Richness, composition, and similarity of birds from restored forest fragments

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Abstract

Environmental degradation has been increasing over the years. As forests being altered, bird communities are directly affected by their inability to remain in their habitats. This study was developed to describe and discuss the restoration of environments and its influence on birdlife. The research was conducted in the municipality of Lavras, located in the *Cerrado*/Atlantic Forest ecotonal region in the south of the state of Minas Gerais, southeastern Brazil. Three restored forest fragments were selected, where species were monitored using binoculars during two seasonal periods. A total of 80 bird species were recorded, distributed across 30 families; however, richness estimators suggest that greater species richness could be found in the restored forests. Two of the forests show greater similarity in bird communities compared to the third, which is not influenced by water bodies or understory, it has compacted soil, and is subject to constant anthropogenic influence. It was concluded that the restored areas have the potential to support bird communities in alignment with the requirements of each species and the availability of ecological niches. This study has provided an understanding of the distribution of bird communities in restored areas and how restoration may contribute to the conservation and preservation of species in future conservation projects

Keywords: Birdlife. Forest restoration. Ecotone.

Introduction

Restoration efforts aim to recover native forests, being able to preserve environments and prevent the extinction of many animal and plant species. Due to the constant growth of urban centers and the various forms of deforestation conducted by anthropogenic action, one of the biggest consequences is the fragmentation of habitats (Edwards, Cerullo, 2024).

Because of forest fragmentation, the increase in edge effects stands out, which, combined with the low connectivity between fragments, acts synergistically in the threat against biodiversity, by isolating species, changing the microclimate and luminosity, affecting the potential for germination, survival and the establishment of plants, and survival of animals (Betts *et al.*, 2022). Regarding the isolation of patches of native forest, ecological restoration is a relevant tool for rebuilding forest communities and implementing ecological corridors between the remaining fragments (Lessa *et al.,* 2024).

Birds are directly affected in degraded environments. In addition to their importance for food chain, they are bioindicators of the environment (Sangwan *et al.*, 2024). Admittedly, forest restoration of degraded areas provides an increase in biodiversity (Joyce *et al.*, 2024; Can *et al.*, 2024; Kings *et al.,* 2007). The reduction

of forests to very small fragments has caused negative consequences for avifauna, considerably impoverishing the community and reducing the number of more specialized species, retaining, for the most part, only the generalist ones (D'Angelo Neto *et al.*, 1998).

In simpler terms, birds reflect changes in vegetation. This phenomenon is called ecological succession and describes the gradual evolution of an ecosystem after a disruptive, natural, or anthropogenic event. After the impact, the environment goes through stages that portray this progression, each housing a distinct community. Stages of succession include the primary stage, marked by pioneer species that spread easily and grow fast, withstanding difficult conditions; secondary stage, which link the initial stage to the climax, with greater diversity and complexity; and the climax stage, in which the community reaches a point of lasting equilibrium with the environment (Shugart, 2024).

Regarding this panorama, this research was developed to describe and analyze the richness, composition, and similarity of bird diversity in three restored forest fragments, as well as develop arguments that address the influence on the avifauna of the area.

Material and methods

This study was carried out in the municipality of Lavras (21°13'39.85" S, 44°58'41.17" W, 917 meters up, above sea level), southern Minas Gerais State, southeastern Brazil, in three restored forest fragments (Figure 1). The first area was named P1 (incubator), with ten years of restoration at the time of sampling. This area is located behind the old university restaurant of the Universidade Federal de Lavras (UFLA), with restoration conducted in 2009 in a 0.4 ha area. A total of 700 seedlings were used in this restoration, of which the area is delimited by an urban stream and an access avenue.

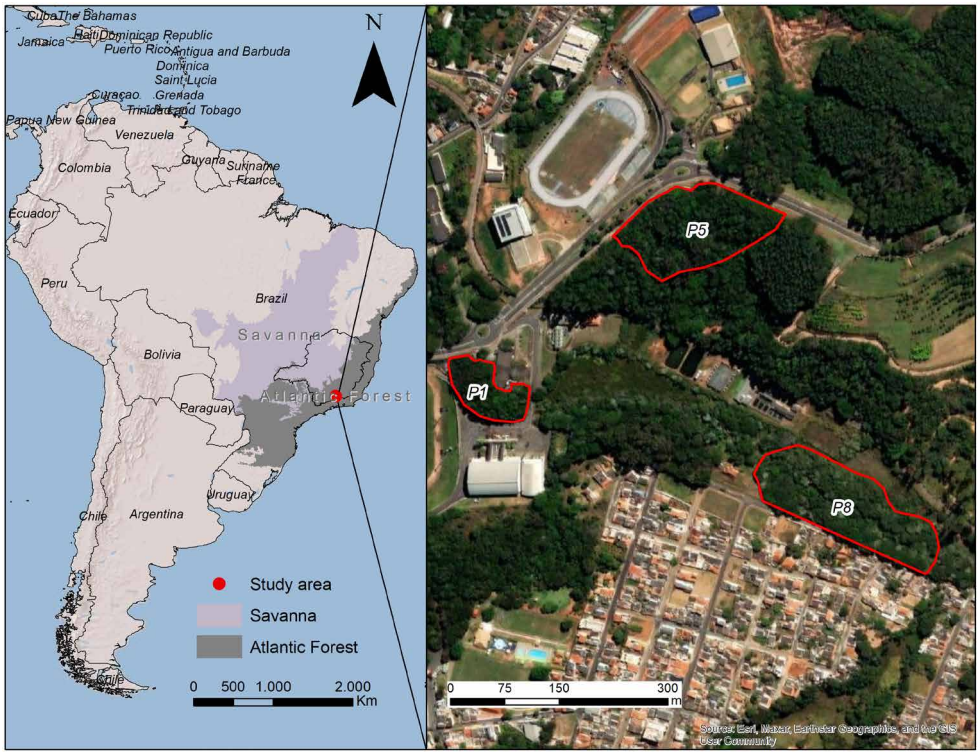
The second area was named P5 (jackfruit curve), also with ten years of restoration at the time of sampling. This area is located 800 m from P1 and exactly at the bend where there are jackfruit trees. It was restored in 2009, with a 0.9 ha area, with 1,450 seedlings, and the access avenue as its limit. It does not have a water body as in the other areas with samples. The third area was named P8 (gymnasium), which had nine years of restoration at the time of sampling. This area has 0.6 ha, in which 900 seedlings were used, and is delimited by an urban stream and a street in a city neighborhood.

At the time of sampling, the successional stage of all fragments was considered intermediate, i.e., the transition between the initial stage and the climax, with an increase in species diversity and ecosystem complexity.

The tree species used in the forest restoration of areas P1, P5, and P8 were: *Citharexylum myrianthum* (pau-viola or fiddlewood), *Inga* sp. (Ingazeira or inga tree), *Eugenia jambolana* (jamelão or indian black berry), *Peltophorum dubium* (angico-amarelo or horsebush), *Schinus terebinthifolius* (aroeira-vermelha or Brazilian peppertree), *Myracrodruon urundeuva* (aroeira-do-sertão or Brazilian aroeira tree), *Handroanthus impetiginosus* (ipê-roxo or purple trumpet tree), *Handroanthus ochraceus* (ipê-do-cerrado or yellow trumpet tree), *Ochroma pyramidale* (pau-de-balsa or balsa tree), and *American Genipa* (jenipapo or genipap).

The landscape of the three areas is composed of fragments of semideciduous seasonal forest, riparian forests, forest restoration areas, eucalyptus and pine cultivation areas, experimental cultivation areas (orchard, maize, beans), built areas (buildings, sheds, greenhouses), *Cerrado sensu stricto*, pastures, gardens and lakes, and is located in the south of the state of Minas Gerais, in an ecotonal region between the *Cerrado* and the Atlantic Forest (Oliveira-Filho, Fluminhan-Filho, 1999;

Figure 1. In red, the restored areas in which there was an inventory of birds in Lavras city, in the southern Minas Gerais State.



Source: authors (2025).

Moura *et al.*, 2020; Moura *et al.*, 2021), two *Hotspots* world championships (Mittermeier *et al.*, 2005; Myers *et al.*, 2000). According to the Köppen climate classification, the climate of the municipality is of the Cwa type, with wet and hot summers and dry and cold winters, average annual precipitation of 1,529.7 mm and average annual temperature of 19.4° C (Alvares *et al*., 2013).

The records of the birds were systematized in the restored forest fragments and obtained in the summer (hot and wet) and winter (cold and dry) seasons, in a period of the day, with inversion of schedules for a standardization of the sampling time at each point. Trails were chosen in each fragment, which were covered between 6:03 am and 11:03 am, 1:00 pm and 6:00 pm, and 6:05 am and 11:05 am on October 22nd to 24th, 2019 in the first campaign (summer), and on August 19th and 20th, 2021 in the winter campaign. A pair of Nikon® 08X40 and 10X50 binoculars and a Canon® T5 digital camera were used. The observation method was like those described by Moura (2014) and Moura *et al*. (2017). The nomenclature of the bird species recorded followed Pacheco *et al*. (2021), and food guilds followed WikiAves (2025).

Statistical analyses included rarefaction curve and richness estimator curve. Both were generated from a matrix of presence and absence, using the EstimateS 7.0 program (Cowell, 2006), with 1,000 randomizations. The richness estimator used was the first-order Jackknife (Burnham and Overton, 1978). Similarity and grouping between physiognomies were also developed, obtained by the Jaccard index (Valentin, 2000) and the UPGMA linkage method, to assemble the physiognomies according to the composition of the bird species. These were evaluated by PERMDISP dispersion measures, with permutation analysis of variance with 999 permutations.

Results

A total of 80 species of birds were recorded, allocated to 30 families (Table 1). Most species belong to the families Tyrannidae and Thraupidae, with greater richness of species in the summer, compared to the winter (Figure 2), with representatives of all food guilds.

Table 1. List of bird species inventoried in three fragments of restored forests in Lavras city, in the south of the state of Minas Gerais.

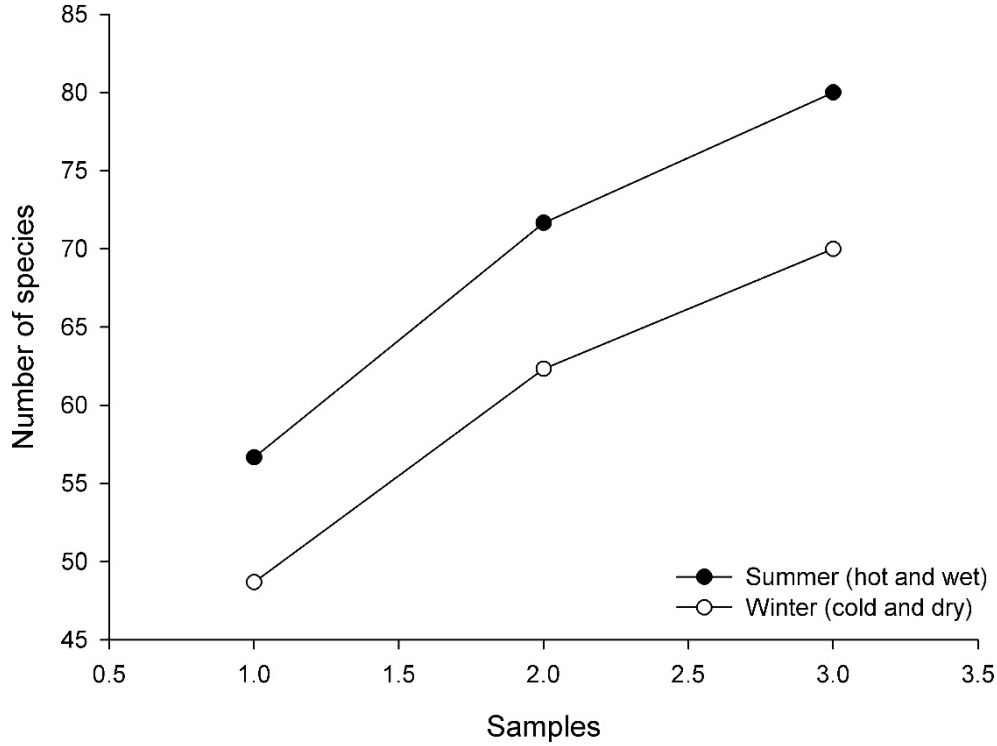
Family	Species	Common Name	Guild	Summer			Winter		
				P1	P5	P8	P1	P5	P8
Cracidae	*Penelope obscura* Temminck, 1815	Dusky-legged guan	Fr	X	X	X	X	X	X
Ardeidae	*Nycticorax nycticorax* (Linnaeus, 1758)	Black-crowned night heron	In, Ca, Pi			X			X
	Bubulcus ibis (Linnaeus, 1758)	Western cattle egret	In	X		X	X		X
Threskiornithidae	*Mesembrinibis cayennensis* (Gmelin, 1789)	Green ibis	In, Ma			X			X
Cathartidae	*Coragyps atratus* (Bechstein, 1793)	Black vulture	Sc	X	X	X	X	X	X
Accipitridae	*Rupornis magnirostris* (Gmelin, 1788)	Roadside hawk	Ca, In	X	X	X	X	X	X
Rallidae	*Aramides saracura* (Spix, 1825)	Slaty-breasted wood rail	Ca	X		X			X
Columbidae	*Columbina talpacoti* (Temminck, 1810)	Columbina	He	X	X	X	X	X	X
	Columbina squammata (Lesson, 1831)	Scaled dove	He			X			X
	Patagioenas picazuro (Temminck, 1813)	Picazuro pigeon	Fr, Gr	X	X	X	X	X	X
	Leptotila sp.	White-tipped dove	Fr, Gr		X				
Cuculidae	*Piaya cayana* (Linnaeus, 1766)	Squirrel cuckoo	In	X	X	X	X		X
	Crotophaga ani Linnaeus, 1758	Smooth-billed ani	Ca	X		X			X
	Guira guira (Gmelin, 1788)	Guira cuckoo	Ca	X	X		X	X	
Trochilidae	*Phaethornis pretrei* (Lesson & Delattre, 1839)	Planalto hermit	Sc	X	X		X	X	X
	Eupetomena macroura (Gmelin, 1788)	Swallow-tailed hummingbird	Sc	X	X	X	X	X	X
	Chlorostilbon lucidus (Shaw, 1812)	Glittering-bellied emerald	Sc	X	X	X	X		X
	Thalurania glaucopis (Gmelin, 1788)	Violet-capped woodnymph	Sc		X				
	Chionomesa lactea (Lesson, 1832)	Sapphire-sprangled emerald	NE	X	X	X	X	X	
Galbulidae	*Galbula ruficauda* Cuvier, 1816	Jacamar	In	X		X			X
Ramphastidae	*Ramphastos toco* Statius Muller, 1776	Toco toucan	Fr	X	X	X	X	X	X
Picidae	*Picumnus cirratus* Temminck, 1825	White-barred piculet	In		X	X	X	X	X
	Veniliornis passerinus (Linnaeus, 1766)	Little woodpecker	In			X			X
	Colaptes campestris (Vieillot, 1818)	Campo flicker	In		X			X	
Falconidae	*Milvago chimachima* (Vieillot, 1816)	Yellow-headed caracara	In, Ca	X	X	X	X	X	X
	Falco sparverius Linnaeus, 1758	American kestrel	In, Ca		X			X	X
	Caracara plancus (Miller, 1777)	Crested caracara	Om	X	X	X	X	X	X
Psittacidae	*Psittacara leucophthalmus* (Statius Muller, 1776)	White-eyed parakeet	Fr	X	X	X	X	X	X
	Aratinga auricapillus (Kuhl, 1820)	Golden-capped parakeet	Fr		X		X	X	
	Brotogeris chiriri (Vieillot, 1818)	Yellow-chevroned parakeet	Fr	X			X		X
Thamnophilidae	*Thamnophilus caerulescens* Vieillot, 1816	Variable antshrike	Fr, In		X	X	X		X
	Pyriglena leucoptera (Vieillot, 1818)	White-shouldered fire-eye	In			X			X
Dendrocolaptidae	*Lepidocolaptes angustirostris* (Vieillot, 1818)	Narrow-billed woodpecker	In	X	X	X	X	X	X
Xenopidae	*Xenops rutilans* Temminck, 1821	Streaked xenops	In		X				
Furnariidae	*Furnarius rufus* (Gmelin, 1788)	Rufous hornero	In		X			X	X
	Lochmias nematura (Lichtenstein, 1823)	Sharp-tailed streamcreeper	In	X		X			X
	Synallaxis spixi Sclater, 1856	Spix's spinetail	In		X			X	

Family	Species	Common Name	Guild	Summer			Winter		
				P1	P5	P8	P1	P5	P8
Rhynchocyclidae	*Tolmomyias sulphurescens* (Spix, 1825)	Yellow-olive flycatcher	In	X		X			X
	Todirostrum poliocephalum (Wied, 1831)	Yellow-lored tody-flycatcher	In	X		X			X
Tyrannidae	*Hirundinea ferruginea* (Gmelin, 1788)	Cliff flycatcher	In	X	X		X	X	
	Camptostoma obsoletum (Temminck, 1824)	Southern beardless tyrannulet	Fr, In	X	X	X			
	Elaenia flavogaster (Thunberg, 1822)	Yellow-bellied elaenia	Fr, In	X	X	X	X	X	X
	Myiarchus ferox (Gmelin, 1789)	Short-crested flycatcher	In	X	X	X	X	X	X
	Pitangus sulphuratus (Linnaeus, 1766)	Great kiskadee	Fr, In, Ca	X	X	X	X	X	X
	Machetornis rixosa (Vieillot, 1819)	Cattle tyrant	In		X			X	
	Myiodynastes maculatus (Statius Muller, 1776)	Streaked flycatcher	Fr, In	X	X	X			
	Megarynchus pitangua (Linnaeus, 1766)	Boat-billed flycatcher	Fr, In		X		X	X	
	Myiozetetes similis (Spix, 1825)	Social flycatcher	Fr, In	X	X	X			X
	Tyrannus albogularis Burmeister, 1856	White-throated kingbird	In		X				
	Tyrannus melancholicus Vieillot, 1819	Kingbird	Fr, In	X	X	X	X	X	X
	Tyrannus savana Daudin, 1802	Fork-tailed flycatcher	Fr, In	X	X	X			
	Colonia colonus (Vieillot, 1818)	Long-tailed tyrant	In	X		X			X
	Fluvicola nengeta (Linnaeus, 1766)	Masked water tyrant	In	X		X	X		X
	Knipolegus lophotes Boie, 1828	Crested black tyrant	In		X			X	
	Satrapa icterophrys (Vieillot, 1818)	Yellow-browed tyrant	In		X				
Hirundinidae	*Pygochelidon cyanoleuca* (Vieillot, 1817)	Blue-and-white swallow	In		X			X	
Troglodytidae	*Troglodytes musculus* Naumann, 1823	Southern house wren	In	X	X	X	X	X	X
Turdidae	*Turdus leucomelas* Vieillot, 1818	Pale-breasted thrush	Fr, In	X	X	X	X	X	X
	Turdus leucomelas Vieillot, 1818	Rufous-bellied thrush	Fr, In	X	X	X	X	X	X
	Turdus amaurochalinus Cabanis, 1850	Creamy-bellied thrush	Fr, In			X			
Mimidae	*Mimus saturninus* (Lichtenstein, 1823)	Chalk-browed mockingbird	Om	X	X	X	X	X	X
Passerellidae	*Zonotrichia capensis* (Statius Muller, 1776)	Rufous-collared sparrow	Fr, In	X	X	X	X	X	X
Parulidae	*Basileuterus culicivorus* (Deppe, 1830)	Golden-crowned warbler	In		X	X			X
Icteridae	*Psarocolius decumanus* (Pallas, 1769)	Oropendola	Fr	X	X	X	X		X
	Molothrus bonariensis (Gmelin, 1789)	Shiny cowbird	Fr, In		X			X	
Thraupidae	*Thraupis sayaca* (Linnaeus, 1766)	Sayaca tanager	Fr	X	X	X	X	X	X
	Thraupis palmarum (Wied, 1821)	Palm tanager	In, Fr	X			X	X	X
	Stilpnia cayana (Linnaeus, 1766)	Burnished-buff tanager	In, Fr	X	X	X	X	X	X
	Sicalis flaveola (Linnaeus, 1766)	Saffron finch	Gr	X	X	X	X	X	X
	Volatinia jacarina (Linnaeus, 1766)	Blue-black grassquit	Gr, In		X	X		X	X
	Coryphospingus pileatus (Wied, 1821)	Grey pileated finch	Gr, In		X			X	
	Tersina viridis (Illiger, 1811)	Swallow tanager	Fr, In	X	X	X	X		X
	Dacnis cayana (Linnaeus, 1766)	Blue dacnis	Sc, In, Fr	X	X	X	X	X	X
	Coereba flaveola (Linnaeus, 1758)	Bananaquit	Sc, In, Fr	X	X	X	X	X	X
	Sporophila lineola (Linnaeus, 1758)	Lined seedeater	Gr, He		X				
	Sporophila nigricollis (Vieillot, 1823)	Yellow-bellied seedeater	Gr		X	X			X
	Sporophila nigricollis (Vieillot, 1823)	Double-collared seedeater	Gr		X	X		X	X
	Saltator similis d'Orbigny & Lafresnaye, 1837	Buff-throated saltator	Om		X	X			X
Fringillidae	*Euphonia chlorotica* (Linnaeus, 1766)	Purple-throated euphonia	Fr	X	X	X	X	X	X
Passeridae	*Passer domesticus* (Linnaeus, 1758)	Passer	Fr, In, He, Gr	X	X		X	X	

Food guilds are represented by acronyms, in which "Fr" stands for frugivore; "Om," omnivores; "In," insectivorous; "Ca," carnivores; "Pi," piscivores; "Ma," malacophagous; "Sc," scavengers; "He," herbivores; "Gr," granivores, and "Ne," nectarivores.

Source: authors (2025).

Figure 2. Variation in the number of bird species inventoried in different seasons (summer and winter) in the three restored areas (samples) in Lavras city, in the south of the state of Minas Gerais.



Source: authors (2025).

The rarefaction curve did not reach the asymptote. The first-order Jackknife estimator showed that richness of species can be as high as 91 species (Figure 3). By the analysis of similarity between the summer and winter seasons (Figure 4), the restored forest fragments P1 and P8 have more recurrent species, regardless of the season, and the P5 area, therefore, is more similar. Permdisp had a pseudo-F of 2.934 and p(perm) of 0.038, which indicates that dispersions between groups are significantly different.

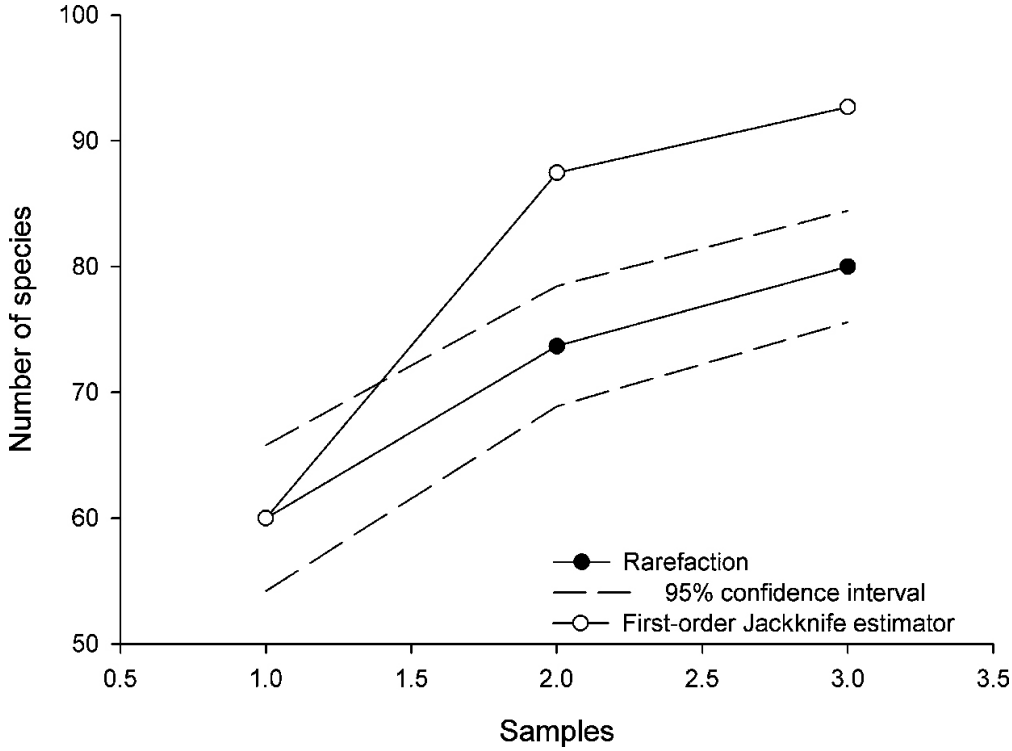
Discussion

The restored environments have their own vegetation and environmental characteristics, since heterogeneity and environmental complexity are the result of the work of recovering areas, soil attributes, plant composition, among other characteristics (Brancalion *et al.*, 2015). Birds are affected by changes in vegetation composition (Lawton, 1996), and the restoration of degraded environments favors the increase of functional diversity and resilience of birds (Melo *et al.*, 2020).

In this context, the richness of the avifauna in the forest fragments restored in this research corresponds to 4.11 % of the bird species described for the country (Pacheco *et al.*, 2021). The birdlife recorded included representatives of all food guilds, considerable diversity in view of the size and location of the areas (within an urban matrix). Similarities in species composition with other restored areas were also identified, showing analogous characteristics in southeastern Brazil (Vogel *et al.*, 2017; Volpato *et al.*, 2018)

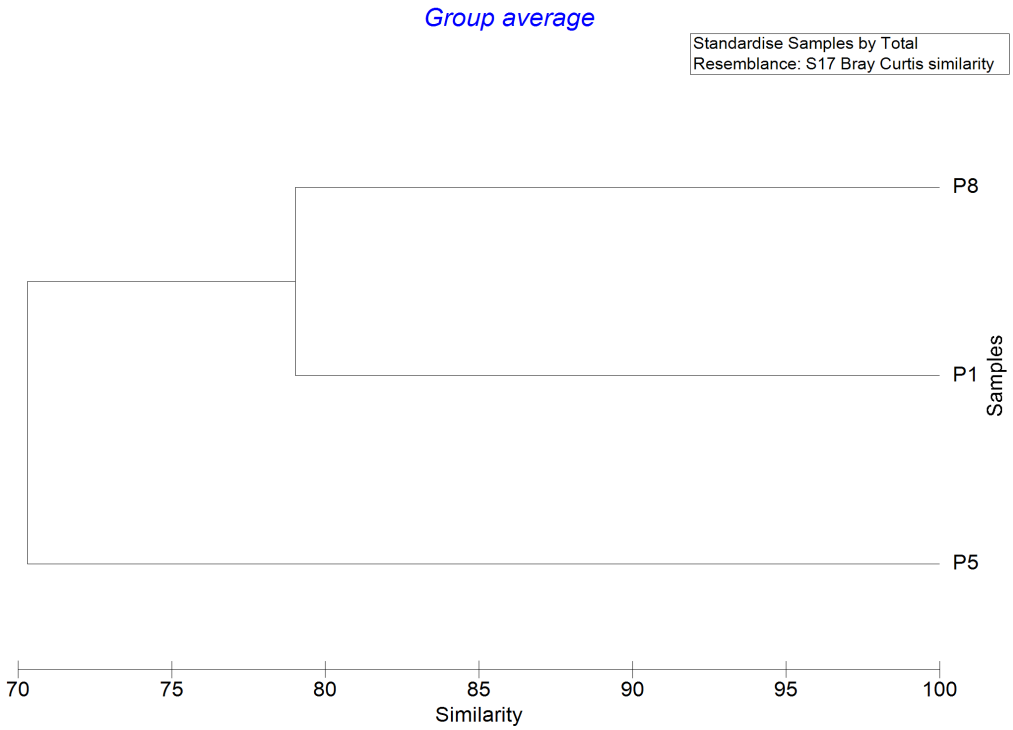
The representativeness of species belonging to the order Passeriformes, of the family Tyrannideae and Thraupidae, was expected due to the fact that most of the birds recorded in the country belong to these families (Pacheco *et al.*, 2021), in line with D'Angelo-Neto's

Figure 3. Rarefaction curve, first-order Jackknife richness estimator and confidence interval of birds inventoried in three restored areas (samples) in Lavras city, in the south of the state of Minas Gerais.



Source: authors (2025).

Figure 4. Cluster of similarity of the inventoried bird community between the three fragments of restored forests (P1, P5, and P8) in Lavras city, in the south of the state of Minas Gerais.



Source: authors (2025).

et al. (1998) observations for adjacent areas in 1998, and by Moura *et al.* (2021), in long-scale studies in the south of the state of Minas Gerais. The high representativeness of species of the Tyrannidae and Thraupidae families had already been observed in previous studies conducted in the region (Braga *et al*., 2010; Lombardi *et al.,* 2007; Ribon, 2000).

The three areas also differed between the seasonal seasons (winter/summer). Such differences are attested by summer-visiting species: *Tyrannus savana*, *Myodinastes maculatus,* and *Sporophila lineola*, which are found in this season due to the great availability of insects, fruits, and grains (Braga *et al*., 2010; Moura *et al.*, 2021).

The study area is in a *Cerrado*/Atlantic Forest ecotonal region, the bird community in the restored forest fragments has endemic elements of both the *Cerrado* and the Atlantic Forest, corroborating the prior studies in the region (Lombardi *et al.,* 2007; Moura *et al.*, 2021).

By the results obtained from the cluster with the Jaccard index, there is a greater similarity between points P1 and P8, because they have a water body and understory, in addition to approximate ages (ten and nine years). On the other hand, although P5 has a similar age (ten years), it is not directly influenced by a body of water nor it has understory due to the highly compacted soil, and is located close to a busy avenue. All this factor demonstrate that its own environmental characteristics are associated with the restoration process and favor the appearance of unique diversity, not found elsewhere. Places with bodies of water include more specialized species, corroborating what was recorded by Moura *et al*. (2021).

The three restored areas studied have great efficacy in terms of species composition, as the bird community shows elements that are not normally found in urban areas such as squares and gardens of the municipality (Braga *et al*., 2010). Notably, some species that have greater environmental requirements were found dwelling these areas. According to Lawton (1996), studies with birds and the comparison of groups of vertebrates from one area with others are primordial factors for the elaboration of effective conservation and preservation projects, which possibly enable us to think the same about restoration projects. In this way, new studies in restored areas are suggested to create bases, encouraging more in-depth studies in restoration areas.

Conclusions

The richness and composition of birds was relevant for environments in forest restoration, as some species are more demanding and are not found in other urban green areas, such as squares and gardens. The similarity between them is conditioned by their own environmental conditions, in addition to the restoration process. Note that even though they are in the urban perimeter, they have a community of birds with representatives of all food guilds that require forested areas to forage, demonstrating the efficiency of forest restoration for fauna.

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References

ALVARES, C. A.; STAPE, J. L.; SENTELHAS, P. C.; MORAES, G.; LEONARDO, J.; SPAROVEK, G. Köppen's climate classification map for Brazil. **Meteorologische Zeitschrift**, v. 22, n. 6,

p. 711-728. 2013. Disponível em: https://www.schweizerbart.de/papers/metz/detail/22/82078/Koppen_s_climate_classification_map_for_Brazil?af=crossref Acesso em: 27 jan. 2024.

BETTS, M. G.; YANG, Z.; HADLEY, A. S.; SMITH, A. C.; ROUSSEAU, J. S.; NORTHRUP, J. M.; NOCERA, J. J.; GORELICK, N.; GERBER, B. D. Forest degradation drives widespread avian habitat and population declines. **Nature Ecology and Evolution**, v. 6, p. 709-719. 2022. Disponível em: https://www.nature.com/articles/s41559-022-01737-8 Acesso em: 27 jan. 2024.

BRAGA, T. V.; ZANZINI, A. C. S.; CERBONCINI, R. A. S.; MIGUEL, M, MOURA, A. S. Avifauna em praças da cidade de Lavras (MG): riqueza, similaridade e influência de variáveis do ambiente urbano. **Revista Brasileira de Ornitologia**, v. 18, n. 1, p. 26-33, 2010. Disponível em: https://www.researchgate.net/publication/268976586_Avifauna_em_pracas_da_cidade_de_Lavras_MG_riqueza_similaridade_e_influencia_de_variaveis_do_ambiente_urbano Acesso em: 03 fev. 2024.

BRANCALION, P.H.S.; GANDOLFI, S.; RODRIGUES, R.R. **Restauração florestal.** São Paulo: Oficina de Textos, 2015. 432p.

BURNHAM. K. P.; OVERTON, W. S. Estimation of size of a closed population when capture probabilities vary among animals. **Biometrika**, v. 65, n. 1, p. 625–633, 1978. Disponível em: https://academic.oup.com/biomet/article-abstract/65/3/625/234287?redirectedFrom=fulltext&login=false Acesso em: 07 mar. 2024.

COWELL, R. K. Estimates: statistical estimation of species richness and shared species from samples. **Version 7.0, User's Guide and application.** 2006. University of Connecticut: USA. Disponível em: http://viceroy.eeb.uconn.edu/estimates Acesso em: 13 fev. 2024.

D'ANGELO NETO, S.; VENTURIN, N.; OLIVEIRA-FILHO, A. T.; COSTA F. A. F. Avifauna de quatro fisionomias florestais de pequeno tamanho (5-8 ha) no campus da UFLA. **Revista Brasileira de Biologia**, v. 58, p. 463-472, 1998. Disponível em: https://www.scielo.br/j/rbbio/a/wbny6MbDFn66NFZWK9NrJHS/abstract/?lang=pt Acesso em: 13 fev. 2024.

EDWARDS, D. P.; CERULLO, G. R. Biodiversity is central for restoration. **Current Biology**, v. 34, n. 9, R371-R379, 2024. Disponível em: https://www.cell.com/current-biology/abstract/S0960-9822(24)00174-X?_returnURL=https%3A%2F%2Flinkinghub.elsevier.com%2Fretrieve%2Fpii%2FS096098222400174X%3Fshowall%3Dtrue Acesso em: 19 mar. 2024.

JOYCE, F. H.; ROSALES, J. A.; HOLL, K. D.; ZAHAWI, R. A.; BUI, A.; REID, J. L. Active restoration accelerates recovery of tropical forest bird assemblages over two decades. **Biological Conservation**, v. 293, e110593, 2024. Disponível em: https://linkinghub.elsevier.com/retrieve/pii/S0006320724001551 Acesso em: 19 mar. 2024.

LAWTON, J. H. Population abundance, geographic range and conservation. Witherbylecture. **Bird Study**, v. 43, p. 3-19, 1996. Disponível em: https://www.tandfonline.com/doi/pdf/10.1080/00063659609460991 Acesso em: 20 mar. 2024.

LESSA, M. F. G.; BARBOSA, M. A. C.; MOREIRA, J. G. F.; FONSECA, M. A.; FONSECA, M. F. V.; MOTA, K. N.; PADILHA, K. S. M. A., SILVA, P. V. S. Eficácia dos corredores ecológicos na conservação florestal. **Revista Contemporânea**, v. 4, n. 3, e3633-e3633, 2024. Disponível em: https://www.researchgate.net/publication/379322297_EFICACIA_DOS_CORREDORES_ECOLOGICOS_NA_CONSERVACAO_FLORESTAL Acesso em: 20 mar. 2024.

LOMBARDI, V. T.; VASCONCELOS, M. F.; D'ANGELO NETO, S. Novos registros ornitológicos para o centro-sul de Minas Gerais (Alto Rio-Grande): municípios de Lavras, São João Del Rei e adjacências, com a listagem revisada da região. **Atualidades Ornitológicas**, v. 139, p. 33-42, 2007. Disponível em: https://www.researchgate.net/publication/274032037_Novos_registros_ornitologicos_para_o_centro-sul_de_Minas_Gerais_alto_Rio_Grande_municipios_de_Lavras_Sao_Joao_Del_Rei_e_adjacencias_com_a_listagem_revisada_da_regiao Acesso em: 17 jan. 2024.

MELO, M. A.; SILVA, M. A. G.; PIRATELLI, A. J. Improvement of vegetation structure enhances bird functional traits and habitat resilience in an area of ongoing restoration in the Atlantic Forest. **Anais da Academia Brasileira de Ciências**, v. 92, e20191241, 2020. Disponível em: https://www.scielo.br/j/aabc/a/nG6KbXPKMvsD9rTLz56TRjn/ Acesso em: 23 nov. 2024.

MITTERMEIER, R. A.; FONSECA, G. A. B.; RYLAND, A. B.; BRANDON, K. A brief history of biodiversity conservation in Brazil. **Conservation Biology**, v. 19, n. 3, p. 601-611, 2005. Disponível em: https://conbio.onlinelibrary.wiley.com/doi/10.1111/j.1523-1739.2005.00709.x Acesso em: 23 nov. 2024.

MOURA, A. S. Registro de um novo item alimentar na dieta de *Phibalura flavirostris*. **Atualidades Ornitológicas**, v. 178, p. 24-25, 2014. Disponível em: https://www.academia.edu/6833150/Registro_de_um_novo_item_alimentar_na_dieta_de_Phibalura_flavirostris Acesso em: 23 nov. 2024.

MOURA, A. S.; MARIANO, R. F.; MACHADO, F. S.; CEBONCINI R. A. S.; FONTES, M. A. L. Frugivory by birds in *Siphoneugena widgreniana* O. Berg (Myrtaceae)in the Chapada dos Perdizes, Minas Gerais, Brazil. **Natureza online**, v. 18, n. 3, p. 035-040, 2017. Disponível em: https://www.naturezaonline.com.br/revista/article/download/459/445/853 Acesso em: 26 nov. 2024.

MOURA, A. S.; MACHADO, F. S.; MARIANO, R. F.; SOUZA, C. R.; FONTES, M. A. L. Bird community of upper-montane rupestrian fields in South of Minas Gerais state, Southeastern Brazil. **Acta Scientiarum**, v. 42, e48765, 2020. Disponível em: https://periodicos.uem.br/ojs/index.php/ActaSciBiolSci/article/view/48765 Acesso em: 15 jun. 2024.

MOURA, A. S.; MACHADO, F. S.; MARIANO, R. F.; SOUZA, C. R.; MENGEZ, U. C. L.; FONTES, M. A. L. Mesoscale bird distribution pattern in montane phytophysiognomies along an ecotone between two hotspots. *Acta Scientiarum*, v. 43. p. e56931, 2021. Disponível em: https://periodicos.uem.br/ojs/index.php/ActaSciBiolSci/article/view/56931 Acesso em: 15 jun. 2024.

MYERS, N.; MITTERMEIER, R.A.; MITTERMEIER, C.G.; FONSECA, G.A.B.; KENT, J. Biodiversity hotspots for conservation priorities. **Nature**, v. 403, p. 853-858. 2000. Disponível em: https://www.nature.com/articles/35002501 Acesso em: 26 nov. 2024.

OLIVEIRA-FILHO, A.T.; FLUMINHAN-FILHO, M. Vegetation ecology of the Parque Florestal Quedas do Rio Bonito, Brazil. **Cerne**, v. 5, n. 2, p. 051-064, 1999. Disponível em https://cerne.ufla.br/site/index.php/CERNE/article/view/525/452 Acesso em: 03 ago. 2024.

PACHECO, J. F.; SILVEIRA, L. F.; ALEIXO, A.; AGNE, C. E.; BENCK, G. A.; BRAVO, G. A.; BRITO, G. R. R.; COHN-HAFT, M.; MAURÍCIO, G. N.; NAKA, L. N.; OLMOS, F.; POSSO, S. R.; LEES, A. C.; FIGUEIRA, L. F. A.; CARRANO, E.; GUEDES, R. C.; CESARI, E.; FRANZ, I.; SCHUNCK, F.; PIACENTINI, V. Q. Annotated checklist of the birds of Brazil by the Brazilian Ornithological Records Committee - second

edition. **Ornithology Research**, v. 29, n. 2, p. 94-105, 2021. Disponível em: https://fabioschunck.com.br/site/wp-content/uploads/2021/10/Pacheco-et-al.-2021.pdf Acesso em: 03 ago. 2024.

POSSO, S. R.; BRINCK, R. R.; RAGUSA-NETTO, J.; HEPP, L. U.; MILESI, S. V. How bird community responds to different ages of reforestation? Implications for restoration of a highly threatened Atlantic Forest phytophysiognomy. **Anais da Academia Brasileira de Ciências**, v. 96, n. 1, e20220691, 2024. Disponível em: https://www.scielo.br/j/aabc/a/gfD7Z5CnFvJqyj9jRKWxHCd/?lang=en Acesso em: 02 ago. 2024.

REIS, A.; TRES, D. R.; SCARIOT, E. C. Restauração na Floresta Ombrófila Mista através da sucessão natural. **Pesquisa Florestal Brasileira**, v. 55, p. 67-67, 2007. Disponível em: https://pfb.cnpf.embrapa.br/pfb/index.php/pfb/article/view/120 Acesso em: 02 ago. 2024.

RIBON, R. Lista preliminar da avifauna do município de Ijaci, Minas Gerais. **Revista Ceres**, v. 47, n. 274, p. 665-682, 2000.

SANGWAN, S.; KUMAR, M.; LAMBA, R.; SINGH, S., KUMARI, A., WATI, L. Bioindicators: natural biotic sensors of environmental pollution and ecological disturbance. In: BHAT, S.A.; KUMAR, V.; LI, F.; AMEEN, F.; KUMAR, S. **Environmental nexus approach:** management of water, waste and soil**.** Boca Raton: CRC Press, 2024. p. 311-337.

SHUGART, H. H. Phenomenon of succession. **Encyclopedia of Biodiversity,** v. 6, p. 272-281, 2024. Disponível em: https://doi.org/10.1016/b978-0-12-822562-2.00385-6 Acesso em: 18 jul. 2025.

VALENTIN, J. L. **Ecologia numérica:** uma introdução à análise multivariada de dados ecológicos. Rio de Janeiro: Interciência, 2000. 117 p.

VOGEL, H. F.; CAMPOS, J. B.; SHELDON, K.; BECHARA, F. C. Comparative analysis of birdlife in different ecological restoration methods with emphasis in the role of artificial perches. **Revista de Biologia Neotropical/Journal of Neotropical Biology**, v. 14, n. 2, p. 111-134, 2017. Disponível em: https://revistas.ufg.br/RBN/article/view/47000 Acesso em: 05 ago. 2024.

VOLPATO, G. H.; MIRANDA, A.; MARTINS, S. V. Avifauna como bioindicadora para avaliação da restauração florestal: estudo de caso em uma floresta restaurada com 40 anos em viçosa-MG. **Ciência Florestal**, v. 28, n. 1, p. 336-344, 2018. Disponível em: https://doi.org/10.5902/1980509831604 Acesso em: 05 set. 2024.

WIKIAVES. **A enciclopédia das aves do Brasil**. 2025. Disponível em: <http://www.wikiaves.com> Acesso em: 23 jun. 2025.