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	1	0	0	1	0	0	1	1	1	1	0	0	1	1	1	0	1	1
Dacnis cayana	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Dendrocincla turdina	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Dendrocolaptes platyrostris	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	1	0	0	0
Drymophila ferruginea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Drymophila malura	1	1	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	1	1	0	0	0	0	1	0	1	1
Drymophila rubricollis	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
Dysithamnus mentalis	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Elaenia flavogaster	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
Elaenia mesoleuca	0	0	0	1	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	1	0	1	0	1	0	0	0	0	0	1	0	1	0
Elaenia obscura	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Elaenia parvirostris	0	0	0	0	0	0	0	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Elanoides forficatus	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eleoscytalopus indigoticus	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0
Empidonomus varius	0	0	0	0	0	0	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Euphonia chalybea	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Euphonia chlorotica	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Euphonia cyanocephala	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Euphonia violacea	0	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Florisuga fusca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
Formicarius colma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Geothlypis aequinoctialis	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
Geotrygon montana	0	1	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	1	1	1	0	1	0	0
Glaucidium brasilianum	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Grallaria varia	0	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	1	0	0
Habia rubica	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	0	0	1	0	0

Haplospiza unicolor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
Heliobletus contaminatus	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	1	1	1	0	0	1	1	1	1	0	1	1	1	1	0	1	1	1	1	0	0	0	0	0	0	1	0	0	0
Hemithraupis guira	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1	0
Hemitriccus diops	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0
Hemitriccus nidipendulus	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hemitriccus obsoletus	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Hemitriccus orbitatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Herpetotheres cachinnans	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1
Herpsilochmus rufimarginatus	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
Hylatomus lineatus	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Hylopezus nattereri	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hylophilus amaurocephalus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Hylophilus poicilotis	0	1	0	1	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
Hypoedaleus guttatus	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ilicura militaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Knipolegus cyanirostris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Lathrotriccus euleri	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	0	1	0	1	0	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	1	1	0	1
Laniisoma elegans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Legatus leucophaius	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Lepidocolaptes angustirostris	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Lepidocolaptes falcinellus	0	0	1	1	1	1	1	1	0	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	1	0	0	0
Leptasthenura setaria	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
Leptasthenura striolata	0	0	0	0	0	1	1	1	0	1	1	0	0	0	0	1	1	1	0	1	1	1	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leptodon cayanensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Leptopogon amaurocephalus	1	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	1	1	1	1	0	1	0	1	0	0	0	0
Leptotila rufaxilla	1	0	1	0	0	1	1	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	0	0	0	0	0	1	1	1	1	0	0
Leptotila_verreauxi	1	0	1	1	1	1	1	0	1	0	1	0	1	1	0	1	0	1	0	0	0	1	0	0	0	1	0	0	0	0	1	1	1	1	1	1	1	1	0	0	1	0	1	0	1	0	1	1
Leucochloris albicollis	0	0	1	0	1	1	1	1	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0
Lochmias nematura	0	1	0	1	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0

Mackenziaena leachii	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
Mackenziaena severa	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
Malacoptila striata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Manacus manacus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Megarynchus pitangua	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	1	0
Melanerpes flavifrons	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0
Micrastur ruficollis	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0
Micrastur semitorquatus	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	1	0
Microspingus cabanisi	0	0	0	0	0	1	0	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Milvago chimachima	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Mionectes rufiventris	1	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	1	1	1	1	1	1	1	1	0	0
Muscipipra vetula	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Myiarchus ferox	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
Myiarchus swainsoni	0	1	0	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	1	1	0	0	0	0	0	0	1	0	1	1
Myiarchus tyrannulus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
Myiodynastes solitarius	1	1	1	1	1	0	1	1	1	1	1	0	0	0	0	0	1	0	0	0	1	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1	0	1	0
Myiopagis caniceps	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0
Myiopagis viridicata	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Myiophobus fasciatus	0	0	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
Myiornis auricularis	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0
Myiothlypis leucoblephara	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0
Myrmoderus squamosus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Nemosia pileata	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nonnula rubecula	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Notharchus swainsoni	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odontophorus capueira	0	0	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Orchesticus abeillei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Orthogonys chloricterus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Pachyramphus castaneus	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	1	0	0	0
Pachyramphus polychopter	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1	0	0	1	0	1	1	0	0	1	0	1	1	1	1	1	1	1	1	1	0	1	0	0	0	1	1	0	0	0

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Pachyramphus validus	0	0	1	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	1	0	0	0
Pachyramphus viridis	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Patagioenas cayennensis	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
Patagioenas picazuro	1	1	1	1	1	0	0	1	0	1	1	1	1	1	0	1	0	1	1	1	0	1	0	0	1	0	0	0	1	0	1	1	1	1	1	1	1	0	1	1	0	0	0	0	0	0	1	1
Patagioenas plumbea	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0
Penelope obscura	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Phaeomyias murina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Phaethornis eurynome	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	1	0	0	0	0	0
Phaethornis pretrei	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1
Philydor rufum	1	1	1	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	1	1	1	1	1	0	0	0	0	1	0	0	0
Phyllomyias burmeisteri	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Phyllomyias fasciatus	0	0	0	1	1	1	1	1	0	1	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	1	0	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Phyllomyias _virescens	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	1	0	1	1	1	1	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
Phylloscartes difficilis	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phylloscartes paulista	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phylloscartes ventralis	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	1	1	1	0	0	0	0	1	1	0	0	0
Piaya cayana	0	0	1	1	0	0	1	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	1	1	0	0	0	0	0	0	1
Piculus_aurulentus	1	0	1	1	1	1	1	1	0	1	0	1	1	0	0	0	0	0	0	0	1	1	0	0	1	0	1	0	1	0	0	1	0	1	1	1	0	1	1	1	0	0	0	0	1	0	0	0
Picumnus nebulosus	0	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Picumnus temminckii	1	1	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	1	1	1	1	0	0	1	1	0	1	0
Pionopsitta pileata	0	1	1	1	0	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0
Pionus maximiliani	1	1	1	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	1	0
Pipraeidea melanonota	1	1	1	0	0	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	1	0	0	0	0	0	0	0	1	1	0	0
Piranga flava	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pitangus sulphuratus	0	0	1	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	1	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	1	0	1	1
Platyrinchus mystaceus	1	1	1	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0
Poecilotriccus plumbeiceps	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
Pogonotriccus eximius	0	0	0	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Poospiza nigrorufa	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Procnias nudicollis	0	0	1	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Psittacara leucophthalmus	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0
Pteroglossus bailloni	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0
Pteroglossus castanotis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Pyriglena leucoptera	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1	1
Pyrrhura frontalis	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	0	1
Ramphastos dicolorus	1	1	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	1
Ramphocaenus melanurus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Rhopias gularis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Rupornis magnirostris	1	0	1	1	0	0	1	0	1	0	1	1	1	1	0	0	1	0	1	0	1	0	0	0	0	0	1	0	0	0	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	1
Saltator fuliginosus	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Saltator maxillosus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Saltator similis	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	0	1	1
Satrapa icterophrys	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Schiffornis virescens	1	1	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	1	1	1	1	1	0	0	1	0	0	0
Sclerurus scansor	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Scytalopus speluncae	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Serpophaga subcristata	0	0	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
Setophaga pitiayumi	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1	0	1	1
Sicalis flaveola	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sicalis luteola	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Sirystes sibilator	0	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0
Sittasomus griseicapillus	1	1	1	1	1	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	1	1	1	1	1	1	1	1	1	0	1	0	0	1	1	0	0
Spinus magellanicus	0	0	0	0	0	0	1	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Spizaetus melanoleucus	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spizaetus tyrannus	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Sporophila angolensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Sporophila caerulescens	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Stephanophorus diadematus	0	0	0	0	0	1	1	1	1	1	1	1	0	0	1	0	0	1	1	1	0	1	0	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Stephanoxis lalandi	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Synallaxis cinerascens	1	0	1	1	1	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	1	1	1	1	0	0	0	0	1	0	0	0
Synallaxis frontalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Synallaxis ruficapilla	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	1	1	1	1	0	1	1	1	1	1	0	0
Synallaxis spixi	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
Syndactyla rufosuperciliata	0	0	0	1	1	1	1	1	0	0	0	1	1	1	1	0	1	1	1	1	1	1	1	0	0	1	1	1	1	1	0	0	0	0	0	0	1	0	0	0	1	1	1	1	1	0	0	0
Tachyphonus coronatus	1	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	1	0	1	1	1	1	0	1
Tangara cyanocephala	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Tangara desmaresti	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Tangara flava	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Tangara preciosa	1	0	1	1	0	1	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Tangara sayaca	1	1	1	0	0	1	1	1	1	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1
Tangara seledon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Tapera naevia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
Tersina viridis	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1
Thalurania glaucopis	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0
Thamnophilus caerulescens	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1	0	1	1	1	0	0	0	1	1	1	1	1	0	1	1	1	1	0	1	1	0	1	1	1	1	1	1	1
Thamnophilus ruficapillus	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
Thlypopsis pyrrhocoma	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
Thlypopsis sordida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
Tityra braziliensis	0	1	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	0	0	0	0	0	0	0	1	0	0
Tityra inquisitor	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tolmomyias sulphurescens	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	1	0	1	0	0	1	0	0	1	1	1	0	0	0
Trichothraupis melanops	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	0	0	1	1	1	1	1	1	1	1	0	0
Troglodytes aedon	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
Trogon rufus	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Trogon surrucura	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1	1
Trogon viridis	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turdus albicollis	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	0	1	0	1	1	0	1	0	1	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
Turdus amaurochalinus	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	1	0	0	0	0	0	1	0	0	1	0	0	1	0	1	1
Turdus flavipes	1	0	0	0	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0

Turdus leucomelas	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	1
Turdus rufiventris	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Turdus subalaris	1	1	0	1	0	0	1	1	0	0	1	0	0	1	0	1	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
Tyrannus melancholicus	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	1	1	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1
Tyrannus savana	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Veniliornis spilogaster	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	1	1	0	1	1	1	1	1	1	1	0	0	0	0	1	1	0	0
Vireo olivaceus	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1	1	0	1	1	1	1	1	1	1	0	0	1	1	0	1	0	0	0	0	0	0	0	1	1	0	0
Xenops minutus	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Xenops rutilus	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0
Xiphocolaptes albicollis	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	1	0	1	0	0	0	0	1	0	0	0
Xiphorhynchus fuscus	1	1	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	1	1	1	0	0	0	1	1	0	1	0	1	0	1	1	1	0	0
Zenaida auriculata	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Zonotrichia capensis	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	1	1	0	1	1	1	0	0	1	1	1	1	0	1	0	0	0	0	0	0	0	1	0	1	1

Appendix E. Bird functional traits. List of functional traits related to bird ecology and natural history of species.

Species	Diet Insect	Diet vertebrate	Diet fruit	Diet nectar	Diet seed	Diet plant	Stratum ground	Stratum understory	Stratum mid.high	Stratum canopy	seed/ fruit	flower	Living Foliage	Dead Foliage	bark	air	Body Mass	Bill_length mm.mean	Bill_width mm.mean	Bill_depth mm.mean	Wing_length mm.mean	Tail_length mm.mean
Amaurospiza moesta	1	0	0	0	2	2	3	2	0	0	3	0	2	1	0	0	14.49	11.28	10	7.33	63.2	57.5
Amazilia lactea	1	0	0	3	0	0	0	2	2	0	0	3	0	0	0	1	4.95	18.36	2.98	2.25	48.1	29.56
Amazona aestiva	0	0	2	0	2	0	0	2	3	2	3	0	0	0	0	0	400	31.04	18.3	29.82	213.2	154.4
Amazona vinacea	0	0	2	0	2	1	0	2	3	2	3	0	1	0	0	0	254	26.68	15.64	25.22	212.8	134.6
Anabacerthia amaurotis	3	0	0	0	0	0	1	3	0	1	0	0	1	3	1	0	20.55	12.6	7.4	5.44	76.2	72.88
Anabacerthia lichtensteini	3	0	0	0	0	0	0	0	2	2	0	0	0	3	0	0	21.98	14.58	7.66	5.71	78.44	75.93
Anabazenops fuscus	3	0	0	0	0	0	1	2	3	0	0	0	2	2	1	0	33.67	21	8.97	8.02	88.12	80.23
Anumbius annumbi	3	0	0	0	0	0	3	2	0	0	0	0	3	1	0	0	39.12	18.35	4.8	5.3	84	79.67
Aramides saracura	2	2	0	0	0	2	3	1	0	0	0	0	2	2	0	0	254.43	12.25	17.19	15.21	169	69.76
Aratinga auricapillus	0	0	2	0	2	0	1	2	2	0	3	0	0	0	0	0	116	23.6	13.57	23.36	137	167
Arremon semitorquatus	2	0	2	0	2	0	3	1	0	0	2	0	2	2	0	0	25.05	12.23	8.75	7.47	70.33	69.98
Attila rufus	2	2	2	0	0	0	3	2	2	1	2	0	2	0	1	2	41.57	24.22	11.25	7.66	93.34	78.54
Automolus leucophthalmus	3	0	0	0	0	0	0	3	2	0	0	0	2	2	0	0	33.75	20.01	8.23	7.01	86.56	82.41
Baryphthengus ruficapillus	3	2	2	0	0	0	1	3	2	0	1	0	2	1	0	0	130.85	41.28	12.2	13.22	150	214.45
Basileuterus auricapilla	3	0	1	0	0	0	0	3	1	0	1	0	2	1	0	2	9.6	10.63	5.66	3.8	56.15	53.38
Batara cinerea	3	1	0	0	0	0	1	3	1	0	0	0	3	0	0	0	136.67	38.08	9.04	13.48	124.8	179.4
Brotogeris tirica	1	0	0	1	2	2	0	0	0	3	2	2	0	0	0	0	67.75	16.42	9.86	15.33	114.06	117.3
Cacicus chrysopterus	2	0	2	0	0	0	0	0	3	1	2	0	2	0	0	0	38.76	22.13	7.23	9.63	102	93.25
Cacicus haemorrhous	3	0	2	1	0	0	0	1	3	1	1	0	3	0	0	0	70.72	32.18	10.29	11.63	138.1	102.44
Campephilus robustus	3	0	0	0	0	0	0	2	2	2	0	0	2	1	3	0	262	49.46	12.98	13.94	191.8	138.2
Camptostoma obsoletum	3	0	1	0	0	0	0	0	0	3	1	0	3	0	0	1	8.06	9.16	4.91	3.34	54.07	50.81
Campylorhamphus falcularius	3	0	0	0	0	0	0	2	2	0	0	0	1	0	3	0	39.38	64.75	10.92	6.74	97.56	98.79
Capsiempis flaveola	3	0	1	0	0	0	0	0	3	0	1	0	3	0	0	0	7.3	9.32	6.61	3.46	49.4	51.79
Caracara plancus	2	2	1	0	0	0	3	2	0	0	0	0	2	0	0	2	944.4	44.58	27.43	27.71	343.19	277.4
Celeus flavescens	3	0	1	0	0	0	1	0	2	2	1	0	0	0	3	0	134.03	29.72	12.11	9.35	157.32	99.34
Chamaeza campanisona	2	0	2	0	0	0	3	0	0	0	1	0	0	3	0	0	93.59	17	9.22	7.25	104.56	67.19
Chamaeza ruficauda	3	0	0	0	0	0	3	0	0	0	0	0	1	3	0	0	73.43	18.3	10.1	6.5	94	84

Chiroxiphia caudata	2	0	2	0	0	0	0	2	2	0	2	0	3	0	0	1	24.9	9.88	9.19	5.23	74.92	56.4
Chlorostilbon lucidus	1	0	0	3	0	0	0	2	2	2	0	3	0	0	0	1	3.44	19.44	3.67	2.04	50.2	30.21
Cichlocolaptes holti	3	0	0	0	0	0	0	2	2	2	0	0	3	0	0	0	39.8	23.14	7.54	7.34	94	80.82
Cissopis leverianus	1	0	3	0	0	0	1	1	3	2	3	0	1	0	0	0	71.25	18.41	11.11	10.09	105	144.22
Claravis pretiosa	1	0	0	0	3	0	3	0	0	0	1	0	0	3	0	0	60.66	15.11	5.7	4.77	110.25	70.87
Clibanornis dendrocolaptoides	3	0	0	0	0	0	2	2	0	0	0	0	2	2	0	0	49.92	23.36	5.94	6.99	96	98.29
Cnemotriccus fuscatus	3	0	0	0	0	0	1	3	0	0	0	0	3	1	0	1	12.96	13.42	6.67	4.18	67.09	64.37
Coccyzus americanus	2	2	1	0	0	0	0	0	2	3	1	0	3	0	0	0	65.4	27.32	13.61	9.73	140.45	136.93
Coereba flaveola	1	0	1	3	0	0	0	2	2	1	1	3	1	0	0	0	9.55	13.25	4.59	4.12	55.35	36.56
Colaptes campestris	3	0	0	0	0	0	3	0	0	0	0	0	0	0	3	0	163.5	34.55	13.75	10.65	164	120.81
Colaptes melanochloros	3	0	1	0	0	0	1	2	2	0	1	0	0	0	3	0	108.54	28.68	11.95	9.14	128.75	111.4
Colibri serrirostris	0	0	0	3	0	0	0	3	0	0	0	3	0	0	0	0	6.58	20.09	3.13	2.31	66.8	45.82
Colonia colonus	3	0	0	0	0	0	0	2	3	1	0	0	0	1	0	3	16.32	15.06	5.4	4.08	80.46	127.4
Columbina talpacoti	1	0	0	0	3	0	3	0	0	0	3	0	1	0	0	0	47.53	13.27	5.01	4.79	89.1	70.44
Conirostrum speciosum	3	0	1	1	0	0	0	0	0	3	0	0	3	0	0	0	9.3	10.43	3.95	3.8	57.92	42.14
Conopophaga lineata	3	1	1	0	0	0	2	2	0	0	0	0	2	2	0	2	21.28	12.56	7.54	4.4	70.41	46.89
Conopophaga melanops	3	0	0	0	0	0	2	3	0	0	0	0	2	2	0	0	20.74	13.56	8.18	4.65	63.81	31.51
Contopus cinereus	3	0	0	0	0	0	0	2	3	0	0	0	2	0	0	1	10.33	16.78	5.54	3.9	73.24	67.34
Coryphospingus cucullatus	0	0	2	0	2	0	3	2	0	0	3	0	1	1	0	0	15.3	11.96	7.05	6.34	62.96	57.89
Corythopis delalandi	3	2	0	0	0	0	3	1	0	0	0	0	1	3	0	0	16.17	14.56	5.94	3.69	64.76	51.47
Cranioleuca obsoleta	3	0	0	0	0	0	0	2	2	0	0	0	3	0	1	0	13.56	12.92	3.31	3.65	61.75	61.6
Cranioleuca pallida	3	0	0	0	0	0	0	0	2	2	1	1	2	2	0	0	11.85	16.82	3.62	3.5	61.44	72.52
Crypturellus obsoletus	2	0	0	0	2	0	3	0	0	0	1	0	0	3	0	0	631	22.5	14.43	9.37	188	69.5
Crypturellus parvirostris	2	0	0	0	3	0	3	0	0	0	1	0	0	3	0	0	198.99	27.1	5.12	5.08	121.4	48.9
Crypturellus tataupa	2	0	0	0	3	1	2	2	0	0	1	0	0	3	0	0	218.8	29.98	5.38	5.88	124.8	54.58
Cyanocorax chrysops	3	1	2	0	0	0	1	2	2	2	1	0	2	2	0	0	161.42	34.44	15.23	16.75	150.88	160.63
Cyanocorax coeruleus	1	1	2	0	3	0	1	2	2	2	2	0	2	0	0	1	298.67	33.79	15.66	16.71	203.67	168
Cyanoloxia brissonii	1	0	2	0	2	0	2	2	0	0	3	0	1	0	0	0	21.34	15.03	10	12.48	74.35	67.59
Cyclarhis gujanensis	3	0	1	0	0	0	0	0	2	2	1	0	3	0	3	0	27.41	16.3	9.13	9.34	75.81	68.49
Dacnis cayana	2	0	2	0	0	0	0	0	2	3	2	0	2	0	0	0	13.36	13.3	6.6	4.49	63.01	44.19

Dendrocincla turdina	3	0	0	0	0	0	1	2	2	0	0	0	1	1	3	1	37.97	23.66	9.77	7.06	104.4	90.33
Dendrocolaptes platyrostris	3	1	0	0	0	0	1	2	2	1	0	0	2	1	0	0	58.65	33.97	11.83	8.66	120.08	116.78
Drymophila ferruginea	3	0	0	0	0	0	1	2	2	0	0	0	2	0	0	2	10.72	13.81	4.09	3.89	54	60.88
Drymophila malura	3	0	0	0	0	0	0	3	0	0	0	0	2	2	0	0	11.28	12.18	3.32	3.29	56	74.18
Drymophila rubricollis	3	0	0	0	0	0	0	3	1	0	0	0	3	0	0	0	11.16	12.21	4.61	3.59	52	67.92
Dysithamnus mentalis	3	0	1	0	0	0	1	2	2	1	1	0	2	1	0	3	12.63	13.65	7.03	4.78	58.71	42.36
Elaenia flavogaster	2	0	2	0	0	0	0	1	3	2	0	0	2	0	0	2	19.76	11.34	7.12	4.39	75.39	69.63
Elaenia mesoleuca	2	0	2	0	0	0	0	1	2	2	0	0	3	0	0	2	16.69	10.23	6.15	4.41	76.44	68.06
Elaenia obscura	2	0	2	0	0	0	0	0	0	3	2	0	1	0	0	2	26.67	11.92	5.94	4.15	85.81	79.66
Elaenia parvirostris	3	0	1	0	0	0	0	2	2	1	1	0	2	0	0	2	16.09	10.8	4.48	3.33	72.63	65.5
Elanoides forficatus	3	2	0	0	0	0	0	2	2	2	0	0	0	0	0	3	490	27.6	9.96	10.86	446.4	299
Eleoscytalopus indigoticus	3	0	0	0	0	0	3	2	0	0	0	0	2	2	0	0	14.76	9.6	7.1	4.4	48	34.5
Empidonomus varius	3	0	2	0	0	0	0	2	3	0	2	0	3	0	0	0	26.22	13.09	7.23	5.8	98.62	79.3
Euphonia chalybea	1	0	3	0	0	0	0	2	2	0	3	0	1	0	1	0	17.76	9.75	8.8	8.53	67.67	48.17
Euphonia chlorotica	1	0	3	0	0	0	0	0	1	3	3	0	1	0	0	0	11.04	7.82	5.68	4.25	56.93	35.33
Euphonia cyanocephala	0	0	3	0	0	0	0	1	2	2	3	0	0	0	0	0	14	8.74	5.6	4.38	63.06	40.56
Euphonia violacea	0	0	3	1	0	0	0	1	1	3	3	0	1	0	0	3	15.1	9.81	7.61	5.58	59.04	36.17
Florisuga fusca	1	0	0	3	0	0	0	2	3	0	0	3	0	0	0	1	7.97	20.26	3.53	2.88	74.9	45.63
Formicarius colma	3	0	0	0	0	0	3	1	0	0	0	0	3	0	0	0	48.41	18.01	8.86	6.04	83.78	54.29
Geothlypis aequinoctialis	3	0	0	0	0	0	1	3	0	0	0	0	3	0	0	0	12.29	12.88	6.28	4.55	56.47	54.64
Geotrygon montana	2	0	2	0	2	0	3	0	0	0	1	0	1	3	0	3	136.89	13.65	7.17	5.65	136.89	85.57
Glaucidium brasilianum	3	2	0	0	0	0	2	2	1	0	0	0	3	0	0	1	73.5	16.64	9.42	9.81	97.17	66.24
Grallaria varia	3	0	0	0	0	0	3	0	0	0	0	0	1	3	0	0	134.38	23.36	15.1	9.53	125	56.45
Habia rubica	3	0	1	0	0	0	1	2	2	0	1	0	2	2	0	0	34.82	15.84	9.79	9.09	90.78	86.49
Haplospiza unicolor	1	0	0	0	3	0	0	3	0	0	3	0	0	0	1	0	15.11	11.12	6.33	6.78	62.2	52.61
Heliobletus contaminatus	3	0	0	0	0	0	0	1	2	2	0	0	3	0	0	0	15.07	12.25	5.92	4.31	73	60.43
Hemithraupis guira	3	0	1	0	1	0	0	0	1	3	1	0	3	0	0	0	11.39	12.52	7.25	5.07	66.67	53.7
Hemitriccus diops	3	0	0	0	0	0	0	3	0	0	0	0	2	0	0	2	9.54	8.67	7.95	3.5	51.95	48.6
Hemitriccus nidipendulus	3	0	0	0	0	0	0	3	1	0	0	0	3	0	0	1	7.5	16.54	4.12	3.24	43.34	38.7
Hemitriccus obsoletus	3	0	0	0	0	0	0	3	0	0	0	0	3	0	0	0	10.72	9.77	6.65	3.62	55.8	51.4

Hemitriccus orbitatus	3	0	0	0	0	0	0	2	3	0	0	0	3	0	0	1	9.58	12.28	4.91	3.32	52.09	47.66
Herpetotheres cachinnans	0	3	0	0	0	0	2	2	2	0	0	0	2	2	0	0	32	27.64	13.58	20.44	281.8	239.6
Herpsilochmus rufimarginatus	3	0	1	0	0	0	0	0	3	0	0	0	3	0	0	0	10.25	14.08	5.93	3.97	50	51.63
Hylatomus lineatus	3	0	1	0	1	0	2	2	3	1	1	0	0	0	3	0	186.67	43	16	15	182	122.5
Hylopezus nattereri	3	0	0	0	0	0	2	2	0	0	0	0	2	2	0	1	27.65	22.26	5.28	5.36	75.24	36.8
Hylophilus amaurocephalus	3	0	2	0	0	2	0	3	1	0	0	0	3	0	0	0	9.11	11.19	6.04	5.02	53.69	49.9
Hylophilus poicilotis	3	0	1	0	0	0	0	1	2	2	1	0	3	0	0	2	10.24	10.75	6.93	4.47	56.2	54.29
Hypoedaleus guttatus	3	1	0	0	0	0	0	0	3	0	0	0	3	0	0	0	37	17	14	10	82	99
Ilicura militaris	2	0	2	0	0	0	0	2	2	0	2	0	2	0	0	0	13.17	7.19	6.66	3.51	58.44	52.98
Knipolegus cyanirostris	3	0	0	0	0	0	0	3	0	0	0	0	2	0	0	3	16.12	13.95	6.33	4.39	78.36	69.72
Lathrotriccus euleri	3	0	0	0	0	0	0	3	0	0	0	0	3	0	2	0	11.6	12.3	6.86	3.88	64.99	59.15
Laniisoma elegans	3	0	0	0	0	0	0	3	0	0	0	0	3	0	2	0	46	12.3	6.86	3.88	64.99	59.15
Legatus leucophaius	3	0	1	0	0	0	0	0	1	3	1	0	0	0	0	3	23	10.1	6.24	5.38	84.38	61.43
Lepidocolaptes angustirostris	3	1	0	0	0	0	0	0	3	0	0	0	2	0	3	1	30.47	33.97	8.11	5.3	95.99	81.73
Lepidocolaptes falcinellus	3	0	0	0	0	0	0	0	2	2	0	0	1	0	3	0	26.4	27.81	10.52	5.73	89.75	84.65
Leptasthenura setaria	3	0	0	0	0	0	0	0	2	3	0	0	3	0	0	0	13.07	18.14	3.18	3.18	55.56	108.74
Leptasthenura striolata	3	0	0	0	0	0	0	2	2	2	0	0	3	0	0	0	9.18	12.86	2.76	2.93	54.3	88.8
Leptodon cayanensis	3	2	0	0	0	0	0	2	2	0	0	0	3	0	0	2	435	35	24.7	18.74	323.5	230
Leptopogon amaurocephalus	3	0	1	0	0	0	0	0	3	1	1	0	3	0	0	0	12.31	12.59	6.48	4.23	64.87	58.47
Leptotila rufaxilla	1	0	1	0	3	0	3	0	0	0	1	0	0	3	0	0	177.72	18.21	6.79	5.45	142.67	110.85
Leptotila verreauxi	1	0	1	0	3	0	3	0	0	0	1	0	0	3	0	0	166.34	18.07	7.07	5.61	144.23	119
Leucochloris albicollis	1	0	0	3	0	0	0	2	2	2	0	3	0	0	0	0	6.09	20.43	3.06	2.25	58.96	38.75
Lochmias nematura	3	0	0	0	0	0	3	0	0	0	0	0	2	2	0	3	23.3	16.76	5.19	4.24	66.05	47.96
Mackenziaena leachii	3	0	0	0	0	0	0	3	0	0	0	0	3	0	2	0	64.69	28.08	6.3	9	87.66	139
Mackenziaena severa	3	1	0	0	0	0	1	3	1	0	0	0	3	1	0	1	51.08	18.03	13.8	8.9	93.25	112.05
Malacoptila striata	3	1	0	0	0	0	2	2	0	0	0	0	3	0	0	0	43.85	22.84	11.97	10.1	95.45	90.71
Manacus manacus	1	0	3	0	0	0	0	3	0	0	3	0	1	0	0	0	15.97	10.87	8.18	4.63	52.53	36.56
Megarynchus pitangua	3	1	1	0	1	0	0	1	3	2	1	0	3	0	0	1	57.22	30.88	17.1	11.8	109.14	92.07
Melanerpes flavifrons	3	0	2	0	2	0	0	2	2	0	1	0	0	0	3	0	56	29.86	6.58	6.06	111.24	68.8
Micrastur ruficollis	1	3	0	0	0	0	2	2	0	0	0	0	3	0	0	0	160.5	14.8	12.03	14.97	182.4	169.31

Micrastur semitorquatus	0	3	0	0	0	0	2	2	1	0	0	0	3	0	0	0	441	30.68	12	18.32	265	293
Microspingus cabanisi	2	0	0	0	2	0	1	3	0	0	2	0	2	0	0	0	17.95	12.02	7.1	6.51	66.67	66.79
Milvago chimachima	2	2	2	0	0	0	3	0	0	0	2	0	2	0	0	2	256.67	29.64	10.1	13.02	288	202.8
Mionectes rufiventris	2	0	2	0	0	0	0	3	0	0	2	0	2	0	0	0	13.81	11.52	7.2	4.25	66.54	55.04
Muscipipra vetula	3	0	0	0	0	0	0	0	1	3	0	0	0	0	0	3	28.65	15.25	10.7	6.04	107.5	126.75
Myiarchus ferox	2	0	2	0	0	0	0	2	2	0	2	0	0	0	0	2	26.43	18.69	10.31	5.96	88.15	84.38
Myiarchus swainsoni	3	0	1	0	0	0	0	1	3	1	1	0	3	0	0	2	24.75	17.98	9.1	5.47	90.27	86.95
Myiarchus tyrannulus	3	1	1	0	0	1	1	3	0	0	1	0	3	0	0	1	26.59	18.64	9.75	6.37	92.41	86.6
Myiodynastes solitarius	3	1	1	0	0	0	0	1	2	2	1	0	2	0	0	2	45.25	21.1	12.22	8.86	106.49	86.13
Myiopagis caniceps	3	0	1	0	0	0	0	0	0	3	1	0	3	0	0	0	11.95	10.85	6.37	3.56	60.6	53.43
Myiopagis viridicata	3	0	2	0	2	0	0	0	2	2	1	0	3	0	0	0	14.47	11.84	9.02	4.7	72.08	58.56
Myiophobus fasciatus	3	0	1	0	0	0	2	0	0	2	1	0	2	0	0	0	10.91	11.66	5.92	3.45	61.87	56.12
Myiornis auricularis	3	0	0	0	0	0	0	2	2	0	0	0	3	0	0	0	5.21	9.94	6.64	3.18	37.91	29.51
Myiothlypis leucoblephara	3	0	0	0	0	0	2	2	0	0	0	0	3	1	0	0	15.57	11.31	5.31	3.85	64.54	61.72
Myrmoderus squamosus	3	0	0	0	0	0	3	1	0	0	0	0	2	2	0	0	18.17	12.94	8.22	4.2	61.41	66.55
Nemosia pileata	3	0	1	0	0	0	0	2	3	0	1	0	2	0	0	2	16.57	12.92	7.63	5.49	71.25	47.67
Nonnula rubecula	3	0	0	0	0	0	1	1	3	1	0	0	3	0	0	0	17.4	20.01	11.25	6.14	67	62.45
Notharchus swainsoni	3	2	0	0	0	1	0	0	2	3	0	0	0	0	0	3	60.72	39.48	14.5	13.84	107.72	89.94
Odontophorus capueira	0	0	3	0	1	0	3	0	0	0	1	0	0	3	0	0	296	19.28	9.82	12.18	144.9	85.52
Orchesticus abeillei	3	0	0	0	0	0	0	0	3	0	0	0	3	0	0	0	35.1	15.56	8.64	8.9	83.22	81.42
Orthogonys chloricterus	3	0	1	0	0	0	0	0	3	0	1	0	3	0	0	0	38.1	18.04	9.55	9.3	96.1	85.84
Pachyramphus castaneus	3	0	1	0	0	0	0	0	3	0	1	0	3	0	0	0	24.17	16.84	7.02	5.5	75.32	74.9
Pachyramphus polychopterus	2	0	2	0	0	0	0	1	3	0	2	0	2	0	0	0	20.68	13.93	8.98	6.22	77.61	62.04
Pachyramphus validus	3	0	0	0	0	0	0	2	2	0	0	0	3	0	0	0	39.89	16.99	10.8	8.05	100	71.37
Pachyramphus viridis	3	0	1	0	0	0	0	2	2	2	1	0	3	0	0	1	18.88	14.99	9.54	5.99	61.93	68.02
Patagioenas cayennensis	0	0	3	0	2	0	2	0	2	2	3	0	1	0	0	0	252	17.5	7.8	3.6	182	104
Patagioenas picazuro	2	0	2	0	2	2	2	2	2	1	1	0	2	2	0	0	329.1	18.99	6.33	6.38	222.6	108
Patagioenas plumbea	0	0	2	0	2	0	0	0	2	3	2	0	2	0	0	0	198.74	16.1	9.2	5.8	195	143
Penelope obscura	0	0	3	0	1	2	2	2	2	1	3	0	0	1	0	0	1284.24	41.46	12.18	12.18	306	342.6
Phaeomyias murina	2	0	2	0	0	0	0	3	0	0	2	0	2	0	0	2	9.11	8.84	4.88	2.91	53.88	50.12

Phaethornis eurynome	1	0	0	3	0	0	0	3	0	0	0	3	0	0	0	0	5.41	32.61	4.26	2.92	57.4	66.05
Phaethornis pretrei	1	0	0	3	0	0	0	3	0	0	0	3	0	0	0	0	5.21	32.64	6.41	3.16	59.73	72.33
Philydor rufum	3	0	0	0	0	0	0	0	2	2	0	0	2	3	0	0	25.97	22.03	7.9	5.89	86.18	89.95
Phyllomyias burmeisteri	2	0	2	0	0	0	0	0	3	0	2	0	2	0	0	0	13.86	14	3.72	3.78	61.26	50.56
Phyllomyias fasciatus	3	0	1	0	0	0	0	0	0	3	1	0	3	0	0	0	9.6	9.4	4.9	3.25	62.25	53.75
Phyllomyias virescens	3	0	1	0	0	0	0	1	2	2	1	0	3	0	0	1	10	10.22	3.6	2.88	60.46	60.18
Phylloscartes difficilis	3	0	0	0	0	0	0	3	0	0	0	0	2	0	0	2	8.85	11.81	8.48	4.57	55.71	48.6
Phylloscartes paulista	3	0	0	0	0	0	0	2	2	0	0	0	2	0	0	2	7.48	13.875	2.9	3.075	45.025	44.125
Phylloscartes ventralis	3	0	0	0	0	0	0	1	2	2	0	0	3	0	0	1	8.56	10.72	4.33	2.93	54.41	53.43
Piaya cayana	3	0	0	0	0	0	0	0	0	3	0	0	3	0	3	0	104.52	28.05	16.83	11.52	173.36	295.74
Piculus aurulentus	3	0	0	0	0	0	0	0	3	0	0	0	0	0	3	0	64	26.36	7.2	6.52	117.54	85.4
Picumnus nebulosus	3	0	0	0	0	0	0	2	2	0	0	0	0	1	3	0	15.12	11.25	11.62	8.6	62.4	40.98
Picumnus temminckii	3	0	0	0	0	0	0	3	0	0	0	0	1	0	3	0	11.04	11.33	7.24	5.07	53.41	34.69
Pionopsitta pileata	0	0	3	0	2	2	0	0	2	2	3	0	1	0	0	0	105.67	17.98	12.34	17.66	144.22	88.8
Pionus maximiliani	0	0	2	0	3	1	0	1	2	2	3	0	1	0	0	1	256	24.7	18.68	23.9	184.8	106.4
Pipraeidea melanonota	2	0	2	0	2	0	0	1	2	2	2	0	2	0	0	2	19.97	10.16	6.57	5.45	80.35	60.9
Piranga flava	2	0	2	0	0	0	0	1	2	3	2	0	2	0	2	2	39.29	20.02	10.48	10.33	93.38	72.14
Pitangus sulphuratus	2	1	2	0	0	0	2	2	2	0	1	0	2	0	0	0	61.73	29.07	13.21	9.76	118.33	97.19
Platyrinchus mystaceus	3	0	0	0	0	0	0	3	0	0	0	0	3	0	0	0	9.35	10.22	8.75	3.54	53.41	31.31
Poecilotriccus plumbeiceps	3	0	0	0	0	0	3	0	0	0	0	0	1	0	0	3	6.67	11.86	5.78	3.63	45.01	39.38
Pogonotriccus eximius	3	0	0	0	0	0	0	0	3	0	0	0	3	0	0	0	7.1	14.28	3.62	3.14	52.36	51.44
Poospiza nigrorufa	0	0	0	0	3	0	2	2	0	0	3	0	1	0	0	0	16.99	11.92	4.95	5.11	62.75	63.07
Procnias nudicollis	0	0	3	0	0	0	0	0	2	2	3	0	0	0	0	0	132.67	16.1	18.45	7.58	153	84.17
Psittacara leucophthalmus	1	0	2	0	2	1	1	1	2	2	3	0	1	0	0	0	188.78	21.9	16.4	27.66	171.6	160.4
Pteroglossus bailloni	0	0	3	0	0	0	0	0	2	2	3	0	1	0	0	0	144.6	57	23.2	24.22	131	165.5
Pteroglossus castanotis	1	1	3	0	1	1	0	1	2	1	3	0	1	0	0	0	244.5	94.48	26.92	31.44	147.4	168.8
Pyriglena leucoptera	3	1	0	0	0	0	1	3	0	0	0	0	3	0	0	0	28.86	15.97	7.42	5.63	77.53	76.8
Pyrrhura frontalis	1	0	2	0	2	1	0	1	2	2	3	0	1	0	0	0	83.94	18.69	11.73	19.11	137.67	129.15
Ramphastos dicolorus	1	1	3	0	0	0	1	0	0	3	3	0	1	0	0	2	350.84	90.28	31.44	37.58	196	186.32
Ramphocaenus melanurus	3	0	0	0	0	0	0	3	2	1	0	0	3	0	0	0	9.33	22.26	5.92	4.03	50.4	45.37

Rhopias gularis	3	0	0	0	0	0	0	3	0	0	0	0	2	2	0	0	12.06	11.9	5.34	3.55	53.4	27.63
Rupornis magnirostris	2	2	0	0	0	0	2	2	0	0	0	0	3	0	0	1	251.45	23.14	18.03	16.71	227.72	158.85
Saltator fuliginosus	3	0	2	1	0	0	0	1	2	2	1	0	3	0	0	0	61.75	21.22	13.78	16.96	107	101.44
Saltator maxillosus	0	0	2	0	0	2	0	2	2	1	2	0	2	0	0	0	52.58	20.18	13.5	14.17	101.67	96.71
Saltator similis	3	0	1	0	1	0	0	2	2	0	1	0	3	0	0	2	46.81	19.1	11.47	12.18	98.71	95.44
Satrapa icterophrys	3	0	0	0	0	0	0	2	2	0	0	0	3	0	0	0	20.52	15.04	5.04	4.1	84.88	79.07
Schiffornis virescens	2	0	2	0	0	0	0	3	0	0	1	0	3	0	0	0	24.64	11.69	7.98	5.02	79.92	66.23
Sclerurus scansor	3	0	0	0	0	0	3	0	0	0	0	0	0	3	0	2	39.6	22.07	7.29	5.36	90.5	72.56
Scytalopus speluncae	3	0	0	0	0	0	3	2	0	0	0	0	2	2	0	0	13.82	9.4	6.7	4.4	49	41.6
Serpophaga subcristata	3	0	0	0	0	0	0	3	0	0	0	0	3	0	0	0	7.41	9.7	3.53	2.47	50.82	48.14
Setophaga pitiayumi	3	0	1	0	0	1	0	0	0	3	1	0	3	0	0	0	8.31	10.83	3.44	3.05	52.99	43.03
Sicalis flaveola	2	0	0	0	2	0	3	0	0	0	2	0	2	0	3	0	17.99	9.77	6.22	6.92	61.39	57.21
Sicalis luteola	1	0	0	0	3	0	3	0	0	0	3	0	0	0	0	0	14.63	10.29	7.1	7.2	71.32	53.22
Sirystes sibilator	3	0	1	0	0	0	0	0	0	3	1	0	2	0	0	2	26.18	22.04	11.8	6.59	93.3	83.62
Sittasomus griseicapillus	3	0	0	0	1	0	0	2	2	2	0	0	1	1	3	0	12.93	11.96	6.92	3.81	75.02	73.63
Spinus magellanicus	1	0	0	0	2	2	2	2	2	2	2	0	2	0	0	0	12.96	10.16	5.42	6.25	69.93	43.29
Spizaetus melanoleucus	0	3	0	0	0	0	2	1	1	2	0	0	3	0	0	0	850	39.96	12.43	20.16	390.66	256
Spizaetus tyrannus	0	3	0	0	0	0	1	1	3	2	0	0	3	0	0	0	1007.11	41.8	13.5	21.24	436.6	416.4
Sporophila angolensis	2	0	0	0	2	0	3	2	0	0	2	0	2	0	0	0	14.28	12.74	11.22	11.28	61.5	56.1
Sporophila caerulescens	0	0	0	0	3	0	3	0	0	0	2	0	2	0	0	0	10.49	8.86	6.26	6.6	55.96	47.51
Stephanophorus diadematus	1	0	3	0	0	1	0	2	2	2	3	0	1	0	0	1	34.74	11.98	8.19	7.9	99.67	90.2
Stephanoxis lalandi	1	0	0	3	0	0	0	2	2	2	0	3	1	0	0	0	3.52	20.92	1.42	1.46	50.68	35
Synallaxis cinerascens	3	0	0	0	0	0	3	1	0	0	0	0	3	0	0	0	13.3	10.94	4.39	3.72	54.14	64.29
Synallaxis frontalis	3	0	0	0	0	0	1	3	0	0	0	0	3	0	0	0	13.74	11.65	5.86	4.02	57.39	73.97
Synallaxis ruficapilla	3	0	0	0	0	0	1	3	1	0	0	0	3	0	0	0	14.32	12.1	7.03	4.01	56.21	75.17
Synallaxis spixi	3	0	0	0	0	0	1	3	0	0	0	0	3	0	0	0	13.27	11.36	3.01	3.38	51.66	73.85
Syndactyla rufosuperciliata	3	0	0	0	0	0	1	3	1	0	0	0	2	2	0	2	25.1	15.97	7.34	6.34	74.91	76.95
Tachyphonus coronatus	2	0	2	0	2	0	0	0	2	2	1	0	3	0	0	0	27.51	15.4	8.9	7.99	81.49	75.38
Tangara cyanocephala	1	0	3	0	0	0	0	1	2	3	3	0	0	0	0	0	15.97	10.11	7.09	5.05	65.5	47.24
Tangara desmaresti	1	0	3	0	0	0	0	1	2	3	3	0	1	0	0	0	21.01	9.52	7.26	5.16	74.5	58.11

Tangara flava	1	0	3	0	0	0	0	2	2	2	3	0	1	0	0	0	19.44	13.68	7.9	6.07	72.75	53.94
Tangara preciosa	2	0	3	0	0	0	0	2	3	2	1	0	3	0	0	0	22.41	10.97	7.72	5.75	77.14	65.22
Tangara sayaca	1	0	2	0	2	0	0	0	1	3	1	0	3	0	0	0	33.97	14.49	8.02	7.43	90.44	66.81
Tangara seledon	1	0	3	0	0	0	0	1	2	2	3	0	1	0	0	0	18.42	9.72	6.75	5.55	68.36	52.04
Tapera naevia	3	0	0	0	0	0	3	0	0	0	0	0	3	0	0	1	49.79	18.4	7.42	7.39	115.5	136.4
Tersina viridis	2	0	3	0	0	0	0	1	3	2	1	0	3	0	0	1	34.27	12.62	12.66	6.57	89.16	58.64
Thalurania glaucopis	1	0	0	3	0	0	0	2	2	0	0	0	3	0	0	0	4.84	18.78	3.84	2.21	55.13	42.53
Thamnophilus caerulescens	3	0	1	0	0	0	1	3	1	0	1	0	3	0	0	0	22.11	15.27	8.98	6.5	69.59	64.66
Thamnophilus ruficapillus	3	0	0	0	0	0	0	3	0	0	0	0	3	0	0	0	19.77	18.26	5.53	5.91	67.33	56.55
Thlypopsis pyrrhocoma	3	0	0	0	0	0	0	3	0	0	0	0	3	0	0	0	14.77	12.72	8.45	5.78	62.58	61.44
Thlypopsis sordida	2	0	2	0	2	0	0	0	3	1	2	0	2	0	0	0	55.43	11.87	8.16	5.86	98.71	66.22
Tityra braziliensis	1	0	3	0	0	0	0	2	3	0	1	0	3	0	0	3	71.3	23.93	14.66	11.16	124	73.06
Tityra inquisitor	1	0	3	0	0	0	0	0	2	3	3	0	2	0	0	0	43.1	27.3	17.01	11.88	178.5	68.6
Tolmomyias sulphurescens	3	0	1	0	0	0	0	2	2	2	1	0	2	0	0	2	15.63	13.09	10.25	4.54	68.4	60.11
Trichothraupis melanops	2	0	2	0	2	0	1	2	2	1	1	0	2	0	0	0	23.82	14.31	7.85	6.2	80.43	74.75
Troglodytes aedon	3	0	0	0	0	1	3	1	0	0	0	0	3	0	0	0	12.12	14.81	4.79	4.13	51.07	43.47
Trogon rufus	2	0	2	0	0	0	0	2	2	0	1	0	3	0	0	2	61.05	18.53	17.9	9.19	122.47	145.4
Trogon surrucura	3	0	1	0	0	0	0	2	2	0	1	0	3	0	0	0	65.5	18.92	17.55	11.9	141.92	151.71
Trogon viridis	2	1	3	0	0	0	1	0	2	3	3	0	1	0	0	0	103.83	27.4	11.28	11.86	151	184.8
Turdus albicollis	2	0	2	0	0	0	3	1	1	0	1	0	2	2	0	0	66.78	19.38	9.37	6.82	112.45	89.71
Turdus amaurochalinus	2	0	2	0	0	0	1	2	2	2	1	0	0	3	0	0	59.67	20.11	8.6	6.39	112.82	96.8
Turdus flavipes	1	0	3	0	0	0	3	1	0	0	3	0	0	1	0	0	60.37	17.57	11.81	7.01	112.03	91.23
Turdus leucomelas	1	1	3	0	1	0	3	1	1	1	1	0	2	2	0	0	63.41	20.37	11	7.41	114.8	97.27
Turdus rufiventris	2	0	2	0	0	0	3	1	1	1	1	0	2	2	0	0	72.42	21.12	9.44	7.37	118.8	106.77
Turdus subalaris	2	0	2	0	0	0	2	2	2	0	1	0	2	2	0	2	54.05	18.59	11.48	6.63	108.77	85.54
Tyrannus melancholicus	3	0	0	0	0	0	0	0	2	2	0	0	2	0	0	3	39.55	22.89	12.08	8.08	109.3	91.26
Tyrannus savana	3	0	2	0	0	0	1	3	1	0	1	0	1	0	0	3	30.71	11.95	6.89	5.37	108.48	198.12
Veniliornis spilogaster	3	0	1	0	0	0	0	2	2	2	1	0	2	0	3	0	38.23	21.52	10.6	6.89	95.4	63.93
Vireo olivaceus	3	0	1	0	0	0	0	1	2	2	1	0	3	0	2	0	14.61	13.27	7.23	4.64	70.22	53.01
Xenops minutus	3	0	0	0	0	0	0	2	2	0	0	0	2	0	2	0	9.29	11.16	6.52	4.48	57.6	47.42

Xenops rutilus	3	0	0	0	0	0	0	2	2	0	0	0	2	0	3	0	10.58	10.89	5.07	4.82	64.67	50.82
Xiphocolaptes albicollis	3	1	0	0	0	0	1	3	1	1	0	0	0	0	2	0	103.78	43.76	12.37	10.3	130.36	115.65
Xiphorhynchus fuscus	3	0	0	0	0	0	0	2	2	1	0	0	2	0	0	2	21.6	23.94	8.41	5.63	79.68	71.86
Zenaida auriculata	0	0	0	0	3	0	3	0	0	0	3	0	0	0	0	0	118.38	15.45	5.58	4.79	140.04	95.46
Zonotrichia capensis	2	0	0	0	3	1	3	0	0	0	2	0	1	2	0	0	21.11	12.52	6.49	6.88	67.15	61.42

Anexo B

Dados do capítulo 2

A1 Table. Bird species contacts. List of bird species sampled at 24 local sites of Araucaria forest, South Brazil. Bird nomenclature is based on BirdLife International (2017).

Species	su1	su2	su3	su4	su5	su6	su7	su8	su9	su10	su11	su12	su13	su14	su15	su16	su17	su18	su19	su20	su21	su22	su23	su24
Amazona vinacea	0	0	0	0	0	6	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anabacerthia amaurotis	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aramides saracura	0	0	0	0	0	0	0	0	0	2	0	1	1	0	0	0	0	0	0	0	1	0	0	0
Attila rufus	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Baryphthengus ruficapillus	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Basileuterus auricapilla	1	7	9	7	7	7	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Batara cinerea	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brotogeris tirica	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cacicus chrysopterus	3	1	0	0	0	0	0	0	1	1	0	0	1	1	2	3	0	0	0	0	0	0	0	1
Cacicus haemorrhous	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Campephilus robustus	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Camptostoma obsoletum	0	0	0	0	3	1	0	0	1	0	1	1	0	0	0	0	0	0	0	1	2	0	0	0
Campylorhamphus falcularius	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caracara plancus	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Celeus flavescens	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chamaeza campanisona	0	7	9	2	5	5	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chiroxiphia caudata	0	4	5	2	6	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clibanornis dendrocolaptoides	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cnemotriccus fuscatus	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Colaptes campestris	0	0	0	0	0	0	0	0	0	1	0	3	1	0	2	0	0	0	0	0	0	1	0	0
Conirostrum speciosum	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Conopophaga lineata	3	1	1	1	3	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Contopus cinereus	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cranioleuca obsoleta	1	1	0	0	1	0	0	5	1	3	2	2	1	3	2	0	1	0	2	0	1	0	1	0
Crypturellus obsoletus	3	1	3	0	0	3	3	4	0	0	0	0	0	0	0	1	0	0	1	0	0	2	0	1
Cyanocorax chrysops	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyanocorax coeruleus	1	0	0	0	0	0	1	0	0	1	2	1	1	0	0	3	1	0	0	0	0	1	2	0
Cyclarhis gujanensis	8	6	1	0	1	1	3	6	1	0	1	1	2	2	2	5	6	1	0	2	2	2	5	1
Dendrocincla turdina	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dendrocolaptes platyrostris	2	6	4	1	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	1
Drymophila malura	3	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Drymophila rubricollis	0	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dysithamnus mentalis	0	7	3	6	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elaenia mesoleuca	13	1	0	0	0	0	28	30	4	4	5	4	6	4	2	8	13	13	3	10	10	10	5	6
Elanoides forficatus	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eleoscytalopus indigoticus	0	1	3	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geotrygon montana	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glaucidium brasilianum	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grallaria varia	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Habia rubica	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Heliobletus contaminatus	0	0	0	1	0	0	0	0	1	0	0	0	0	2	0	0	1	0	1	1	2	0	2	1
Hemithraupis guira	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hylatomus lineatus	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hylopezus nattereri	1	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hylophilus poicilotis	2	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lathrotriccus euleri	0	0	1	0	3	0	1	0	0	0	2	0	1	0	0	0	0	3	1	1	4	4	2	4
Lepidocolaptes falcinellus	3	5	1	0	6	0	4	3	2	0	3	2	3	2	3	1	6	5	2	5	4	3	3	4
Leptasthenura setaria	1	2	3	7	3	4	2	0	1	0	3	5	3	0	2	5	7	6	2	5	1	3	1	5
Leptasthenura striolata	0	0	0	0	0	0	0	0	1	0	0	1	1	1	1	0	0	0	1	0	1	2	1	0
Leptopogon amaurocephalus	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leptotila rufaxilla	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Leptotila verreauxi	0	4	0	1	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	3	0
Leucochloris albicollis	1	0	1	0	0	0	6	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lochmias nematura	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Megarynchus pitangua	0	3	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Melanerpes flavifrons	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Micrastur ruficollis	0	2	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Micrastur semitorquatus	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Milvago chimachima	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mionectes rufiventris	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Myiarchus swainsoni	4	1	0	0	1	0	2	2	4	3	3	2	3	2	1	2	4	7	1	5	6	3	2	3
Myiodynastes solitarius	0	3	3	3	2	4	4	1	0	0	0	0	2	0	0	1	2	3	2	3	2	3	0	3
Myiopagis viridicata	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Myiornis auricularis	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Myiothlypis leucoblephara	7	7	14	7	10	9	2	7	0	2	0	0	0	1	0	3	2	4	1	2	3	3	3	1
Odontophorus capueira	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pachyramphus castaneus	0	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pachyramphus polychopterus	0	4	1	3	0	0	0	1	2	0	3	0	0	0	0	6	2	0	0	1	2	0	0	0
Pachyramphus viridis	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patagioenas cayennensis	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patagioenas picazuro	0	0	0	0	0	1	0	0	1	0	2	2	0	1	1	0	1	0	0	0	0	1	0	0
Patagioenas plumbea	0	0	0	0	0	3	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Penelope obscura	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phaethornis eurynome	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phyllomyias fasciatus	0	0	0	0	0	0	0	2	0	0	0	0	0	1	1	0	0	0	0	0	6	5	3	2
Phyllomyias virescens	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	1	1	1	0	2	2	1	2	0
Phylloscartes ventralis	4	0	0	0	2	0	0	0	2	2	1	1	1	0	2	1	6	2	1	3	3	6	4	8
Piculus aurulentus	0	1	0	0	0	0	0	2	1	0	0	0	0	0	0	0	1	0	2	0	0	3	0	2
Picumnus nebulosus	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pionopsitta pileata	0	0	2	0	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pionus maximiliani	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Pipraeidea melanonota	1	0	0	1	0	1	3	2	2	1	3	3	1	0	1	8	2	3	1	3	1	1	1	1
Pitangus sulphuratus	0	0	0	0	0	0	0	0	1	3	3	3	2	2	1	0	1	0	1	1	0	0	0	0
Platyrinchus mystaceus	0	2	1	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Poospiza nigrorufa	4	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Procnias nudicollis	0	3	3	0	11	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psittacara leucophthalmus	0	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pyriglena leucoptera	0	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pyrrhura frontalis	0	3	4	1	1	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ramphastos dicolorus	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rupornis magnirostris	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	1
Saltator similis	1	2	1	4	1	0	0	3	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
Schiffornis virescens	0	3	0	4	8	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scytalopus speluncae	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Setophaga pitiayumi	4	3	1	8	6	1	7	2	2	4	4	5	2	3	3	3	2	1	1	2	8	4	7	6
Sirystes sibilator	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sittasomus griseicapillus	1	5	2	4	11	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3	1
Stephanophorus diadematus	1	0	0	0	0	0	1	2	1	1	2	0	0	1	1	2	2	0	0	0	1	0	1	0
Synallaxis cinerascens	0	1	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Synallaxis ruficapilla	1	0	1	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Syndactyla rufosuperciliata	4	0	0	0	0	0	3	8	1	1	1	0	1	2	1	0	0	3	1	3	4	3	2	1
Tachyphonus coronatus	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tangara preciosa	0	0	1	0	0	0	0	1	3	0	1	0	1	2	1	0	3	2	2	5	1	3	2	6
Tangara sayaca	1	1	1	0	0	1	0	0	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0
Thamnophilus caerulescens	4	2	3	0	3	1	1	6	1	2	0	0	0	1	0	1	0	4	0	2	3	1	0	0
Thlypopsis pyrrhocoma	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tityra braziliensis	0	1	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tityra inquisitor	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tolmomyias sulphurescens	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2
Trichothraupis melanops	0	1	3	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Troglodytes aedon	0	0	0	0	0	0	0	0	1	2	0	3	0	0	0	0	0	0	0	0	0	0	0	0

Trogon rufus	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trogon surrucura	1	4	1	3	7	8	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turdus albicollis	0	2	9	5	2	1	0	0	0	1	0	0	2	0	0	1	0	0	0	0	0	3	3	1
Turdus amaurochalinus	4	0	1	3	1	1	8	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0
Turdus flavipes	0	0	0	0	0	0	5	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turdus leucomelas	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turdus rufiventris	2	4	7	1	6	3	1	5	2	2	2	2	4	1	4	2	1	3	2	2	5	2	4	1
Turdus subalaris	0	0	0	0	0	1	17	1	1	0	1	2	0	0	0	0	1	0	0	0	0	0	0	0
Tyrannus melancholicus	0	0	0	0	0	0	0	0	0	1	0	1	1	0	2	0	0	1	1	0	0	0	0	2
Veniliornis spilogaster	1	2	2	0	1	2	0	1	1	1	1	1	1	0	1	2	1	2	2	0	1	1	1	1
Vireo olivaceus	8	6	0	0	2	0	13	12	3	3	3	0	0	4	0	0	3	3	2	3	8	9	9	3
Xiphocolaptes albicollis	0	2	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Xiphorhynchus fuscus	0	0	0	3	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0
Zonotrichia capensis	0	0	0	0	0	0	0	1	1	1	2	3	4	0	2	3	1	0	0	2	0	1	0	2

A2 Table. Bird functional traits. List of bird functional traits used to calculate functional diversity metrics, including Community Weighted Mean (CWM).

Species	Diet Inset	Diet vertebrate	Diet fruit	Diet nectar	Diet seed	Diet plant	Stratum ground	Stratum understory	Stratum mid_high	Stratum canopy	Bill length/width	Bill length/depth	Wing/tail	Body Mass
Amazona vinacea	0	0	2	0	2	1	0	2	3	2	1.71	1.06	1.58	254
Anabacerthia amaurotis	3	0	0	0	0	0	1	3	0	1	1.7	2.32	1.05	20.55
Aramides saracura	2	2	0	0	0	2	3	1	0	0	0.71	0.81	2.42	254.43
Attila rufus	2	2	2	0	0	0	3	2	2	1	2.15	3.16	1.19	41.57
Baryphthengus ruficapillus	3	2	2	0	0	0	1	3	2	0	3.38	3.12	0.7	130.85
Basileuterus auricapilla	3	0	1	0	0	0	0	3	1	0	1.88	2.8	1.05	9.6
Batara cinerea	3	1	0	0	0	0	1	3	1	0	4.21	2.82	0.7	136.67
Brotogeris tirica	1	0	0	1	2	2	0	0	0	3	1.67	1.07	0.97	67.75
Cacicus chrysopterus	2	0	2	0	0	0	0	0	3	1	3.06	2.3	1.09	38.76
Cacicus haemorrhous	3	0	2	1	0	0	0	1	3	1	3.13	2.77	1.35	70.72
Campephilus robustus	3	0	0	0	0	0	0	2	2	2	3.81	3.55	1.39	262
Camptostoma obsoletum	3	0	1	0	0	0	0	0	0	3	1.87	2.74	1.06	8.06
Campylorhamphus falcularius	3	0	0	0	0	0	0	2	2	0	5.93	9.61	0.99	39.38
Caracara plancus	2	2	1	0	0	0	3	2	0	0	1.63	1.61	1.24	944.4
Celeus flavescens	3	0	1	0	0	0	1	0	2	2	2.45	3.18	1.58	134.03
Chamaeza campanisona	2	0	2	0	0	0	3	0	0	0	1.84	2.34	1.56	93.59
Chiroxiphia caudata	2	0	2	0	0	0	0	2	2	0	1.08	1.89	1.33	24.9
Clibanornis dendrocolaptoides	3	0	0	0	0	0	2	2	0	0	3.93	3.34	0.98	49.92
Cnemotriccus fuscatus	3	0	0	0	0	0	1	3	0	0	2.01	3.21	1.04	12.96
Colaptes campestris	3	0	0	0	0	0	3	0	0	0	2.51	3.24	1.36	163.5
Conirostrum speciosum	3	0	1	1	0	0	0	0	0	3	2.64	2.74	1.37	9.3
Conopophaga lineata	3	1	1	0	0	0	2	2	0	0	1.67	2.85	1.5	21.28
Contopus cinereus	3	0	0	0	0	0	0	2	3	0	3.03	4.3	1.09	10.33
Cranioleuca obsoleta	3	0	0	0	0	0	0	2	2	0	3.9	3.54	1	13.56

Crypturellus obsoletus	2	0	0	0	2	0	3	0	0	0	1.56	2.4	2.71	631
Cyanocorax chrysops	3	1	2	0	0	0	1	2	2	2	2.26	2.06	0.94	161.42
Cyanocorax coeruleus	1	1	2	0	3	0	1	2	2	2	2.16	2.02	1.21	298.67
Cyclarhis gujanensis	3	0	1	0	0	0	0	0	2	2	1.79	1.75	1.11	27.41
Dendrocincla turdina	3	0	0	0	0	0	1	2	2	0	2.42	3.35	1.16	37.97
Dendrocolaptes platyrostris	3	1	0	0	0	0	1	2	2	1	2.87	3.92	1.03	58.65
Drymophila malura	3	0	0	0	0	0	0	3	0	0	3.67	3.7	0.75	11.28
Drymophila rubricollis	3	0	0	0	0	0	0	3	1	0	2.65	3.4	0.77	11.16
Dysithamnus mentalis	3	0	1	0	0	0	1	2	2	1	1.94	2.86	1.39	12.63
Elaenia mesoleuca	2	0	2	0	0	0	0	1	2	2	1.66	2.32	1.12	16.69
Elanoides forficatus	3	2	0	0	0	0	0	2	2	2	2.77	2.54	1.49	490
Eleoscytalopus indigoticus	3	0	0	0	0	0	3	2	0	0	1.35	2.18	1.39	14.76
Geotrygon montana	2	0	2	0	2	0	3	0	0	0	1.9	2.42	1.6	136.89
Glaucidium brasilianum	3	2	0	0	0	0	2	2	1	0	1.77	1.7	1.47	73.5
Grallaria varia	3	0	0	0	0	0	3	0	0	0	1.55	2.45	2.21	134.38
Habia rubica	3	0	1	0	0	0	1	2	2	0	1.62	1.74	1.05	34.82
Heliobletus contaminatus	3	0	0	0	0	0	0	1	2	2	2.07	2.84	1.21	15.07
Hemithraupis guira	3	0	1	0	1	0	0	0	1	3	1.73	2.47	1.24	11.39
Hylatomus lineatus	3	0	1	0	1	0	2	2	3	1	2.69	2.87	1.49	186.67
Hylopezus nattereri	3	0	0	0	0	0	2	2	0	0	4.22	4.15	2.04	27.65
Hylophilus poicilotis	3	0	1	0	0	0	0	1	2	2	1.55	2.4	1.04	10.24
Lathrotriccus euleri	3	0	0	0	0	0	0	3	0	0	1.79	3.17	1.1	11.6
Lepidocolaptes falcinellus	3	0	0	0	0	0	0	0	2	2	2.64	4.85	1.06	26.4
Leptasthenura setaria	3	0	0	0	0	0	0	0	2	3	5.7	5.7	0.51	13.07
Leptasthenura striolata	3	0	0	0	0	0	0	2	2	2	4.65	4.39	0.61	9.18
Leptopogon amaurocephalus	3	0	1	0	0	0	0	0	3	1	1.94	2.98	1.11	12.31
Leptotila rufaxilla	1	0	1	0	3	0	3	0	0	0	2.68	3.34	1.29	177.72
Leptotila verreauxi	1	0	1	0	3	0	3	0	0	0	2.56	3.22	1.21	166.34
Leucochloris albicollis	1	0	0	3	0	0	0	2	2	2	6.68	9.08	1.52	6.09

Lochmias nematura	3	0	0	0	0	0	3	0	0	0	3.23	3.95	1.38	23.3
Megarynchus pitangua	3	1	1	0	1	0	0	1	3	2	1.81	2.62	1.19	57.22
Melanerpes flavifrons	3	0	2	0	2	0	0	2	2	0	4.54	4.93	1.62	56
Micrastur ruficollis	1	3	0	0	0	0	2	2	0	0	1.23	0.99	1.08	160.5
Micrastur semitorquatus	0	3	0	0	0	0	2	2	1	0	2.56	1.67	0.9	441
Milvago chimachima	2	2	2	0	0	0	3	0	0	0	2.93	2.28	1.42	256.67
Mionectes rufiventris	2	0	2	0	0	0	0	3	0	0	1.6	2.71	1.21	13.81
Myiarchus swainsoni	3	0	1	0	0	0	0	1	3	1	1.98	3.29	1.04	24.75
Myiodynastes solitarius	3	1	1	0	0	0	0	1	2	2	1.73	2.38	1.24	45.25
Myiopagis viridicata	3	0	2	0	2	0	0	0	2	2	1.31	2.52	1.23	14.47
Myiornis auricularis	3	0	0	0	0	0	0	2	2	0	1.5	3.13	1.28	5.21
Myiothlypis leucoblephara	3	0	0	0	0	0	2	2	0	0	2.13	2.94	1.05	15.57
Odontophorus capueira	0	0	3	0	1	0	3	0	0	0	1.96	1.58	1.69	296
Pachyramphus castaneus	3	0	1	0	0	0	0	0	3	0	2.4	3.06	1.01	24.17
Pachyramphus polychopterus	2	0	2	0	0	0	0	1	3	0	1.55	2.24	1.25	20.68
Pachyramphus viridis	3	0	1	0	0	0	0	2	2	2	1.57	2.5	0.91	18.88
Patagioenas cayennensis	0	0	3	0	2	0	2	0	2	2	2.24	4.86	1.75	252
Patagioenas picazuro	2	0	2	0	2	2	2	2	2	1	3	2.98	2.06	329.1
Patagioenas plumbea	0	0	2	0	2	0	0	0	2	3	1.75	2.78	1.36	198.74
Penelope obscura	0	0	3	0	1	2	2	2	2	1	3.4	3.4	0.89	1284.24
Phaethornis eurynome	1	0	0	3	0	0	0	3	0	0	7.65	11.17	0.87	5.41
Phyllomyias fasciatus	3	0	1	0	0	0	0	0	0	3	1.92	2.89	1.16	9.6
Phyllomyias virescens	3	0	1	0	0	0	0	1	2	2	2.84	3.55	1	10
Phylloscartes ventralis	3	0	0	0	0	0	0	1	2	2	2.48	3.66	1.02	8.56
Piculus aurulentus	3	0	0	0	0	0	0	0	3	0	3.66	4.04	1.38	64
Picumnus nebulosus	3	0	0	0	0	0	0	2	2	0	0.97	1.31	1.52	15.12
Pionopsitta pileata	0	0	3	0	2	2	0	0	2	2	1.46	1.02	1.62	105.67
Pionus maximiliani	0	0	2	0	3	1	0	1	2	2	1.32	1.03	1.74	256
Pipraeidea melanonota	2	0	2	0	2	0	0	1	2	2	1.55	1.86	1.32	19.97

Pitangus sulphuratus	2	1	2	0	0	0	2	2	2	0	2.2	2.98	1.22	61.73
Platyrinchus mystaceus	3	0	0	0	0	0	0	3	0	0	1.17	2.89	1.71	9.35
Poospiza nigrorufa	0	0	0	0	3	0	2	2	0	0	2.41	2.33	0.99	16.99
Procnias nudicollis	0	0	3	0	0	0	0	0	2	2	0.87	2.12	1.82	132.67
Psittacara leucophthalmus	1	0	2	0	2	1	1	1	2	2	1.34	0.79	1.07	188.78
Pyriglena leucoptera	3	1	0	0	0	0	1	3	0	0	2.15	2.84	1.01	28.86
Pyrrhura frontalis	1	0	2	0	2	1	0	1	2	2	1.59	0.98	1.07	83.94
Ramphastos dicolorus	1	1	3	0	0	0	1	0	0	3	2.87	2.4	1.05	350.84
Rupornis magnirostris	2	2	0	0	0	0	2	2	0	0	1.28	1.38	1.43	251.45
Saltator similis	3	0	1	0	1	0	0	2	2	0	1.67	1.57	1.03	46.81
Schiffornis virescens	2	0	2	0	0	0	0	3	0	0	1.46	2.33	1.21	24.64
Scytalopus speluncae	3	0	0	0	0	0	3	2	0	0	1.4	2.14	1.18	13.82
Setophaga pitiayumi	3	0	1	0	0	1	0	0	0	3	3.15	3.55	1.23	8.31
Sirystes sibilator	3	0	1	0	0	0	0	0	0	3	1.87	3.34	1.12	26.18
Sittasomus griseicapillus	3	0	0	0	1	0	0	2	2	2	1.73	3.14	1.02	12.93
Stephanophorus diadematus	1	0	3	0	0	1	0	2	2	2	1.46	1.52	1.1	34.74
Synallaxis cinerascens	3	0	0	0	0	0	3	1	0	0	2.49	2.94	0.84	13.3
Synallaxis ruficapilla	3	0	0	0	0	0	1	3	1	0	1.72	3.02	0.75	14.32
Syndactyla rufosuperciliata	3	0	0	0	0	0	1	3	1	0	2.18	2.52	0.97	25.1
Tachyphonus coronatus	2	0	2	0	2	0	0	0	2	2	1.73	1.93	1.08	27.51
Tangara preciosa	2	0	3	0	0	0	0	2	3	2	1.42	1.91	1.18	22.41
Tangara sayaca	1	0	2	0	2	0	0	0	1	3	1.81	1.95	1.35	33.97
Thamnophilus caerulescens	3	0	1	0	0	0	1	3	1	0	1.7	2.35	1.08	22.11
Thlypopsis pyrrhocoma	3	0	0	0	0	0	0	3	0	0	1.51	2.2	1.02	14.77
Tityra braziliensis	1	0	3	0	0	0	0	2	3	0	1.63	2.14	1.7	71.3
Tityra inquisitor	1	0	3	0	0	0	0	0	2	3	1.6	2.3	2.6	43.1
Tolmomyias sulphurescens	3	0	1	0	0	0	0	2	2	2	1.28	2.88	1.14	15.63
Trichothraupis melanops	2	0	2	0	2	0	1	2	2	1	1.82	2.31	1.08	23.82
Troglodytes aedon	3	0	0	0	0	1	3	1	0	0	3.09	3.59	1.17	12.12

Trogon rufus	2	0	2	0	0	0	0	2	2	0	1.04	2.02	0.84	61.05
Trogon surrucura	3	0	1	0	0	0	0	2	2	0	1.08	1.59	0.94	65.5
Turdus albicollis	2	0	2	0	0	0	3	1	1	0	2.07	2.84	1.25	66.78
Turdus amaurochalinus	2	0	2	0	0	0	1	2	2	2	2.34	3.15	1.17	59.67
Turdus flavipes	1	0	3	0	0	0	3	1	0	0	1.49	2.51	1.23	60.37
Turdus leucomelas	1	1	3	0	1	0	3	1	1	1	1.85	2.75	1.18	63.41
Turdus rufiventris	2	0	2	0	0	0	3	1	1	1	2.24	2.87	1.11	72.42
Turdus subalaris	2	0	2	0	0	0	2	2	2	0	1.62	2.8	1.27	54.05
Tyrannus melancholicus	3	0	0	0	0	0	0	0	2	2	1.89	2.83	1.2	39.55
Veniliornis spilogaster	3	0	1	0	0	0	0	2	2	2	2.03	3.12	1.49	38.23
Vireo olivaceus	3	0	1	0	0	0	0	1	2	2	1.84	2.86	1.32	14.61
Xiphocolaptes albicollis	3	1	0	0	0	0	1	3	1	1	3.54	4.25	1.13	103.78
Xiphorhynchus fuscus	3	0	0	0	0	0	0	2	2	1	2.85	4.25	1.11	21.6
Zonotrichia capensis	2	0	0	0	3	1	3	0	0	0	1.93	1.82	1.09	21.11