Avian inventory through the use of mobile applications to strengthening avitourism in El Magdalena

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Abstract

GeometricAI es una aplicación móvil que apoya el aprendizaje de la geometría básica en estudiantes de educación secundaria. Esta herramienta integra un modelo de inteligencia artificial (IA) que reconoce automáticamente figuras geométricas y guía al usuario en la resolución de problemas relacionados con el área, el perímetro y otros parámetros esenciales, sin necesidad de conexión a internet para realizar ejercicios o validaciones. This article highlights the impact of emerging technologies on bird research and monitoring, with an emphasis on the use of mobile applications that enable species identification through photographs and calls. These tools have transformed fieldwork, benefiting both researchers and birdwatchers. The presentation focuses on an avian inventory conducted in two areas of the Magdalena Department: the Lower Toribio River zone and the Minca Pozo Azul zone. The paper also explores the potential of these apps to enrich biodiversity inventories, strengthen citizen science, and promote conservation. To develop this study, transect and observation point methods were used. Species richness and abundance were recorded in both areas using specialized apps that capture images and bird calls for identification purposes.

The results show significant differences in species diversity and avian community structure between the two areas. The Minca Pozo Azul zone had lower species richness (12 families) and a lower total number of individuals (52), compared to the Lower Toribio River zone, which recorded 23 families and 67 individuals. The indices used included the Margalef, Shannon, and Simpson indices. The results indicated greater diversity in the Lower Toribio River zone according to the Margalef and Shannon indices, while the Minca Pozo Azul zone showed lower species dominance according to the Simpson index.

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These findings suggest a richer avifauna in the Lower Toribio River zone and a more equitable community structure in the Minca Pozo Azul zone.

Keywords: diversity indices, birdwatching, citizen science, mobile applications

1. Introduction

Colombia, with more than 1,900 recorded bird species, ranks first in the world in bird diversity (Humboldt Institute, 2023). This richness represents not only an incalculable ecological value but also an opportunity for the development of birdwatching, environmental education, and scientific research. In this context, the use of technological tools has revolutionized the way bird monitoring and inventories are conducted. Mobile applications such as Merlin Bird ID, eBird, Xeno-Canto, BirdNET, and iNaturalist allow users to record observations, identify species, and share data in real time with both scientific and citizen communities. Bird inventories are essential tools for conservation, as they provide reliable and replicable information on the composition and structure of avian communities. This, in turn, allows for the assessment of ecosystem conservation status and enables comparisons (Álvarez et al., 2004). This study focuses on comparing the avifauna of two areas, the Lower Toribio River zone and the Minca Pozo Azul zone, with different ecological characteristics, assessing species diversity and abundance in both, and determining how habitat differences influence avian community structure. Both areas represent key habitats within the Sierra Nevada de Santa Marta, but differ in altitude, vegetation cover, and degree of human intervention. The results contribute to a better understanding of regional biodiversity and offer valuable input for future conservation strategies and citizen participation in science.

2. Background and Related Work

The study of birdlife in the lower Toribio River basin and the Minca Pozo Azul area responds to the growing concern for biodiversity conservation and the sustainable development of ecotourism. The research is framed within community ecology, which analyzes the composition and structure of species in a given ecosystem (Begon et al., 2006). In particular, bird diversity is a key indicator of environmental health and ecosystem functionality (Bibby, Jones, & Marsden, 1998).

Nature tourism, and birdwatching in particular, has been widely studied as a sustainable development strategy that generates economic benefits and promotes environmental conservation (Buckley, 2009). However, it has also been documented that the unplanned growth of tourism infrastructure can negatively impact natural habitats, affecting the distribution and abundance of species (Steven et al., 2015).

To assess avifaunal diversity in the study areas, ecological indices such as the Margalef, Shannon, and Simpson indices were used, which allow estimating species richness and evenness in the ecosystem (Magurran, 2004). These indicators have been applied in various studies on biodiversity and conservation, demonstrating their effectiveness in environmental impact assessment and natural resource management (Gotelli & Chao, 2013).

Species identification was carried out through direct observation and the use of digital tools such as Merlin Bird ID and Picture Bird, which have significantly improved the accuracy of ornithological research (Sullivan et al., 2009). Previous studies have shown that these applications contribute to citizen science and facilitate data collection in hard-to-reach areas (Bonney et al., 2009).

The most notable applications currently used for bird inventory are:

- Merlin Bird ID: Developed by the Cornell Lab of Ornithology, this application allows bird identification through photographs or song recordings. Its artificial intelligence is powered by a global database that is constantly expanding thanks to user contributions (Cornell Lab of Ornithology, 2024).

- eBird: Also managed by the Cornell Lab, eBird is one of the most widely used platforms in the world for recording bird observations. Users can upload georeferenced checklists, allowing for the generation of distribution maps and analysis of migratory patterns (Sullivan et al., 2009).

- Xeno-Canto: This collaborative platform stores recordings of bird songs from around the world, allowing for the comparison and study of vocalizations across species and regions (Xeno-Canto Foundation, 2023).

- BirdNET: Based on neural networks, BirdNET analyzes bird songs captured by a phone's microphone to provide automatic identification. It is especially useful in dense habitats where visual observation is limited (Kahl et al., 2021).

- iNaturalist: Although not limited to birds, its automatic recognition technology and global community of experts make iNaturalist a powerful tool for participatory biodiversity monitoring (iNaturalist, 2024).

- Picture Bird: This app uses image recognition to identify birds from user-taken photographs. It is especially useful for beginners, as it offers descriptions, habitats, and typical behaviors of the detected species. Although its database is less robust than that of Merlin or eBird, it is an accessible and educational tool that complements participatory monitoring efforts (Picture Bird, 2024).

3. Research Methodology

Study Area

The study was conducted on the northern flank of the Sierra Nevada de Santa Marta, in two of its basins: the Gaira River basin near Minca (Pozo Azul) in the Santa Marta district, and the lower Toribio River basin in the municipality of Ciénaga.

The lower Toribio River basin is characterized by its lower altitude, predominantly tropical dry forest vegetation, and greater human intervention. The second zone, Minca Pozo Azul, located at a higher altitude, features a more conserved tropical dry forest and less human pressure.

Bird Inventory Method

Bird records were made through direct observation during sampling periods between February and April 2023, and July and September 2023, applying the methodology established by Wunderle (1994) and Ralph et al. (1996), which seeks to cover the largest possible area among several researchers.

To conduct the bird inventory, two main methods were used: transects and observation points. These methods provide a representative sample of the birdlife present in each area and are widely used in ornithological studies.

Individual sightings were conducted through free walks along transects, accumulating a total of

60 hours of observation per area on alternating days between morning (6:00 a.m.-10:00 a.m.) and afternoon (3:00 p.m.-6:00 p.m.) according to the guidelines established by Ralph, 1981, considering these are the times when birds are most active.

Transects

Three transect lines, each 350 meters long, were located at each sampling site. To avoid double counting, the transects were separated by at least 150-200 meters (González García 2013).

The start and end of each Transect Line (TL) were marked with a red marker, making them easier to identify. Subsequently, each transect line was slowly covered to record the species found in each habitat (González García 2013), at a speed of approximately 1 km/h. It was also taken into account whether the bird was recorded in the canopy of a tree or bush, on a trunk, on the ground, or in the water. Along each transect, all birds observed and heard were recorded, noting the species, number of individuals, and their behavior.

Observation and Counting Points

Six fixed counting and observation points were located in each sampling area along each transect, identified by yellow caps, so that censuses could be conducted at the same sites throughout all sampling periods. The minimum distance between points was 250 m (Ralph et al. 1996; Mac Gregor-Fors et al. 2010), and to avoid the edge effect, the minimum distance between a CP and the boundary of a different habitat was 100 m (Ralph et al., 1996; Bibby et al., 2000). Continuous observations were conducted at these CPs for 15 minutes. All observed birds were recorded at these points, thus complementing the data obtained from the transects. In addition to the above, to complement the list of families, sound recordings of vocalizations obtained during the tours were included. For this purpose, the methodology established in chapter 5 of the Manual of Methods for the Development of Biodiversity Inventories of the Alexander Von Humboldt Institute, (Álvarez et al., 2006) was used, which proposes to carry out observations and recordings simultaneously and use the techniques of Brutney and Grotke (2000) proposed in the article "Techniques for the recording of tropical birds". It is important to highlight that the recorded vocalizations were first labeled and processed with the help of two Pro Tools programs and the Audiolab App in order to eliminate ambient sounds and noises that could intervene in the contrast and identification of bird vocalizations. These recordings were compared with three mobile applications for bird identification—Merlin, eBird and Picture Bird—where sound fragments were introduced in order to identify the bird and compare it with what was observed.

4. Results

Diversity and Abundance

The results showed significant differences in species richness and abundance between the two study areas. In the Minca Pozo Azul Zone, a total of 52 individuals belonging to 12 families were recorded, while in the Lower Toribio River Zone, 67 individuals belonging to 23 families were recorded. Table 1 Shows a summary of the results obtained for each order and family in both areas.

Table 1. Summary of results for bird richness and abundance in the two study areas

Order	Family	Area 1: Minca	Area 2: Toribio
Passeriformes	Passeridae	1	0
Passeriformes	Eurylaimidae	1	0
Passeriformes	Corvidae	2	1
Passeriformes	Troglodytidae	2	1
Passeriformes	Icteridae	1	5
Passeriformes	Cisticolidae	0	7
Passeriformes	Parulidae	0	2
Passeriformes	Thraupidae	0	2
Passeriformes	Cardinalidae	0	1
Passeriformes	Icteridae	0	1
Passeriformes	Pirangas	0	5
Passeriformes	Coerebidae	0	3
Passeriformes	Turdidae	0	1
Apodiformes	Trochilidae	0	1
Caprimulgiformes	Steatornithdae	12	7
Columbiformes	Columbidae	1	0
Psittacidae	Psittaciformes	6	6
Trogoniformes	Trogonidae-quetzal	23	13
Strigiformes	Strigidae	1	0
Accipitriformes	Tytonidae	1	1
Pelecaniformes	Accipitridae	1	2
Pelecaniformes	Threskiornithidae	0	2
Pelecaniformes	Ardeidae	0	1
Pelecaniformes	Ardeidae	0	1
Pelecaniformes	Pelecanidae	0	1
Tinamiformes	Tinamidae	0	1
Piciformes	Ramphastidae	0	1
Total		52	67

Note. Elaborated by the author

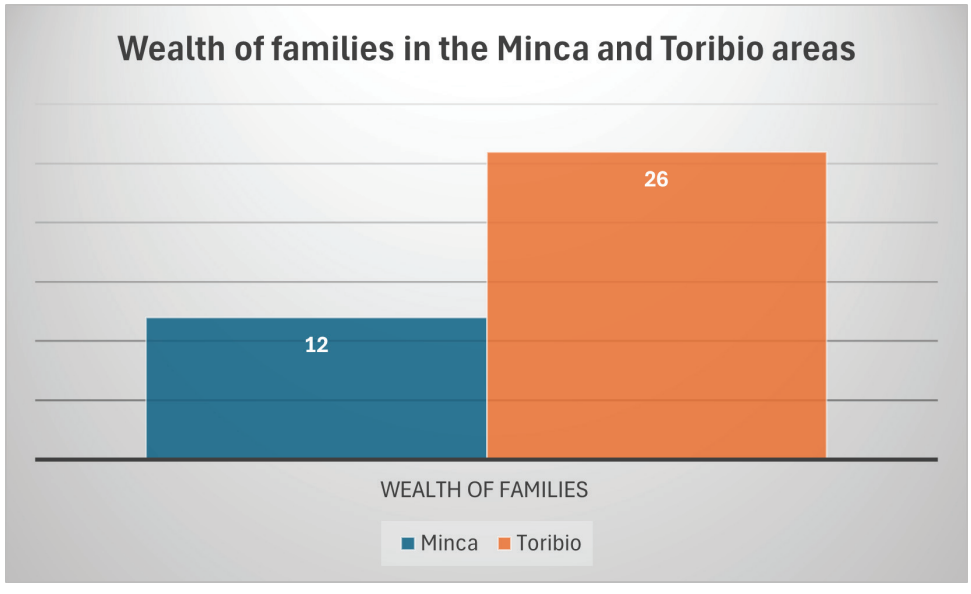
Figure 1 shows that the order richness was higher in the Toribio River compared to the Minca River. The Psittacidae order stands out in both areas, including parrots, parakeets, conures, and macaws, which have a characteristically curved beak shape.

Figure 1. Order richness in the Minca and Toribio areas

Note. Prepared by the authors.

Regarding family richness, we can see in Figure 2 that it was also higher in the Toribio River area, whose richness exceeded that of Minca by 216%. This could be associated with the diverse habitat conditions found in the lower part of the Toribio River where the mouth of the river meets the Caribbean Sea, so some specimens of coastal birds from the Pelecaniformes family could be seen, which include herons and pelicans, among others.

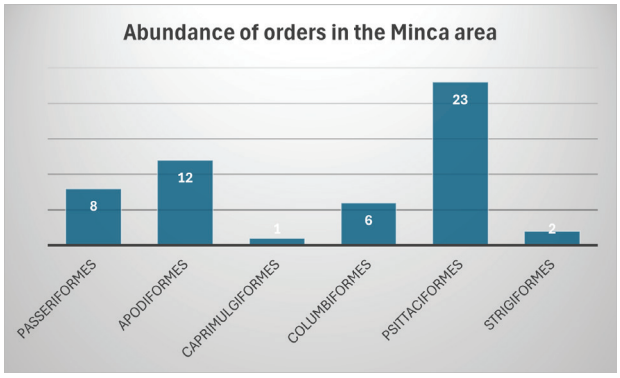
Figure 2. Wealth of families in the Minca and Toribio areas

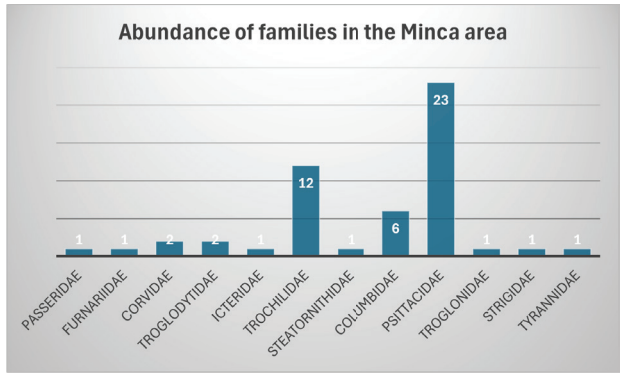


Note. Prepared by the authors.

On the other hand, the abundance of individuals found in each zone was established by order and family. Figures 3 and 4 show the abundance for the Minca zone by order and family level. The most abundant was the family Psittaciformes of the order Psittacidae, with 23 individuals identified.

Figures 3 and 4. Abundance of orders and families in the Minca Area

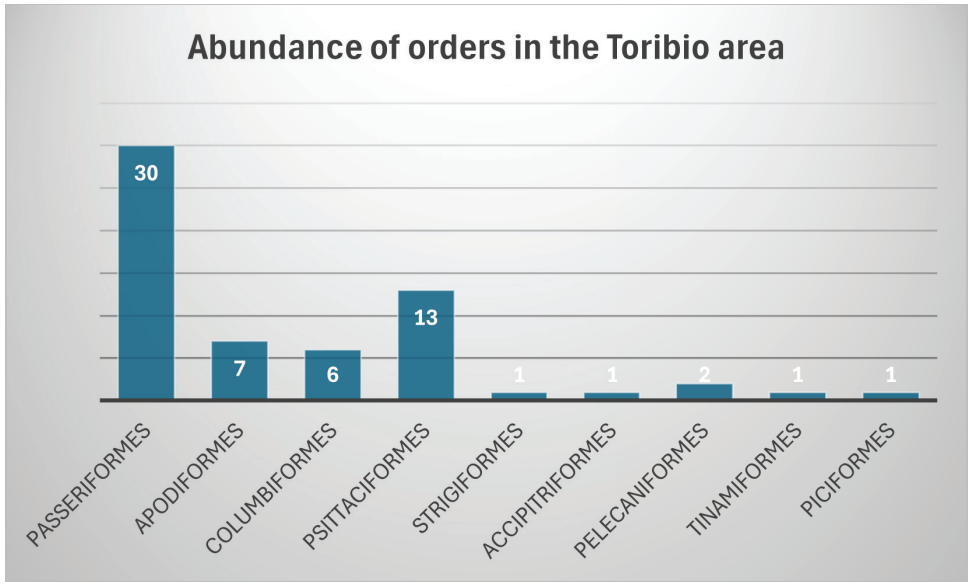




Note. Prepared by the authors.

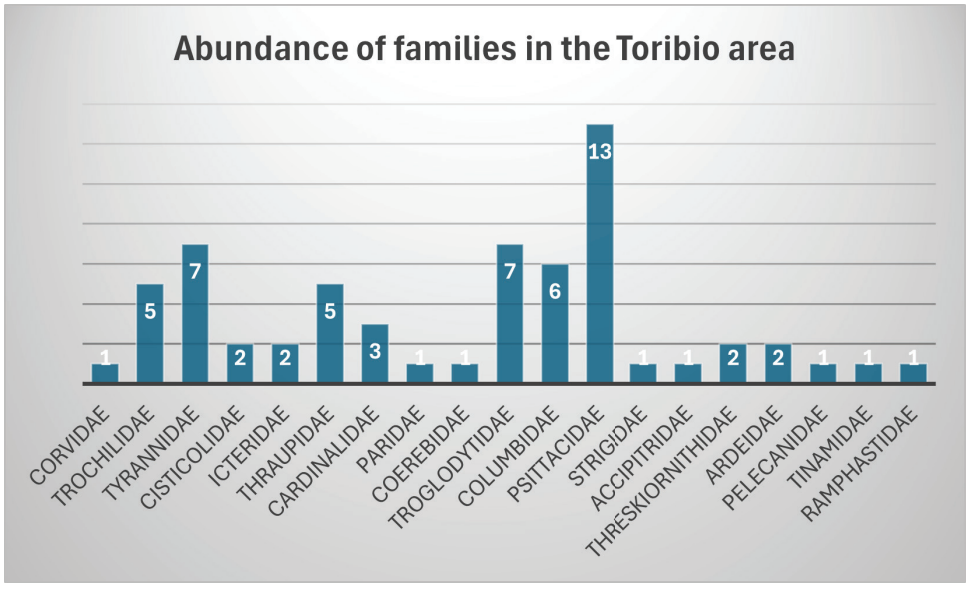
In the case of the lower Toribio Basin Zone, the most abundant family was the Psittaciformes (parrots and parakeets) with 13 individuals, while in the case of the orders, the most abundant were the Passeriformes (commonly called birds or songbirds) with 30 individuals, as can be seen in Figures 5 and 6

Figure 5. Abundance of orders in the Toribio zone



Note. Prepared by the authors.

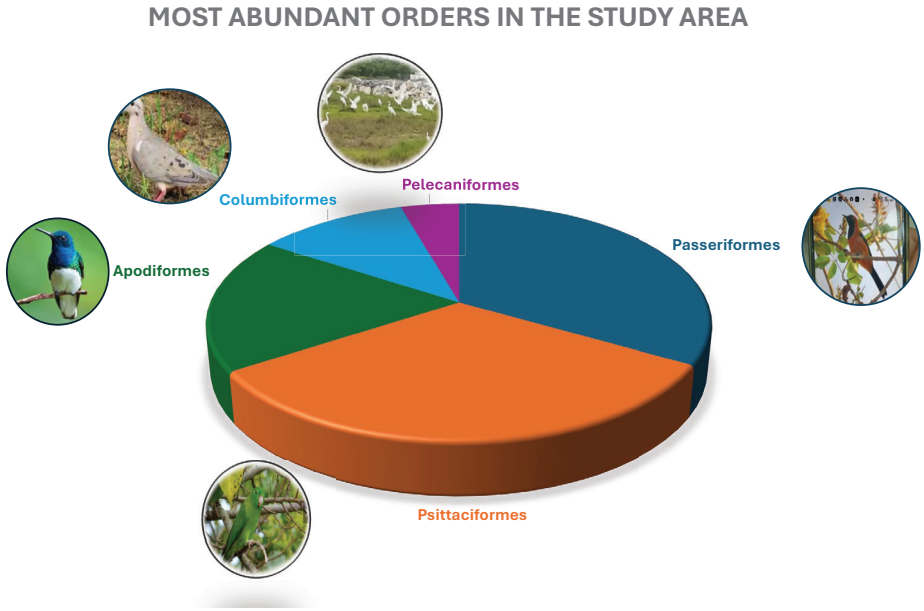
Figure 6. Abundance of families in the Toribio zone



Note. Prepared by the authors.

Taking individuals from both areas, the five most abundant orders were, as can be seen in Figure 7, first, Passeriformes with 34%, Psychidae with 33%, Apodiformes with 19%, Columbiniformes with 12%, and Pelicaniformes with 5% (Figure 7).

Figure 7. Most abundant orders in the study areas



Note. Prepared by the authors.

The diversity indices reflected a greater diversity in the Lower Zone of the Toribio River, with a Shannon Index of 2.182 and a Simpson Index of 0.913, compared to the Minca Pozo Azul Zone, which presented a Shannon Index of 1.731 and a Simpson Index of 0.732 (as can be seen in Table 2). These results suggest a greater heterogeneity in the avian community of the Lower Zone of the Toribio River.

Table 2. Diversity indices

Diversity Indices Alfa	Minca zone	Toribio zone
Margaleff Diversity Index	2.78	5.23
Diversity Alfa Shanonn	1.73	2.18
Simpson Dominance	0.268	0.087
Simpson Diversity	0.732	0.913

Note. Prepared by the authors.

5. Discussion and Conclusions

Differences in species richness and diversity between the two study areas may be related to differences in habitat structure and the degree of human disturbance. The higher species richness in the Lower Toribio River Area may be associated with the diversity of habitats found in this area, which includes both forested and open areas, providing a variety of resources for birds.

On the other hand, the lower diversity observed in the Minca Pozo Azul area may be influenced by its higher elevation and lower level of human disturbance, which could limit the presence of generalist species and favor those adapted to more specific conditions.

The importance of alpha diversity, as measured by the Shannon Index, lies in its ability to reflect the evenness and richness of species within a community. In this regard, the Lower Toribio River area not only exhibited greater species richness but also greater evenness, suggesting a more balanced avian community.

This study reveals significant differences in the avifauna of two ecological zones in the Department of Santa Marta. The Lower Toribio River Zone, with greater species richness and diversity, stands out as an area of high importance for the conservation of avifauna in the region. Meanwhile, the Minca Pozo Azul Zone, despite having lower diversity, still has significant ecological value, particularly due to the presence of species adapted to higher altitudes.

These results underscore the need to continue conducting biodiversity surveys in different areas of the Sierra Nevada de Santa Marta to improve our understanding of the distribution and conservation status of species in this region. Furthermore, these studies are essential for designing conservation strategies that consider the particularities of each ecological zone.

The use of mobile apps for bird surveys represents a significant advance in the practice of field science. By making ornithological knowledge more widely accessible, these tools promote a culture of responsible observation and contribute to biodiversity conservation. Educational institutions and research groups are encouraged to incorporate these apps into their projects and to train new users in their ethical and responsible use.

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