

Biodiversity knowledge through birdwatching: over a decade of bird records in Pinheiral, Atlantic Forest, Brazil

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O município de Pinheiral, estado do Rio de Janeiro, é coberto originalmente pela Floresta Estacional Semidecidual da Mata Atlântica, um ecossistema historicamente marcado por ciclos de desmatamento e mudanças no uso e ocupação do solo, e um dos menos estudados. Neste trabalho apresentamos a primeira compilação de registros de aves para o município. O estudo compreendeu uma série temporal de 10 anos (2014–2024) de registros oportunistas e não sistematizados obtidos a partir de atividades independentes de observação de aves conduzidas por quatro observadores em diversos tipos de habitats. O esforço de amostragem não foi padronizado, com os registros variando espacial e temporalmente de acordo com a atividade do observador e concentrados em áreas acessíveis. Para complementar nosso conjunto de dados, registros adicionais foram compilados a partir de plataformas de ciência cidadã, bancos de dados de museus e literatura científica publicada. A combinação desses dados resultou em 231 espécies de aves, sendo 25 endêmicas da Mata Atlântica, 8 ameaçadas de extinção e 29 com hábitos migratórios. A riqueza encontrada corresponde a aproximadamente 28% das aves do estado do Rio de Janeiro, 25% da avifauna da Mata Atlântica e 12% das espécies do Brasil, destacando a alta relevância biológica local. A ocorrência de espécies ameaçadas, como o azulão *Cyanoloxia brissonii* e o pixoxó *Sporophila frontalis*, evidencia a importância dos remanescentes florestais do município. Apesar do histórico de degradação ambiental, Pinheiral ainda abriga habitats essenciais que podem funcionar como áreas de parada, invernada e/ou reprodução para aves migratórias, além de refúgios para espécies endêmicas e dependentes de floresta. Os resultados demonstram que a região sustenta uma comunidade de aves diversa e reforçam o valor da observação de aves como ferramenta para a produção de conhecimento ornitológico em áreas não amostradas pela ciência tradicional.

Records generated through birdwatching have the potential to expand ornithological knowledge by increasing sampling effort and spatial coverage, and by improving information on species distributions and diversity patterns⁵¹. Birdwatching has become an increasingly prominent activity both in Brazil and worldwide, playing a central role in the advancement of citizen science¹⁰. The participation of observers has enabled the gathering of a large dataset with broad spatial coverage, although sampling effort remains uneven and often concentrated in well-known sites¹⁹. These datasets are fundamental for monitoring populations, understanding distribution patterns and detecting changes in bird communities in response to environmental and anthropogenic factors⁶. They also contribute to conservation strategies, including in historically under-sampled areas^{19,21}. In this context, data derived from citizen science have proven to be an effective tool for characterising biodiversity across different spatial and temporal scales^{7,13,21}.

Although birds are the most thoroughly studied vertebrate group⁶, numerous species are still being discovered and described^{9,18,37}, while knowledge about the distribution of a

wealth of species continues to grow, including range expansions derived from anthropogenic landscape changes^{8,41,57}. Studies indicate that human modifications have altered species richness, composition and abundance globally^{22,38}, to the extent that some species may become extinct before even being formally documented³². These patterns reinforce the importance of continuous generation and compilation of data to expand knowledge on biodiversity and to support conservation actions, particularly at a time of rapid landscape transformations³¹.

The Atlantic Forest constitutes a unique ecosystem due to its high environmental heterogeneity, including diverse soil types, vegetation, relief and temperature regimes, along with a complex evolutionary history of its biota^{34,45,48}. It is the second-largest tropical forest in South America, with an original total area of 1.6 million ha³⁹, the majority of which lies within Brazilian territory (93%), but also extending into eastern Paraguay (5.3%) and northeastern Argentina (1.7%)^{34,56}. Despite its high biological diversity, which includes 458 endemic²⁰ and 311 threatened²⁷ vertebrate species, as well as many still-undescribed species³⁴, the Atlantic

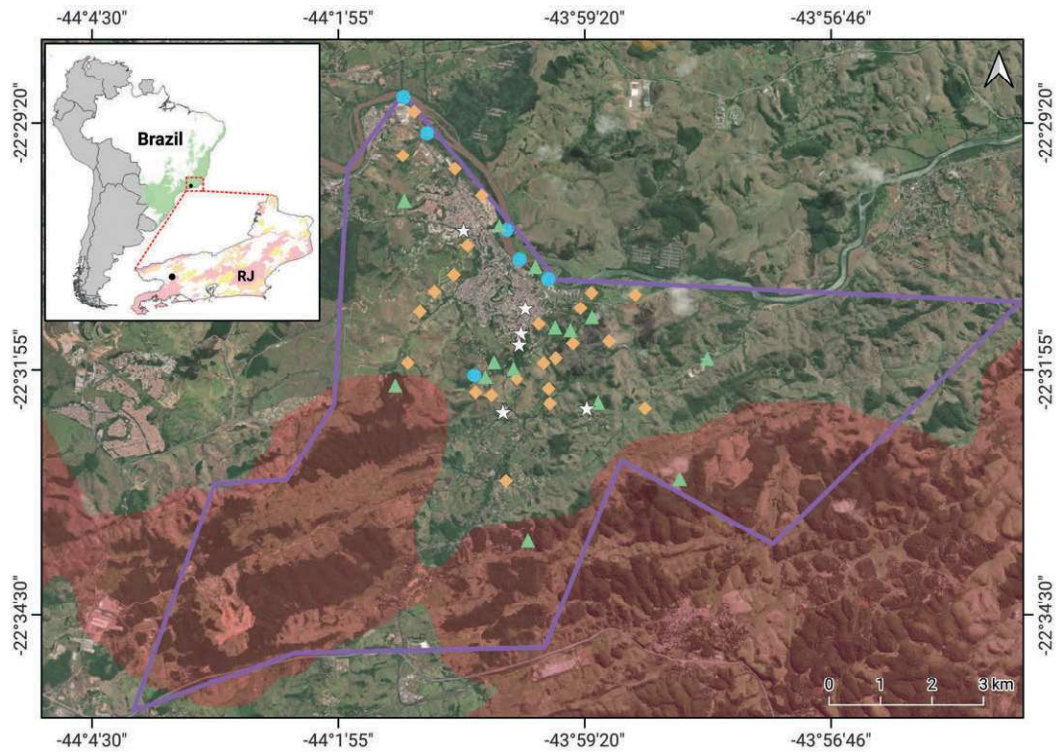


Figure 1. Sampling locations in the municipality of Pinheiral, state of Rio de Janeiro, southeastern Brazil. In the *main map*, the purple polygon indicates the municipal boundaries of Pinheiral. Sampling points are represented by symbols: stars = urban areas, blue circles = aquatic environments, orange diamonds = open areas and green triangles = forest fragments. In the *upper left panel* (South America) the green area shows the original distribution of the Atlantic Forest biome across the continent⁴⁰, and the black dot indicates the location of Pinheiral. In the *inset* highlighting the state of Rio de Janeiro, shaded areas represent categories of biological importance²⁸: pink = 'extremely high', orange = 'very high', yellow = 'high' and grey = 'insufficiently known'. Figure produced in QGIS 3.34 (<http://www.qgis.org>) using satellite imagery from Bing, cartographic data from IBGE (2024) for territorial boundaries, Olson *et al.*⁴⁰ for the Atlantic Forest biome and INEA²⁸ for categories of biological importance, in the SIRGAS 2000 coordinate system.

Forest is currently facing severe degradation and fragmentation, limited protection and insufficient conservation efforts³¹. It is estimated that only 28% of the original forest cover remains, 97% of which consists of fragments smaller than 250 ha, with only 30% covered by protected areas^{47,49}.

Birds of the Atlantic Forest are well studied, particularly in the state of Rio de Janeiro, Brazil⁴². Even so, recently published information indicates that knowledge gaps remain^{2,14,35,56}. Among the forest physiognomies of the Atlantic Forest, the Semideciduous Seasonal Forest is one of the most degraded and least studied, despite harbouring a highly diverse flora and endemic fauna²⁴. In this context, data derived from birdwatching represent a promising tool to complement inventories in such phyto-physiognomies. Thus, this study aims to compile records derived from citizen science, based on opportunistic and non-systematic observations from birdwatching activities, in order to produce

the first checklist of birds for the municipality of Pinheiral, Rio de Janeiro, Brazil. This study contributes to knowledge of the local avifauna and helps fill existing gaps in a region located within one of the most threatened biomes and phyto-physiognomies worldwide.

Study area

The municipality of Pinheiral is located in the state of Rio de Janeiro, southeastern Brazil, covering a total area of 82,254 km², with its geographic centre at 22°31'12''S 43°59'48''W (Fig. 1)²⁷. It is situated within the region known as the *Médio Vale do Paraíba*, an area historically shaped by colonisation and successive economic cycles, particularly during the first half of the 19th century with the expansion of coffee production in Rio de Janeiro, which brought significant alterations to its natural environments¹¹. Over time, the landscape of the Rio Paraíba do Sul valley has been extensively