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Bird community in a mountain ecotonal landscape: how is the distribution between different phytophysiognomies?

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FOREST ECOLOGY

ABSTRACT

Background: The mountainous ecotonal regions of Brazil have a high diversity of species due to the sharing of faunal and floristic elements with adjacent biomes. These areas are preserved on a mesoscale and play a crucial role in biodiversity conservation. This study aims to analyze bird community distribution within an ecotonal region based on phytophysiognomies, focusing on species richness, composition, and seasonality. Additionally, it seeks to estimate species diversity through richness estimators and identify bioindicator species for each environment using statistical models. Direct observations were carried out in 18 areas representing primary environments/phytophysiognomies during two distinct seasons.

Results: 324 bird species from 60 families were recorded, including six species listed as threatened. The species accumulation curves did not reach asymptote, with a greater number of species for the summer. The distribution of species in the landscape was considered unique for each physiognomy and species composition. The INDVAL analysis found *Serpophaga nigricans* as an anthropogenic species, suggesting an adaptation of the species to areas with human activities, such as the tourist waterfall regions in this area.

Conclusion: The distribution of birds in the mountainous ecotonal landscape showed the importance of environments as they are unique in each phytophysiognomy, highlighting the importance for hosts of endemic, rare and endangered species.

Keywords. Distribution; Environments; Biogeography; Hotspot areas; Conservation.

HIGHLIGHTS

The composition in bird community is unique in each phytophysiognomy.
Montane landscapes host endemic, rare, and threatened bird species.
The communities are threatened due mining activities and landscape fragmentation.
The remaining forests require attention with conservation and preservation projects.

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INTRODUCTION

The world contains regions known as "hotspots", characterized by high biodiversity, numerous endemic species, and prioritized conservation efforts (Myers et al., 2000; Mittermeier et al., 2005). Ecotones represent transitional zones where two ecosystems meet, resulting in unique characteristics such as elevated biodiversity. This high diversity arises from overlapping species distributions from adjacent biomes, as demonstrated for plants (Machado et al., 2016) and mammals (Talamoni et al., 2014; Laurindo et al., 2017; Machado et al., 2021; Souza et al., 2020; Cáceres et al., 2007). Brazil's Cerrado and Atlantic Forest domains are prominent examples of such "hotspot" regions (Myers et al., 2000; Mittermeier et al., 2005). Where the Cerrado and Atlantic Forest converge, ecotonal regions emerge, characterized by coexisting fauna and flora from both mega-diverse biomes (Kark and Van Rensburg, 2006).

The Brazilian hotspots, the Atlantic Forest and Cerrado, are significantly fragmented and face advanced deforestation (Ribeiro et al., 2019, for the Atlantic Forest, and Klink and Machado, 2005, for the Cerrado). Many remnants of these biomes are found at higher altitudes, some of which enjoy legal protection under Brazil's Law 12,651/2012. This legislation mandates the preservation of permanent protection areas, including hilltops, mountains exceeding 100 meters with an average slope greater than 25º, and areas above 1,800 meters in altitude, irrespective of vegetation type. The law also defines preservation based on the contour line corresponding to two-thirds of the elevation from the base (Brasil, 2012).

Phytophysiognomies, or plant formations, represent vegetation types shaped by structural, floristic, and spatial organizational characteristics. These formations are crucial to understanding ecosystem dynamics, plant species distribution, and plant adaptations to environmental conditions such as climate, soil, and water availability (Coutinho, 2006). A diverse array of phytophysiognomies occurs within the Cerrado and Atlantic Forest, each defined by distinct edaphic (Vasconcelos, 2011) and floristic attributes that influence their bird communities (Rotenberry, 1985; Munro et al., 2011).

Bird distributions are closely tied to vegetation types (Gussoni et al., 2024; Posso et al., 2024) and are shaped by seasonal cycles. Seasonal variation affects climatic conditions, food availability, and reproductive factors, influencing bird migratory patterns. These migrations enable birds to access resources essential for survival and reproduction (Sick, 1997). Migration patterns range from long-distance continental movements to short-range relocations within a single region (Newton, 2008). Despite their ecological significance, knowledge about bird communities remains limited, particularly for montane ecotonal regions. Examples of these under-researched habitats include forests dominated by *Eremanthus erythropappus* (Moura et al., 2022b) and natural montane grasslands, which harbor some of Brazil's most endangered bird species (Machado et al., 1998; Lopes et al., 2009; BirdLife International, 2011).

Despite the ecological value of montane ecotonal landscapes, ornithological studies focusing on southeastern Brazil—and the country as a whole—remain scarce. These environments, often preserved at meso-scales, are challenging to access, making comprehensive research difficult (Mariano et al., 2019). Consequently, mountain regions designated as permanent preservation areas under the law are understudied, despite being vulnerable to human interference.

This study aims to analyze bird community distribution within an ecotonal region based on phytophysiognomies, focusing on species richness, composition, and seasonality. Additionally, it seeks to estimate species diversity through richness estimators and identify bioindicator species for each environment using statistical models. It is hypothesized that species richness is high due to the ecotonal nature of the area and that community composition reflects the vegetation characteristics of each phytophysiognomy. Greater species diversity is anticipated during summer, driven by the presence of migratory birds. Furthermore, it is hypothesized that richness estimators will yield elevated values, reflecting the diverse landscape and extensive sampling efforts undertaken.

MATERIALS AND METHODS

Study area

This study was conducted in São Tomé das Letras, located in the southern region of Minas Gerais, southeastern Brazil (Figure 1, Appendix 1), during 2014 and 2015. The municipality is characterized by a subtropical highland climate, Cwb climate type, as classified by the Köppen climate classification system, on its mountaintops (Alvares et al., 2013). The type Cwb is humid temperate climate with dry winters and mild summers. This type of climate generally occurs in high-altitude areas in tropical or subtropical regions. The study area is located in a highly fragmented region, in an ecotonal environment of Atlantic Forest and Cerrado. The landscape is a mosaic of rocky fields, Cerrado *stricto sensu*, anthropogenic areas (including quartzite extraction quarries, roads, cultivated fields, artificial lakes, and pastures), swamps, montane semi-deciduous seasonal forest fragments, and riparian forests. Among these, rocky fields are the predominant feature of the landscape. The altitude of the sampling points varied from 1275m to 1440 meters high.

Rupestrian fields are high-altitude ecosystems typically found on rocky outcrops, characterised by shallow, nutrient-poor soils, intense solar radiation, and high daily temperature variation. This environment hosts a high level of endemism and biodiversity, particularly in flora. Montane semideciduous forests occur at intermediate to high elevations and are marked by a seasonal pattern of leaf loss during the dry season. These forests maintain a rich diversity of flora and fauna, with a mixture of evergreen and deciduous tree species. Swamps play an essential role in water filtration, flood control, and as breeding grounds for various amphibians, insects, and birds. Anthropogenic areas refer to landscapes significantly altered by human activity, such as agricultural fields, pastures, urban zones, or managed plantations. These areas usually show reduced biodiversity and ecological complexity due to land use changes. Riparian forests are ecosystems located along the banks of rivers, streams, and other watercourses. They are vital for maintaining water quality, preventing erosion, and providing habitat corridors for wildlife.

Sampling data

Direct observations were carried out across six phytophysiognomic types at three distinct sites within the region: rupestrian fields, montane semi-deciduous seasonal forest fragments, riparian forests, marshes (including artificial lakes), Cerrado *stricto sensu*, and anthropogenic areas (such as roads, pastures, orchards, and cultivated fields) (Appendix 1). Each site was visited during both winter and summer seasons, with observations conducted from 6:00 AM to 6:00 PM. This yielded a total of 72 observation hours per phytophysiognomy (six days) (36h per season), amounting to 648 hours of fieldwork per season and an overall total of 1,296 hours of observations. During these observation hours, quantitative data were obtained on the number of species observed for each sampling point.

Nikon 08x40 and 10x50 binoculars were used to facilitate observations, while photographs were captured, when possible, using Canon EOS Rebel T1i and Canon PowerShot SX50 HS cameras. Species nomenclature followed Pacheco et al. (2021). The methodology and analyses applied in this study were consistent with those outlined by Moura et al. (2015), Moura et al. (2020a), Moura et al. (2020b), Moura et al. (2021a), Moura et al. (2021b), and Moura et al. (2022a) for adjacent ecotonal municipalities.

Data analysis

Species accumulation curves were constructed to evaluate richness, abundance, sampling sufficiency, and seasonality (winter/summer). The first-order Jackknife estimator was applied to estimate species richness. These curves were generated using 1,000 randomizations in the EstimateS software (version 9.10; Colwell et al., 2012). Subsequently, Non-Metric Multidimensional Scaling (NMDS) was performed using the Bray-Curtis distance metric to analyze the composition. The NMDS output was analyzed through Similarity Analysis (ANOSIM) (Clarke, 1993) at a 5% significance level to assess whether distinct environments corresponded to different communities.

The Indicator Value (INDVAL) test was employed to identify species that contributed to distributional differences across various phytophysiognomies. Only species with ≥ 10 records were included in the analysis. INDVAL quantifies species fidelity and specificity in relation to groups of phytophysiognomies based on user-defined classifications. Statistical significance was determined using permutation testing. The Indicator Value Analysis (Dufrene and Legendre, 1997), combined with the Monte Carlo test, was performed using PC-ORD software (McCune and Mefford, 2006).

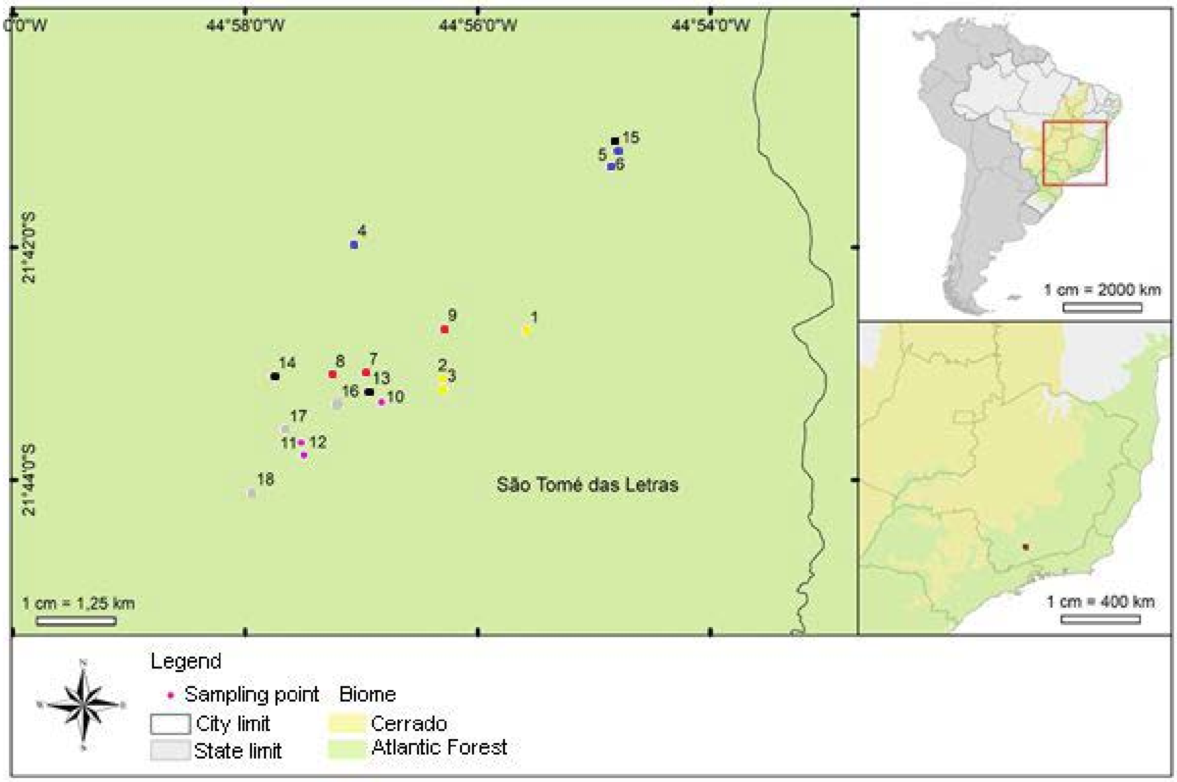

Figure 1: Location of São Tomé das Letras municipality, southern Minas Gerais, southeastern Brazil. The *Cerrado* is in brown and Atlantic Forest in green. Observation points and data collection sites are highlighted in yellow to rupestrian field, blue to montane semideciduous forest, red to swampy, pink to anthropogenic areas, and black to riparian forests.

RESULTS

A total of 324 bird species from 60 families were documented during the study (Supplementary material 1). The families Tyrannidae (N=52), Thraupidae (N=35), Trochilidae and Accipitridae (N=16) demonstrated the highest species representation (Supplementary material 2). The rarefaction curve did not reach an asymptote, and the first-order Jackknife richness estimator indicated a potential richness of approximately 400 species (Figure 2). According to the richness estimator, the study captured 81% of the estimated total species diversity.

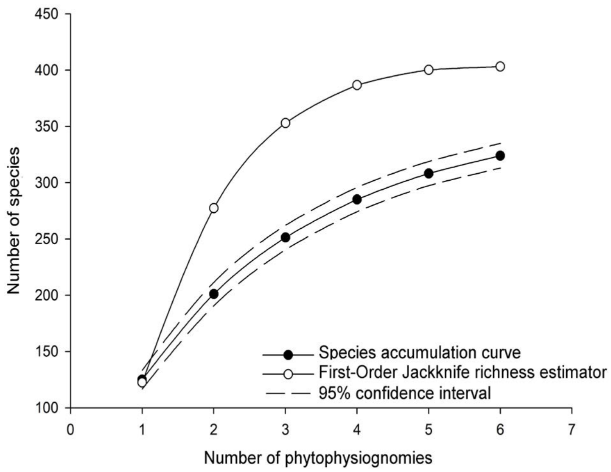

Figure 2: Rarefaction curve, confidence interval, and first-order Jackknife richness estimator for various environments together: Rupestrian Fields, riparian forest remnants, montane semi-deciduous forest, Cerrado *stricto sensu*, swamps, and anthropic areas.

Approximately 2.78% of the species recorded within the municipality were identified as summer visitors. These are migratory birds that migrate to Neotropical regions during the boreal winter (Figure 3). These visitors were primarily observed in *Cerrado stricto sensu*, rupestrian fields, and anthropogenic areas, with a greater number of species recorded during the summer than in the winter.

The NMDS analysis among the phytophysiognomies exhibited greater proximity between the Cerrado areas, anthropic areas, and rupestrian fields (Figure 4).

The overall R for the ANOSIM test reached 0.996 and a significance (p) of 0.0001. The pairwise tests between all groups showed significance (p=0.01), with the standard R value for all groups, with the exception of the Forests and Riparian Forests comparison, which presented an R of 0.82 (Table 1).

The INDVAL test, which quantifies species fidelity and specificity to phytophysiognomies, revealed that 30 species are specific to anthropic areas, 14 to swamps, 13 to rupestrian fields, seven to Cerrado, 11 to seasonal montane semi-deciduous forests, and 10 to riparian forests (Supplementary material 3).

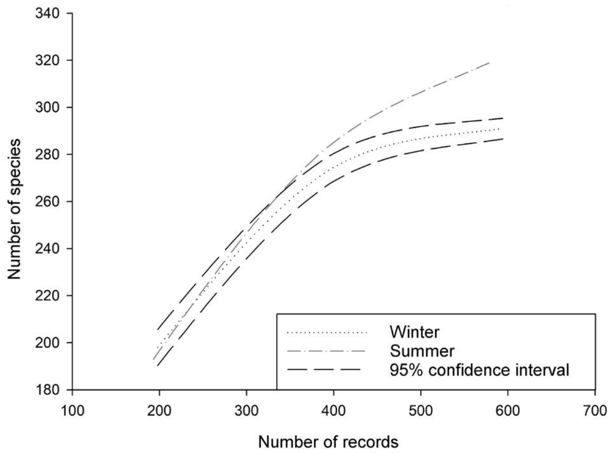

Figure 3: Variation in the number of species between seasons (winter/summer). The Y axis has the number of species recorded and the X axis has the number of total records.

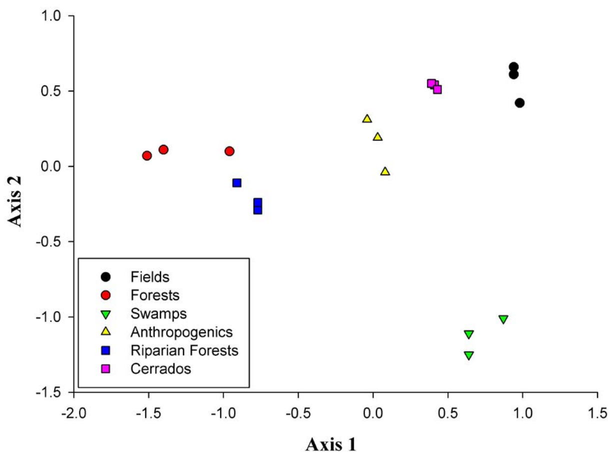

Figure 4: Non-Metric Multidimensional Scaling (NMDS) using Bray-Curtis as a distance measure for the six sampled bird communities: Rupestrian fields, Seasonal Semi-deciduous Montane Forests, Swamps, Anthropogenic areas, Riparian forests, and Cerrado *Strictu sensu*.

DISCUSSION

The diversity of birds in ecotonal landscapes of mountainous regions exhibits particularities according to each phytophysiognomy (Moura et al., 2021a), as the vegetation characteristics of each phytophysiognomy create a specific niche for a 'pool' of species that are uniquely adapted to that environment. The richness and composition tend to be high, because there are preserved areas with high declivity and altitude, as well as extensive and varied vegetative physiognomies (similar to Godoi et al., 2016).

Many of the bird families (above 60%) prominently represented in our study were similarly well-represented in research's conducted within ecotonal areas near São Tomé das Letras (Moura et al., 2021a). Furthermore, these families were prominent in studies conducted in more distant high-altitude regions across Brazil (Rodrigues et al., 2005; Santos & Silva, 2007; Vieira et al., 2013). The most prevalent families in the montane ecosystem; Tyrannidae, Thraupidae, and Trochilidae align with the families possessing the greatest number of species in Brazil (Pacheco et al., 2021) and South America (Erize et al., 2006; Ridgely; Tudor, 2009; Van Perlo, 2015).

Table 1: Anosim pairwise tests to bird communities between different phytophysiognomies, including values and significance.

Pairwise tests	R	P
Fields – Forests	1	0.01
Fields – Swamps	1	0.01
Fields – Anthropic	1	0.01
Fields – Riparian Forests	1	0.01
Fields – Savannahs	1	0.01
Forests – Swamps	1	0.01
Forests – Anthropic	1	0.01
Forests – Riparian Forests	0.82	0.01
Forests – Savannahs	1	0.01
Swamps – Anthropic	1	0.01
Swamps – Riparian Forests	1	0.01
Swamps – Savannahs	1	0.01
Anthropic – Riparian Forests	1	0.01
Anthropic – Savannahs	1	0.01
Riparian Forests – Savannahs	1	0.0i1

The richness of birds corresponds to 16.43% of the bird species described for Brazil (Pacheco et al., 2021), reflecting significant diversity. This area presents numerous points of quartzite extraction (mining), together with high fragmentation of natural phytophysiomies. There are other anthropogenic impacts such as urbanization, road construction and vegetation conversion in cultivated areas and/or pastures that affect bird diversity (Moura et al., 2020a).

Species exclusive to the Cerrado domain were documented among the findings, including *Zenaida auriculata* (Des Murs, 1847), *Synallaxis spixi* Sclater, 1856, *Melanopareia torquata* (Wied, 1831), *Saltatricula atricollis* (Vieillot, 1817), and *Coryphaspiza melanotis* (Temminck, 1822). From the Atlantic Forest, species such as *Pyriglena leucoptera* (Vieillot, 1818), *Conopophaga lineata* (Wied, 1831), *Chiroxiphia caudata* (Shaw and Nodder, 1793), *Mionectes rufiventris* Cabanis, 1846, *Hemitriccus nidipendulus* (Wied, 1831), *Thamnophilus ruficapillus* Vieillot, 1816, *Myiornis auricularis* (Vieillot, 1818), *Knipolegus nigerrimus* (Vieillot, 1818), and *Tachyphonus coronatus* (Vieillot, 1822) were identified (Silva, 1995; Silva and Santos, 2005).

The bird community within the studied region also includes species endemic to Brazil, aligning with the definition of priority conservation areas due to their high biodiversity and high levels of endemism (Myers et al., 2000; Mittermeier et al., 2005). Noteworthy examples of such species include *Ilicura militaris* (Shaw and Nodder, 1809), *Todirostrum poliocephalum* (Wied, 1831), *Polystictus superciliaris* (Wied, 1831), and *Knipolegus nigerrimus* (Vieillot, 1818), recognized by the Brazilian Committee for Ornithological Records as being endemic to the country (Pacheco et al., 2021).

The seasonal variation of community is related to seasonal migration of species, such as *Tyrannus savana*, *Myiodynastes maculatus*, *Elaenia chiriquensis*, and *Sporophila lineola* is well-documented in the southeastern region (Sick, 1997), and aligns with results from other ornithological studies conducted in adjacent ecotonal regions in the southern part of Minas Gerais (Moura et al., 2015; Moura et al., 2021a; Moura et al., 2022a).

Ecotones are transition areas, borders, and edges where ecological communities (both plant and animal) share elements of adjacent domains (Kark & Van Rensburg, 2006, Machado et al., 2021, Machado et al., 2016, Machado et al., 2013). Accordingly, our findings suggest that the bird community reflects an ecotonal composition owing to its location, wherein the landscape encompasses floristic and phytophysiognomic features from biomes. Therefore, the NMDS demonstrates the particularity of each phytophysiognomy, in which the samples are close to each other. Furthermore, the proximity between phytophysiognomies with more open vegetation was observed. Additionally, a similarity was observed between forest and riparian forest areas, mainly because some forests are connected to riparian forests, sharing species composition from Atlantic forest and Cerrado biomes (see similar characteristics in Machado et al., 2016). While marshes appeared dissimilar from other phytophysiognomies. This dissimilarity might be due to the unique community present in marshes, with species adapted to a water-associated ecology.

These patterns align with results reported by Moura et al. (2021a) in an adjacent ecotonal area, where forested communities, including cloud forests and riparian forests, were more related. Similarly, montane grasslands and Cerrado areas exhibited resemblance, whereas swampy landscapes or those influenced by artificial lakes were more distinct.

Six bird species, accounting for 1.85% of the list, were exclusively recorded in rupestrian field areas. These species (*Urubitinga coronata*, *Culicivora caudacuta*, *Geositta poeciloptera*, *Alectrurus tricolor*, *Anthus nattereri*, and *Coryphaspiza melanotis*) are included in Brazilian (MMA, 2014) and global (IUCN, 2022) lists of threatened species. This finding reinforces existing studies highlighting the vulnerability of grassland-associated birds (Machado et al., 1998; Lopes et al., 2009; Bird Life Internacional, 2011), underscoring the urgency for establishing conservation units within these phytophysiognomies. Such units are currently lacking, as mentioned by Moura et al. (2021b) and Moura et al. (2022b).

Although threatened species were not recorded within forest fragment areas (mountain semideciduous forest), many species exclusive to this environment were documented in the study. Notably, was recorded the presence of *Pyroderus scutatus* (Shaw, 1792) (pavó), considered rare throughout its range (Muir et al., 2008), *Phibalura flavirostris* Vieillot, 1816 (earwig), globally threatened (IUCN, 2022), and vulnerable in parts of southeastern Brazil (Silveira et al., 2008), as well as various insectivorous trunk-dwelling birds of the Picidae and Dendrocolaptidae families.

Sampling points inside the forests featuring bamboo and bamboo in their understory exhibited distinct bird species not found in any other sampled phytophysiognomy. These species exclusively inhabit such conditions, including members of the genus Drymophila: *D. ferruginea* (Temminck, 1822), *D. ochropyga* (Hellmayr, 1906), and *D. malura* (Temminck, 1825). These birds have close ecological associations with areas rich in vines and bamboo of the genus Chusquea (Sick, 1997). The presence of *Haplospiza unicolor* Cabanis, 1851 was notably observed in these areas, known for its feeding interactions with *Bambusoidea Poaceae*, facilitating small migrations during the fruiting period of these plants (Sick, 1997; Vasconcelos et al., 2005a). The epicenter of bamboo and bamboo diversity is the Atlantic Forest (Judziewicz et al., 1999), where their fruiting attracts numerous bird and rodent species (Sick, 1997; Judziewicz et al., 1999; Bovendorp et al., 2020), underscoring the importance of greater attention to the limited areas in the region harboring these unique floristic components and their distinct avian compositions.

Riparian forests also shared species with both forest areas and anthropic areas, aligning with expectations due to their semi-open nature and lower tree density, and showing characteristics similar to border area. These characteristics facilitate movement for forest specialist species that utilize these phytophysiognomies as corridors (Corrêa et al., 2012), and also accommodate more generalist species with greater environmental plasticity, originating from anthropic areas and fragment edges.

Swampy environments and areas with artificial lakes exhibited a distinctive avifauna composition compared to other landscapes sampled in the region. These areas hosted representatives from families Anatidae, Rallidae, Jacanidae, Ciconiidae, Ardeidae, and Donacobiidae. Similar results were observed in an adjacent ecotonal area studied by Moura et al. (2021a), emphasizing the exclusive and unique elements present in the bird communities of swampy regions within the Cerrado/Atlantic Forest ecotones. These include birds commonly known as ducks and teals (Anatidae), herons and bitterns (Ardeidae), as well as rails (Rallidae), all of which are closely associated with these types of landscapes (Sick, 1997).

Several records in this manuscript hold significance: *Cyanoloxia glaucocaerulea* (d'Orbigny & Lafresnaye, 1837), the blue finch, despite extensive ornithological study in the south of the state of Minas Gerais (D'angelo Neto et al., 1998; Ribon, 2000; and others), this species had not previously been recorded in the regional literature. Thus, this is the first documented record and a new confirmed locality of this bird for southeastern Brazil.

The species: *Drymophila ochropyga* (Hellmayr, 1906), Red-backed Antwren; *Myiornis auricularis* (Vieillot, 1818), Chickpecker; *Tityra inquisitor* (Lichtenstein, 1823), Brown-cheeked White Antbird; *Polystictus superciliaris* (Wied, 1831), Gray-coasted Flycatcher; and *Thlypopsis pyrrhocoma* Burns, Unitt & Mason, 2016, Brownhead, were previously mentioned only at one location in the region (Moura et al., 2010a; Moura et al., 2010b; Moura et al., 2020a; Moura et al., 2021a; Moura et al., 2022a). The records in this manuscript serve as confirmation of a new locality for these species in the mountainous ecotonal areas of southern Minas Gerais, southeastern Brazil.

The species *Serpophaga nigricans*, which is described in the literature as a bird inhabiting lakesides, rivers, and dams, and feeding on insects captured in flight from trees or stones along riverbanks (Sick, 1997), was indicated by INDVAL as an anthropic species. Nevertheless, observations made during this study revealed that the records were associated with aquatic environments under human influence, suggesting the species' adaptation to areas with human activities, such as the touristy waterfall regions in this area.

This study represents an bird diversity list for this region in constant change, as the species list is dynamic, particularly in rupestrian fields that undergo interventions and fires (Moura and Corrêa, 2012). The diversity of birds in a Neotropical region is constantly dynamic, as it varies seasonally with the arrival of migratory birds during the summer, adapting to changes in climate, food availability and habitat; adapting to processes such as deforestation, urbanization and pollution; among other factors. Further studies are recommended to update this conservation status. The distribution of the bird community across phytophysiognomies emphasizes the need for effective conservation and preservation efforts, with a focus on comprehensive landscape management (Lawton, 1996).

In conclusion, the ornithofauna of this montane landscape within the Cerrado/Atlantic Forest transition area comprises distinct bird communities across various phytophysiognomies. These communities are under threat due to intensive mining activities and landscape fragmentation caused by farming and lodging construction. The study reveals a high species count, emphasizing the urgency for creating conservation units, particularly in rupestrian field areas where numerous endangered species were recorded. The remaining forest areas, especially those on mountain slopes, require significant attention, along with comprehensive conservation and preservation projects. The uneven distribution of the bird community across phytophysiognomies underscores the need to treat the entire landscape holistically, as it harbors endemic, rare, and threatened species across all vegetation types.

AUTHORSHIP CONTRIBUTION

Project Idea: ASM; FSM

Funding: EC; JRSS

Data base: ASM; FSM; DAB; MALF

Processing: FSM; DAB

Analysis: FSM; MALF

Writing: ASM; FSM; DAB; EC; JRSS; MALF

Review: ASM; FSM; MALF

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DATA AVAILABILITY

The datasets supporting the conclusions are included in the article.

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SUPPLEMENTARY MATERIAL

Supplementary material 1: Observation points, coordinates, elevation, and descriptions of sampled phytophysiognomies in São Tomé das Letras, southern Minas Gerais, 2014/2015. Phytophysiognomic types include RF = Rupestrian Field, SFOR = Montane Semi-deciduous Seasonal Forests, SW = Swamps, ANTR = Anthropogenic Areas (roads, cultivated areas, pastures), RFOR = Riparian Forests, and CER = Cerrado *Stricto Sensu*. The number in first columm represents the same number of the map (Figure 1).

Number	Sample	Location	Coordinates	Domain
1	RF1	Campos Cruzeiro do Canta Galo	21º42'42,82''S - 44º55'35.02'' 1374m	Rupestrian field
2	RF2	Campos Cruzeiro do Canta Galo	21º43'07.70''S - 44º56'18.01''W 1309m	Rupestrian field
3	RF3	Campo Rupestre no Sítio do Zé Geraldo	21º43'14.36''S 44º56''56.73''W 1092m	Rupestrian field
4	SFOR1	Curva da estrada sentido Canta Galo	21º43'12.98''S 44º56'18.01''W 1171m	Montane semideciduous forest
5	SFOR2	Serra ao fundo da Cachoeira da Lua	21º41'58.28''S 44º57'03.94''W 1262m	Montane semideciduous forest
6	SFOR3	Floresta no Canta Galo	21º43'06.51''S 44º57''45.29''W 1092m	Montane semideciduous forest
7	SW1	Margens da Estrada para o Sobradinho	21º41'18.78''S 44º54'51.55''W 1118m	Swampy area with pond
8	SW2	Margens da Estrada para o Sobradinho	21º41'17.96''S 44º54'50.99''W 1117m	Swampy area with pond
9	SW3	Margens da Estrada para o Sobradinho	21º41'09.99''S 44º54'48.10''W 1114m	Swampy área
10	ANTR1	Sítio Zé Geraldo	21º43'04.49''S 44º56'58.21''W 1059m	Anthropogenic areas (orchards, pastures), riparian forests and gardens with exotic plants
11	ANTR2	Sítio D. Paulina	21º43'05.68''S 44º57'15.41''W 1044m	Anthropogenic areas (orchards, pastures), riparian forests and gardens with exotic plants
12	ANTR3	Comunidade Harmonia	21º43'20.94''S 44º57'12.88''W 1059m	Anthropogenic areas (orchards, pastures), riparian forests and gardens with exotic plants
13	RFOR1	Córrego Elementais	21º42141.83''S 44º56'17.45''W 1087m	Riparian forest
14	RFOR2	Córrego Cachoeira do mel	21º43'20.08''S 44º56'49.68''W 1141m	Riparian forest
15	RFOR3	Cachoeira Eubiose	21º43'34.03''S 44º57'39.57''W 1044m	Riparian forest
16	CER1	Vila das Panelas	21º43'40.87''S 44º57'31.06''W 1024m	Cerrado *stricto sensu*
17	CER2	Vila das Panelas	21º43'47.12''S - 44º57'29.53''W 1049m	Cerrado *stricto sensu*
18	CER3	Quebra Disco	21º44'06.49''S 44º57'56.47''W 1024m	Cerrado *stricto sensu*

Supplementary material 2: Species list recorded in ecotonal mountain landscape between Cerrado and Atlantic Forest in Southeastherm Brazil. In the columm "Biome", are represented the species endemic.

Family	Species	Biome (Endemic)
Tinamidae	*Crypturellus obsoletus* (Temminck, 1815)	
	Crypturellus parvirostris (Wagler, 1827)	
	Nothura maculosa (Temminck, 1815)	
Anatidae	*Cairina moschata* (Linnaeus, 1758)	
	Amazonetta brasiliensis (Gmelin, 1789)	
Cracidae	*Penelope obscura* Temminck, 1815	
Columbidae	*Columba livia*Gmelin, 1789	
	Patagioenas picazuro (Temminck, 1813)	
	Patagioenas cayennensis (Bonnaterre, 1792)	
	Geotrygon montana (Linnaeus, 1758)	
	Leptotila verreauxi Bonaparte, 1855	
	Leptotila rufaxilla (Richard & Bernard, 1792)	
	Zenaida auriculata (Des Murs, 1847)	Cerrado (Endemic)
	Columbina talpacoti (Temminck, 1811)	
	Columbina squammata (Lesson, 1831)	
Cuculidae	*Guira guira* (Gmelin, 1788)	
	Crotophaga ani Linnaeus, 1758	
	Tapera naevia (Linnaeus, 1766)	
	Piaya cayana (Linnaeus, 1766)	
Nyctibiidae	*Nyctibius griseus* (Gmelin, 1789)	
Caprimulgidae	*Nyctiphrynus ocellatus* (Tschudi, 1844)	
	Antrostomus rufus (Boddaert, 1783)	
	Nyctidromus albicollis (Gmelin, 1789)	
	Hydropsalis parvula (Gould, 1837)	
	Hydropsalis longirostris (Bonaparte, 1825)	
	Hydropsalis torquata (Gmelin, 1789)	
Apodidae	*Cypseloides fumigatus* (Streubel, 1848)	
	Cypseloides senex (Temminck, 1826)	
	Streptoprocne zonaris (Shaw, 1796)	
	Chaetura meridionalis Hellmayr, 1907	
Trochilidae	*Florisuga fusca* (Vieillot, 1817)	
	Phaethornis ruber (Linnaeus, 1758)	
	Phaethornis pretrei (Lesson&Delattre, 1839)	
	Phaethornis eurynome (Lesson, 1832)	Atlantic Forest (Endemic)
	Colibri serrirostris (Vieillot, 1816)	
	Heliothryx auritus (Gmelin, 1788)	
	Polytmus guainumbi (Pallas, 1764)	
	Anthracothorax nigricollis (Vieillot, 1817)	
	Heliomaster squamosus (Temminck, 1823)	
	Calliphlox amethystina (Boddaert, 1783)	
	Chlorostilbon lucidus (Shaw, 1812)	
	Thalurania glaucopis (Gmelin, 1788)	
	Eupetomena macroura (Gmelin, 1788)	
	Chrysuronia versicolor (Vieillot, 1818)	
	Leucochloris albicollis (Vieillot, 1818)	
	Chionomesa lactea (Lesson, 1832)	
Rallidae	*Laterallus leucopyrrhus* (Vieillot, 1819)	
	Mustelirallus albicollis (Vieillot, 1819)	
	Pardirallus nigricans (Vieillot, 1819)	
	Aramides saracura (Spix, 1825)	
	Gallinula galeata (Lichtenstein, 1818)	

Continue...

Supplementary material 2: Continuation.

Family	Species	Biome (Endemic)
Charadriidae	*Vanellus chilensis* (Molina, 1782)	
Scolopacidae	*Tringa solitaria* Wilson, 1813	
Jacanidae	*Jacana jacana* (Linnaeus, 1766)	
Ciconiidae	*Mycteria americana* Linnaeus, 1758	
Anhingidae	*Anhinga anhinga* (Linnaeus, 1766)	
Ardeidae	*Tigrisoma lineatum* (Boddaert, 1783)	
	Nycticorax nycticorax (Linnaeus, 1758)	
	Butorides striata (Linnaeus, 1758)	
	Bubulcus ibis (Linnaeus, 1758)	
	Ardea cocoi Linnaeus, 1766	
	Ardea alba Linnaeus, 1758	
	Syrigma sibilatrix (Temminck, 1824)	
	Egretta thula (Molina, 1782)	
Threskiornithidae	*Mesembrinibis cayennensis* (Gmelin, 1789)	
	Theristicus caudatus (Boddaert, 1783)	
Cathartidae	*Sarcoramphus papa* (Linnaeus, 1758)	
	Coragyps atratus (Bechstein, 1793)	
	Cathartes aura (Linnaeus, 1758)	
	Cathartes burrovianus Cassin, 1845	
Accipitridae	*Elanus leucurus* (Vieillot, 1818)	
	Chondrohierax uncinatus (Temminck, 1822)	
	Leptodon cayanensis (Latham, 1790)	
	Elanoides forficatus (Linnaeus, 1758)	
	Spizaetus tyrannus (Wied, 1820)	
	Harpagus diodon (Temminck, 1823)	
	Ictinia plumbea (Gmelin, 1788)	
	Accipiter bicolor (Vieillot, 1817)	
	Geranospiza caerulescens (Vieillot, 1817)	
	Heterospizias meridionalis (Latham, 1790)	
	Urubitinga urubitinga (Gmelin, 1788)	
	Urubitinga coronata (Vieillot, 1817)	
	Rupornis magnirostris (Gmelin, 1788)	
	Geranoaetus albicaudatus (Vieillot, 1816)	
	Geranoaetus melanoleucus (Vieillot, 1819)	
	Buteo brachyurus Vieillot, 1816	
Tytonidae	*Tyto furcata* (Temminck, 1827)	
Strigidae	*Megascops choliba* (Vieillot, 1817)	
	Bubo virginianus (Gmelin, 1788)	
	Glaucidium brasilianum (Gmelin, 1788)	
	Athene cunicularia (Molina, 1782)	
	Asio flammeus (Pontoppidan, 1763)	
Trogonidae	*Trogon surrucura* Vieillot, 1817	
Momotidae	*Baryphthengus ruficapillus* (Vieillot, 1818)	
Alcedinidae	*Megaceryle torquata* (Linnaeus, 1766)	
	Chloroceryle amazona (Latham, 1790)	
	Chloroceryle americana (Gmelin, 1788)	
Galbulidae	*Galbula ruficauda* Cuvier, 1816	
Bucconidae	*Malacoptila striata* (Spix, 1824)	Atlantic Forest (Endemic)
	Nystalus chacuru (Vieillot, 1816)	

Continue...

Supplementary material 2: Continuation.

Family	Species	Biome (Endemic)
Ramphastidae	*Ramphastos toco* Statius Muller, 1776	
	Ramphastos dicolorus Linnaeus, 1766	
Picidae	*Picumnus cirratus* Temminck, 1825	
	Melanerpes candidus (Otto, 1796)	
	Veniliornis passerinus (Linnaeus, 1766)	
	Veniliornis spilogaster (Wagler, 1827)	
	Veniliornis mixtus (Boddaert, 1783)	
	Campephilus robustus (Lichtenstein, 1818)	
	Campephilu smelanoleucos (Gmelin, 1788)	
	Dryocopus lineatus (Linnaeus, 1766)	
	Celeus flavescens (Gmelin, 1788)	
	Colaptes melanochloros (Gmelin, 1788)	
	Colaptes campestris (Vieillot, 1818)	
Cariamidae	*Cariama cristata* (Linnaeus, 1766)	
Falconidae	*Herpetotheres cachinnans* (Linnaeus, 1758)	
	Micrastur semitorquatus (Vieillot, 1817)	
	Caracara plancus (Miller, 1777)	
	Milvago chimachima (Vieillot, 1816)	
	Falco sparverius Linnaeus, 1758	
	Falco femoralis Temminck, 1822	
Psittacidae	*Brotogeris chiriri* (Vieillot, 1818)	
	Pionus maximiliani (Kuhl, 1820)	
	Forpus xanthopterygius (Spix, 1824)	
	Pyrrhura frontalis (Vieillot, 1817)	
	Eupsittula aurea (Gmelin, 1788)	
	Aratinga auricapillus (Kuhl, 1820)	
	Primolius maracana (Vieillot, 1816)	
	Psittacara leucophthalmus (Statius Muller, 1776)	
Thamnophilidae	*Dysithamnus mentalis* (Temminck, 1823)	
	Herpsilochmus atricapillus Pelzeln, 1868	
	Thamnophilus ruficapillus Vieillot, 1816	Atlantic Forest (Endemic)
	Thamnophilus caerulescens Vieillot, 1816	
	Mackenziaena leachii (Such, 1825)	
	Pyriglena leucoptera (Vieillot, 1818)	Atlantic Forest (Endemic)
	Drymophila ferruginea (Temminck, 1822)	Atlantic Forest (Endemic)
	Drymophila ochropyga (Hellmayr, 1906)	
	Drymophila malura (Temminck, 1825)	Atlantic Forest (Endemic)
Melanopareiidae	*Melanopareia torquata* (Wied, 1831)	Cerrado (Endemic)
Conopophagidae	*Conopophaga lineata* (Wied, 1831)	Atlantic Forest (Endemic)
Rhinocryptinae	*Scytalopus petrophilus* Whitney, Vasconcelos, Silveira & Pacheco, 2010	Atlantic Forest (Endemic)
Scleruridae	*Sclerurus scansor* (Ménétries, 1835)	
	Geositta poeciloptera (Wied, 1830)	
Dendrocolaptidae	*Sittasomus griseicapillus* (Vieillot, 1818)	
	Xiphocolaptes albicollis (Vieillot, 1818)	
	Xiphorhynchus fuscus (Vieillot, 1818)	
	Lepidocolaptes angustirostris (Vieillot, 1818)	
	Lepidocolaptes squamatus (Lichtenstein, 1822)	
Xenopidae	Xenops rutilans Temminck, 1821	

Continue...

Supplementary material 2: Continuation.

Family	Species	Biome (Endemic)
Furnariidae	*Furnarius figulus* (Lichtenstein, 1823)	
	Furnarius rufus (Gmelin, 1788)	
	Lochmias nematura (Lichtenstein, 1823)	
	Syndactyla rufosuperciliata (Lafresnaye, 1832)	
	Dendroma rufa (Vieillot, 1818)	
	Automolus leucophthalmus (Wied, 1821)	
	Phacellodomus rufifrons (Wied, 1821)	
	Phacellodomus ferrugineigula (Pelzeln, 1858)	
	Anumbius annumbi (Vieillot, 1817)	
	Cranioleuca pallida (Wied, 1831)	
	Certhiaxis cinnamomeus (Gmelin, 1788)	
	Synallaxis cinerascens Temminck, 1823	
	Synallaxis ruficapilla Vieillot, 1819	
	Synallaxis spixi Sclater, 1856	Cerrado (Endemic)
	Synallaxis albescens Temminck, 1823	
	Synallaxis frontalis Pelzeln, 1859	
Pipridae	*Neopelma chrysolophum* Pinto, 1944	
	Ilicura militaris (Shaw &Nodder, 1809)	
	Chiroxiphia caudata (Shaw &Nodder, 1793)	Atlantic Forest (Endemic)
Cotingidae	*Phibalura flavirostris* Vieillot, 1816	
	Pyroderus scutatus (Shaw, 1792)	
Tityridae	*Schiffornis virescens* (Lafresnaye, 1838)	Atlantic Forest (Endemic)
	Tityra inquisitor (Lichtenstein, 1823)	
	Pachyramphus viridis (Vieillot, 1816)	
	Pachyramphus castaneus (Jardine &Selby, 1827)	
	Pachyramphus polychopterus (Vieillot, 1818)	
	Pachyramphus validus (Lichtenstein, 1823)	
Platyrinchidae	*Platyrinchus mystaceus* Vieillot, 1818	
Rhynchocyclidae	*Mionectes rufiventris* Cabanis, 1846	Atlantic Forest (Endemic)
	Leptopogonam aurocephalus Tschudi, 1846	
	Corythopis delalandi (Lesson, 1830)	
	Phylloscartes eximius (Temminck, 1822)	
	Phylloscartes ventralis (Temminck, 1824)	
	Tolmomyias sulphurescens (Spix, 1825)	
	Todirostrum poliocephalum (Wied, 1831)	
	Todirostrum cinereum Cory, 1916	
	Poecilotriccus plumbeiceps (Lafresnaye, 1846)	
	Myiornis auricularis (Vieillot, 1818)	Atlantic Forest (Endemic)
	Hemitriccus diops (Temminck, 1822)	
	Hemitriccus nidipendulus (Wied, 1831)	Atlantic Forest (Endemic)
Tyrannidae	*Hirundinea ferruginea* (Gmelin, 1788)	
	Camptostoma obsoletum (Temminck, 1824)	
	Elaenia flavogaster (Thunberg, 1822)	
	Elaenia spectabilis Pelzeln, 1868	
	Elaenia parvirostris Pelzeln, 1868	
	Elaenia mesoleuca (Deppe, 1830)	
	Elaenia cristata Pelzeln, 1868	
	Elaenia chiriquensis Lawrence, 1865	
	Elaenia obscura (d'Orbigny&Lafresnaye, 1837)	
	Myiopagis caniceps (Swainson, 1835)	

Continue...

Supplementary material 2: Continuation.

Family	Species	Biome (Endemic)
Tyrannidae	*Myiopagis viridicata* (Vieillot, 1817)	
	Phaeomyias murina (Spix, 1825)	
	Phyllomyias virescens (Temminck, 1824)	
	Phyllomyias fasciatus (Thunberg, 1822)	
	Culicivora caudacuta (Vieillot, 1818)	
	Polystictus superciliaris (Wied, 1831)	
	Serpophaga nigricans (Vieillot, 1817)	
	Serpophaga subcristata (Vieillot, 1817)	
	Legatusleu cophaius (Vieillot, 1818)	
	Myiarchus swainsoni Cabanis & Heine, 1859	
	Myiarchus ferox (Gmelin, 1789)	
	Myiarchus tyrannulus (Statius Muller, 1776)	
	Sirystes sibilator (Vieillot, 1818)	
	Casiornis rufus (Vieillot, 1816)	
	Pitangus sulphuratus (Linnaeus, 1766)	
	Machetornis rixosa (Vieillot, 1819)	
	Myiodynastes maculatus (Statius Muller, 1776)	
	Megarynchus pitangua (Linnaeus, 1766)	
	Myiozetetes cayanensis (Linnaeus, 1766)	
	Myiozetetes similis (Spix, 1825)	
	Tyrannus albogularis Burmeister, 1856	
	Tyrannus melancholicus Vieillot, 1819	
	Tyrannus savana Daudin, 1802	
	Empidonomus varius (Vieillot, 1818)	
	Sublegatus modestus (Wied, 1831)	
	Colonia colonus (Vieillot, 1818)	
	Arundinicola leucocephala (Linnaeus, 1764)	
	Fluvicola nengeta (Linnaeus, 1766)	
	Pyrocephalus rubinus (Boddaert, 1783)	
	Muscipipra vetula (Lichtenstein, 1823)	
	Gubernetes yetapa (Vieillot, 1818)	
	Alectrurus tricolor (Vieillot, 1816)	
	Myiophobus fasciatus (Statius Muller, 1776)	
	Cnemotriccus fuscatus (Wied, 1831)	
	Lathrotriccus euleri (Cabanis, 1868)	
	Contopus cinereus (Spix, 1825)	
	Satrapa icterophrys (Vieillot, 1818)	
	Knipolegus lophotes Boie, 1828	
	Knipolegus nigerrimus (Vieillot, 1818)	Atlantic Forest (Endemic)
	Knipolegus cyanirostris (Vieillot, 1818)	
	Xolmis velatus (Lichtenstein, 1823)	
	Nengetus cinereus (Vieillot, 1816)	
Vireonidae	*Cyclarhis gujanensis* (Gmelin, 1789)	
	Hylophilus amaurocephalus (Nordmann, 1835)	
	Vireo chivi (Vieillot, 1817)	
Corvidae	*Cyanocorax cristatellus* (Temminck, 1823)	
	Cyanocorax chrysops (Vieillot, 1818)	
Hirundinidae	*Pygochelidon cyanoleuca* (Vieillot, 1817)	
	Alopochelidon fucata (Temminck, 1822)	
	Stelgidopteryx ruficollis (Vieillot, 1817)	
	Progne tapera (Linnaeus, 1766)	
	Progne chalybea (Gmelin, 1789)	
	Tachycineta leucorrhoa (Vieillot, 1817)	

Continue...

Supplementary material 2: Continuation.

Family	Species	Biome (Endemic)
Troglodytidae	*Troglodytes musculus* Naumann, 1823	
	Cistothorus platensis (Latham, 1790)	
Donacobiidae	*Donacobius atricapilla* (Linnaeus, 1766)	
Turdidae	*Turdus flavipes* Vieillot, 1818	
	Turdus leucomelas Vieillot, 1818	
	Turdus rufiventris Vieillot, 1818	
	Turdus amaurochalinus Cabanis, 1850	
	Turdus subalaris (Seebohm, 1887)	
	Turdus albicollis Vieillot, 1818	
Mimidae	*Mimus saturninus* (Lichtenstein, 1823)	
Passeridae	*Passer domesticus* (Linnaeus, 1758)	
Motacillidae	*Anthus chii* Vieillot, 1818	
	Anthus hellmayri Hartert, 1909	
	Anthus nattereri Sclater, 1878	
Fringillidae	*Spinus magellanicus* (Vieillot, 1805)	
	Cyanophonia cyanocephala (Vieillot, 1818)	
	Chlorophonia cyanea (Thunberg, 1822)	
	Euphonia chlorotica (Linnaeus, 1766)	
	Euphonia pectoralis (Latham, 1801)	Atlantic Forest (Endemic)
Passerellidae	*Ammodramus humeralis* (Bosc, 1792)	
	Arremon flavirostris Swainson, 1838	
	Zonotrichia capensis (Statius Muller, 1776)	
Icteridae	*Psarocolius decumanus* (Pallas, 1769)	
	Icterus pyrrhopterus (Vieillot, 1819)	
	Molothrus oryzivorus (Gmelin, 1788)	
	Molothrus rufoaxillaris Cassin, 1866	
	Molothrus bonariensis (Gmelin, 1789)	
	Gnorimopsar chopi (Vieillot, 1819)	
	Chrysomus ruficapillus (Vieillot, 1819)	
	Pseudoleistes guirahuro (Vieillot, 1819)	
Parulidae	*Geothlypis aequinoctialis* (Gmelin, 1789)	
	Setophaga pitiayumi (Vieillot, 1817)	
	Myiothlypis flaveola Baird, 1865	
	Myiothlypisl eucoblephara (Vieillot, 1817)	
	Basileuterus culicivorus (Deppe, 1830)	
Cardinalidae	*Piranga flava* (Vieillot, 1822)	
	Cyanoloxia glaucocaerulea (d'Orbigny&Lafresnaye, 1837)	
	Cyanoloxia brissonii (Lichtenstein, 1823)	
Thraupidae	*Nemosia pileata* (Boddaert, 1783)	
	Coryphaspiza melanotis (Temminck, 1822)	
	Embernagra platensis (Gmelin, 1789)	
	Emberizoides herbicola (Vieillot, 1817)	
	Porphyrospiza caerulescens (Wied, 1830)	
	Hemithraupis ruficapilla (Vieillot, 1818)	
	Tersina viridis (Illiger, 1811)	
	Dacnis cayana (Linnaeus, 1766)	
	Saltatricula atricollis (Vieillot, 1817)	Cerrado (Endemic)
	Saltator similis d'Orbigny&Lafresnaye, 1837	
	Coereba flaveola (Linnaeus, 1758)	
	Volatinia jacarina (Linnaeus, 1766)	

Continue...

Supplementary material 2: Continuation.

Family	Species	Biome (Endemic)
	Trichothraupis melanops (Vieillot, 1818)	
	Coryphospingu spileatus (Wied, 1821)	
	Tachyphonus coronatus (Vieillot, 1822)	Atlantic Forest (Endemic)
	Sporophila lineola (Linnaeus, 1758)	
	Sporophila nigricollis (Vieillot, 1823)	
	Sporophila ardesiaca (Dubois, 1894)	
	Sporophila caerulescens (Vieillot, 1823)	
	Sporophilal eucoptera (Vieillot, 1817)	
	Thlypopsis sordida (d'Orbigny&Lafresnaye, 1837)	
	Thlypopsis pyrrhocoma Burns, Unitt & Mason, 2016	
	Microspingus cinereus Bonaparte, 1850	
Thraupidae	*Conirostrum speciosum* (Temminck, 1824)	
	Sicalis citrina Pelzeln, 1870	
	Sicalis flaveola (Linnaeus, 1766)	
	Sicalis luteola (Sparrman, 1789)	
	Haplospiza unicolor Cabanis, 1851	
	Pipraeidea melanonota (Vieillot, 1819)	
	Schistochlamys ruficapillus (Vieillot, 1817)	
	Thraupis sayaca (Linnaeus, 1766)	
	Thraupis palmarum (Wied, 1821)	
	Stilpnia cayana (Linnaeus, 1766)	
	Tangara cyanoventris (Vieillot, 1819)	
	Tangara desmaresti (Vieillot, 1819)	Atlantic Forest (Endemic)

Supplementary material 3: Indicator value test to species and phytophysiognomies specificity.

Species	Phytophysiognomies Indicator	Indicator value of observed	p
Guira guira	Antropic	100	0.0052
Vanellus chilensis	Antropic	100	0.0052
Athene cunicularia	Antropic	100	0.0052
Melanerpes candidus	Antropic	100	0.0052
Forpus xanthopterygius	Antropic	100	0.0052
Aratinga auricapillus	Antropic	100	0.0052
Furnarius figulus	Antropic	100	0.0052
Furnarius rufus	Antropic	100	0.0052
Phacellodomus rufifrons	Antropic	100	0.0052
Synallaxis frontalis	Antropic	100	0.0052
Serpophaga nigricans	Antropic	100	0.0052
Machetornis rixosa	Antropic	100	0.0052
Satrapa icterophrys	Antropic	100	0.0052
Progne chalybea	Antropic	100	0.0052
Tachycineta leucorrhoa	Antropic	100	0.0052
Turdus amaurochalinus	Antropic	100	0.0052
Passer domesticus	Antropic	100	0.0052
Molothrus rufoaxillaris	Antropic	100	0.0052
Volatinia jacarina	Antropic	100	0.0052
Sporophila lineola	Antropic	100	0.0052
Sporophila nigricollis	Antropic	100	0.0052

Continue...

Supplementary material 3: Continuation.

Species	Phytophysiognomies Indicator	Indicator value of observed	p
Sporophila ardesiaca	Antropic	100	0.0052
Sicalis flaveola	Antropic	100	0.0052
Thraupis palmarum	Antropic	100	0.0052
Cyanocorax chrysops	Antropic	75	0.0224
Columbina squammata	Antropic	75	0.0258
Lochmias nematura	Antropic	75	0.0266
Pygochelidon cyanoleuca	Antropic	75	0.0268
Sporophila caerulescens	Antropic	75	0.0268
Tachyphonus coronatus	Antropic	75	0.027
Mustelirallus albicollis	Swamp	100	0.007
Pardirallus nigricans	Swamp	100	0.007
Jacana jacana	Swamp	100	0.007
Tigrisoma lineatum	Swamp	100	0.007
Nycticorax nycticorax	Swamp	100	0.007
Butorides striata	Swamp	100	0.007
Egretta thula	Swamp	100	0.007
Arundinicola leucocephala	Swamp	100	0.007
Sporophila leucoptera	Swamp	100	0.007
Ardea alba	Swamp	75	0.025
Certhiaxis cinnamomeus	Swamp	75	0.025
Gubernetes yetapa	Swamp	75	0.025
Chrysomus ruficapillus	Swamp	75	0.025
Pseudoleistes guirahuro	Swamp	75	0.025
Sarcoramphus papa	Field	100	0.0056
Geranoaetus melanoleucus	Field	100	0.0056
Culicivora caudacuta	Field	100	0.0056
Muscipipra vetula	Field	100	0.0056
Knipolegus nigerrimus	Field	100	0.0056
Alopochelidon fucata	Field	100	0.0056
Cistothorus platensis	Field	100	0.0056
Anthus chii	Field	100	0.0056
Anthus hellmayri	Field	100	0.0056
Ammodramus humeralis	Field	100	0.0056
Emberizoides herbícola	Field	100	0.0056
Sicalis citrina	Field	100	0.0056
Primolius maracanã	Field	75	0.0268
Casiornis rufus	Cerrado	100	0.007
Sublegatus modestus	Cerrado	100	0.007
Cyanophonia cyanocephala	Cerrado	100	0.007
Microspingus cinereus	Cerrado	100	0.007
Schistochlamys ruficapillus	Cerrado	100	0.007
Porphyrospiza caerulescens	Cerrado	75	0.0308
Elaenia cristata	Cerrado	75	0.0336
Geotrygon montana	Forest	100	0.0082
Hydropsalis parvula	Forest	100	0.0082
Synallaxis ruficapilla	Forest	100	0.0082

Continue...

Supplementary material 3: Continuation.

Species	Phytophysiognomies Indicator	Indicator value of observed	p
Phibalura flavirostris	Forest	100	0.0082
Myiophobus fasciatus	Forest	100	0.0082
Knipolegus cyanirostris	Forest	100	0.0082
Trichothraupis melanops	Forest	100	0.0082
Phaethornis ruber	Forest	75	0.0298
Baryphthengus ruficapillus	Forest	75	0.0298
Campephilus melanoleucos	Forest	75	0.0298
Chiroxiphia caudata	Forest	75	0.0298
Pachyramphus viridis	Riparian Forest	100	0.0086
Pachyramphus castaneus	Riparian Forest	100	0.0086
Pachyramphus polychopterus	Riparian Forest	100	0.0086
Pachyramphus validus	Riparian Forest	100	0.0086
Myiozetetes cayanensis	Riparian Forest	100	0.0086
Lathrotriccus euleri	Riparian Forest	100	0.0086
Basileuterus culicivorus	Riparian Forest	100	0.0086
Automolus leucophthalmus	Riparian Forest	75	0.0298
Leptopogon amaurocephalus	Riparian Forest	75	0.0298
Xenops rutilans	Riparian Forest	75	0.03